IN THE NATIONAL GREEN TRIBUNAL, PRINCIPAL BENCH,

AT NEW DELHI

IN

O.A. NO. 1016/2019

IN THE MATTER OF:

UTKARSH PANWAR ...APPLICANT

VERSUS

CENTRAL POLLUTION CONTROL BOARD & ORS. ...RESPONDENTS

PAPER BOOK

[REPLY TO CPCB REPORT DATED 06.07.2020 ON BEHALF OF THE SONEPAT DISTRICT BRICK KILN OWNERS' ASSOCIATION]

VOLUME-I

Pg No-(1- 231)

PLACE: NEW DELHI

FILED ON: 11.09.2020

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PLACE: NEW DELHI

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FILED BY:

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REPLY TO CPCB REPORT DATED 06.07.2020 ON BEHALF OF THE SONEPAT DISTRICT BRICK KILN OWNERS' ASSOCIATION.

MOST RESPECTFULLY SHOWETH

1. Vide Order dated 23.03.2020, this Hon'ble Court observed that the issues of allowing operation of brick kilns may give rise to following questions:
   (i) The use of cleaner fuels or any other alternative measures to be used to prevent air pollution;
   (ii) Siting and carrying capacity.

2. In addition to the aforesaid issued, this Hon'ble Tribunal also sought expert opinion of CPCB on utilizing fly ash and the following issues:
   (i) How brick kilns can be allowed in NCR without damage to the air quality;
   (ii) Conditions subject to which it may be done;
   (iii) Number of brick kilns to be allowed and criteria for fixing such numbers.

3. While directing the CPCB to file a report on the aforesaid issued, this Hon'ble Court granted liberty to the brick kiln owners' associations who had filed impleadment applications in the present OA to put forth their view point on the aforesaid issues. Accordingly, several representations were submitted to CPCB by several Brick Kiln Owners' Association.

4. After conducting a study of the supportive and assimilative capacity of the districts of Delhi-NCR, CPCB filed a Report on 06.07.2020 in terms of the aforesaid directions issued by this Hon'ble Tribunal. The said Report, *inter alia*, recommended the following :

   (i) Based on the assimilative capacity, some brick kilns, which have adopted zig-zag technology, may operate.

   (ii) Zig-zag brick kilns in NCR districts should preferably be open in summer months only, unless or until there is improvement in the environmental condition through reduction in PM 10 emissions leading to availability in the supportive carrying capacity.

   (iii) Even if there is enough supportive carrying capacity to operate all the zig-zag brick kilns in any district, the start-up firing process may be allowed in three batches of 33% of the total zig-zag type brick kilns which can be operated, with a gap of 7 days within two batches.

   (iv) Distance of 500 meters is to be ensured between two brick kilns.

   (v) Staggered permission for operation may be given to the existing brick kilns in such a way that only estimated number of brick kilns operate in an area during any given time.

   (vi) In districts where ambient air quality data for the past is not available, due to non-availability of CAAQMS, the data of the districts having comparable population and geographical area, may be used for estimating the number of brick kilns which can be operated without affecting the ambient air quality.

   (vii) Techno-economic feasibility study may be conducted by an expert agency for making an assessment with respect to use of PNG and other cleaner fuels such as internal fuels, with different types of firing technologies, for making brick manufacturing sustainable and environment friendly, at locations where such fuels are available.

OBJECTIONS TO METHODOLOGY ADOPTED BY CPCB

5. It is respectfully submitted that a bare perusal of the aforesaid report submitted by the CPCB suggests/shows that it has neither collected adequate technical data nor conducted a proper study of the

material available with it while arriving at the aforesaid conclusions. In fact, it appears that the said report has been prepared without obtaining expert guidance.

6. It is respectfully submitted that the methodology adopted by CPCB with respect to assessment of the assimilative and supportive carrying capacity of the districts of Haryana, Uttar Pradesh and Rajasthan is deeply flawed for the reason that it does not take into consideration PM values for three months i.e. July, August and September. A perusal of Table 2 would show that the PM 2.5 values for the months of July, August and September has been included therein, but the same has been excluded in Table 1, leading to absurd consequences. Since the brick kilns do not operate during the said period, the details with respect to PM 10 values for the said period is extremely necessary to accurately assess the monthly average of air volume available, and the permissible pollution load on monthly basis. The assimilative and supportive carrying capacity calculated on the basis of a partially considered pollution load is inaccurate and unreliable.

7. The study conducted by CPCB is also flawed for the reason that CPCB has failed to provide the details with respect to the districts and the period for which the CAAQMS and AOD data were not available. With respect such districts wherein the CAAQMS and AOD data was not available, the CPCB has applied the data pertaining to districts with comparable area and population, without any basis. Calculations based on such data raise serious concerns and doubts as regards the accuracy of the supportive and assimilative carrying capacity of the districts of Haryana, Uttar Pradesh and Rajasthan in Delhi-NCR.

8. In addition to the above, it is submitted that the CPCB has arbitrarily taken the emission load of one brick kiln as 1000 kg/day, without any calculation. This is without any basis and is patently incorrect. As per calculations accessed by the Applicant, the emission load of one brick kiln using zig-zag technology which is compliant with air pollution standards is only 23 kg/day. A true copy of Expert report as regards emission load of zig-zag brick kilns alongwith presentation by Dr. J.S. Kamyotra, Director CPCB is attached herewith as **ANNEXURE-A-1**.

THE RECOMMENDATIONS OF THE CPCB ARE ARBITRARY, DISCRIMINATORY AND VIOLATIVE OF ARTICLE 14

9. It is respectfully submitted that the entire approach of CPCB in considering the feasibility of brick kilns based on supportive carrying capacity is unlawful and violative of Article 14 of the Constitution of India.

10. It is submitted that by way of the aforesaid recommendations, an entire industry is being singled out by recommending its closure for want of carrying capacity despite the fact that the same is not recognized as the biggest cause of pollution in Delhi-NCR.

11. The discrimination meted out to the brick kiln industry by way of the aforesaid recommendations can clearly be seen from the fact that the CPCB itself observed in its Report that the findings of the study on "Source Apportionment of PM2.5 and PM10 of Delhi NCR for identification of major sources" prepared by ARAI and TERI for Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises in the year 2016 indicates that the brick kiln industry contributed about 5 & 7% with respect to PM10 emissions in winter and summer respectively to the ambient air of Delhi-NCR. It has also been observed by CPCB, citing the aforesaid Report, that further reduction of 4% in total PM10 was expected after conversion to zig-zag technology, which has now been implemented by brick kilns in Delhi-NCR. Further, the number of brick-kilns operating in Delhi-NCR has also reduced after the complete ban imposed on non-zig-zag brick kilns. Thus, the current contribution of brick-kilns to pollution in Delhi-NCR is only about 1-2%. True Copy of Relevant Extract of final Report titled "Source Apportionment of PM2.5 and PM10 of Delhi NCR for identification of major sources" prepared by ARAI and TERI for Department of Heavy Industry, Ministry of Heavy Industries and Public Enterprises alongwith its executive summary is annexed herewith as **ANNEXURE-A-2.**

12. The ban imposed on operation of brick kilns due to lack of supportive carrying capacity in Delhi-NCR is manifestly arbitrary and discriminatory because all industries that contribute to pollution in Delhi-NCR are required to reduce their emission load in the interest of cleaner air. The entire burden of air pollution cannot be placed on one industry. As a matter of fact, as per several expert bodies, comprehensive action has to be taken by all industries contributing to pollution in Delhi-NCR. None of these expert bodies recommend banning or shifting out of brick kilns from Delhi-NCR. Rather, the universally recognized long term action plan for reduction of emission load from brick kilns is conversion of the Bull

Trench Kilns to Zig-Zag Brick Kilns. The brick kiln industry has duly cooperated in this area, at significant cost to each brick kiln, by converting to zig-zag technology. Thus, in these circumstances, it is manifestly arbitrary and unfair to ban one industry that has actually adopted the technological recommendations for reducing its emission load. True Copy of Report titled National Clean Air Programme by Ministry of Environment, Forest & Climate Change, Government of India, 2019 is annexed herewith as **ANNEXURE-A-3.**
True Copy of the NITI Ayog Report of the Task Force on Clean Industry titled 'Action Plan for Clean Industry' is annexed herewith as **ANNEXURE-A-4 .**
True Copy of Report titled 'Market Transformation towards Energy Efficiency in Brick Sector' by Bureau of Energy Efficiency is annexed herewith as **ANNEXURE-A-5.**

13. Under the aforesaid circumstances, there was absolutely no reason for the CPCB to recommend closure of the brick kiln industry, when the other industries, which are known to contribute significantly more to the air pollution in Delhi-NCR are allowed to operate/function.

14. It is further respectfully submitted that the recommendations of CPCB are *manifestly arbitrary* for the reason that no analysis has been made of the air pollution that will be caused on account of transportation of bricks from far-off regions into Delhi-NCR, in case the brick kilns in Delhi-NCR are shut down.

15. It is submitted that brick kilns cannot possible be directed to be shut down on account of lack of carrying capacity, if the necessary corollary of shut down would be more pollution on account of the large distances over which trucks would have to travel to transport bricks into Delhi-NCR. The CPCB report is conspicuously silent on this aspect, and is thus arbitrary.

16. It is submitted that brick kilns support the demand for bricks from construction activities in areas around which they are located. If the recommendations of the CPCB are to be followed on account of saturation of carrying capacity, the demand for bricks in Delhi-NCR will have to be met by transport of bricks from neighbouring States/far off regions outside Delhi-NCR. The increased distance over which trucks would have to travel for transporting bricks into Delhi-NCR would itself cause significant level of pollution. This can be more specifically seen from the following studies:

    (i) A Report titled 'Assessment of traffic-generated gaseous and particulate matter emissions and trends over Delhi (2000-2010)' by Rati Sindhwani and Pramila Goyal, published in

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Atmospheric Pollution Research showcases the emission factor of a diesel truck, which is 1.075 g of PM/km.

(ii) A Report titled 'On-road emissions of CO, CO2 and NOx from four wheeler and emission estimates for Delhi' published in Journal of Environmental Sciences shows that 2.5 kg of CO_2 is released by a truck upon use of one litre of diesel.

Under such circumstances, the aforesaid recommendations of the CPCB will result in a situation wherein the PM10 and CO_2 emission in Delhi- NCR will considerably increase owing to increase in movement of trucks in Delhi-NCR from neighbouring states. True Copy of Report titled 'Assessment of traffic-generated gaseous and particulate matter emissions and trends over Delhi (2000-2010)' by Rati Sindhwani and Pramila Goyal, published in Atmospheric Pollution Research is annexed herewith as **<u>ANNEXURE-A-6.</u>**
True Copy of Report titled 'On-road emissions of CO, CO2 and NOx from four wheeler and emission estimates for Delhi' published in Journal of Environmental Sciences is annexed herewith as **<u>ANNEXURE-A-7.</u>**

17. It is respectively submitted that a simple calculation of the emission of particulate matter and CO_2 from transportation of the bricks to Delhi from neighbouring States and other regions would showcase the increase in pollution that will be caused in Delhi :

(i) In total, there are 2697 zig-zag brick kilns in Delhi-NCR. These brick kilns operate for a period of about six months (180 days) in a year, and each of these brick kilns manufacture around 30, 000 bricks per day. From the same, it is submitted that approx. 14,56,38,00,000 (One Thousand Four Hundred and Fifty Six Crores and Thirty Eight Lacs) bricks are used annually in Delhi-NCR.

(ii) The number of trucks required to transport the aforesaid amount of bricks across the year would be 48, 54, 600, each involving at least 200 km of travel (Since NCR districts spread out to a radius of about 200 km from Delhi). This will lead to an increase of 970, 920, 000 truck-km across the year, on account of transportation of bricks from neighbouring states and other far off regions.

(iii) Taking an emission factor of 1.075 g of PM/km for diesel trucks (as per the aforesaid Report titled 'Assessment of traffic-generated gaseous and particulate matter emissions and trends over Delhi (2000-2010)'), the PM emission across the year in Delhi from transportation of bricks to Delhi from neighbouring States would be 10, 43, 739 kg of PM/year.

(iv) Apart from the aforesaid PM emissions, a truck usually gives a mileage of 4 km/litre. Thus, the daily diesel consumption of one truck is estimated as 50 litre/day. Therefore, the total diesel consumption of the trucks transporting the bricks across the year is estimated at 242, 730, 000 litre/year. Taking an emission factor of 2.5 kg of CO_2/litre of diesel (as per Report titled 'On-road emissions of CO, CO_2 and NOx from four wheeler and emission estimates for Delhi' published in Journal of Environmental Sciences), it can be seen that 606, 825, 000 kg of CO_2/year is also released from the transportation of bricks to Delhi from neighbouring States and other regions.

18. Thus, shifting of brick kilns from Delhi-NCR will not eliminate the 1-2% share contributed by them to the total pollution in Delhi-NCR. Rather it will only add up to 10% PM and 10-15% CO2 load in Delhi-NCR due to transportation of bricks from neighbouring states and far off regions.

19. Therefore, the CPCB ought to have studied the comparative analysis of air pollution caused by brick kilns in Delhi-NCR vis-à-vis air pollution caused by transportation of bricks to Delhi-NCR from far off regions, before recommending the closure of the brick kilns in Delhi-NCR and the staggered operations thereof.

FLY-ASH CANNOT BE UTILIZED IN BRICK-MAKING INDUSTRY IN DELHI-NCR

20. With respect to utilization of fly ash by the Brick Kiln Industry, it is respectfully submitted that there is no conclusive research/study which suggests that the use of fly ash in bricks and other building material is safe for human habitation. In fact, fly ash is a fine powder that is a by-product of burning pulverized coal in thermal power plants. Several studies conducted, in India as well as abroad, suggest that utilization of fly ash in bricks and other building material would cause excessive radiation risks to inhabitants and thus, they are not suitable to use as building material.

21. Apart from the above, it deserves to be noticed that fly-ash is currently utilized in the cement industry and for making of highways, etc. In fact, fly ash generation in the State of Haryana is 5.8995 million tonne per year while fly ash utilization is 6.7716 million tonne per year. Thus, the percentage of fly ash utilization in the State of Haryana is 114.78%. The same has also been highlighted by the Central Electricity Authority, Government of India in its Report pertaining to the year 2018-2019. Under such circumstances,

there is no excess fly ash available for the brick kiln industry. True Copy of Report of Central Electricity Authority, Government of India is annexed herewith as **ANNEXURE-A-8.**

22. Therefore, it is submitted that utilization of fly ash in the manufacture of bricks is not only unfeasible because of lack of availability of fly-ash but also because it poses several health hazards to inhabitants residing in buildings made therefrom, in addition to health hazards to labourers working at brick-kilns and on construction sites.

23. Apart from the above, it is respectfully submitted that since fly ash is a fine-powder, there is much greater probability of fugitive particulate pollution in the handling and transportation of fly-ash, which will also cause much more pollution and pose greater harm for the public at large.

THE CPCB HAS FAILED TO CONSIDER THE EVOLUTION OF THE BRICK-KILN INDUSTRY AS REGARDS REDUCTION IN EMISSION LOAD

24. It is respectfully submitted that brick kilns associated with the applicant have, time and again, cooperated in the endeavour to reduce their emission load. They have, time and again, adhered to the directions, orders and guidelines issued by the regulatory bodies as well as this Hon'ble Tribunal to reduce emissions.

25. Around the year 1990, most of the brick kilns operational in Delhi-NCR were Moving Chimney BTKs. However, owing to the recommendations of COINDS (Comprehensive Industry Document Series) study, the MoEF issued a notification banning all types of Moving Chimney BTKs and ordering all Moving Chimney Kilns to convert to Fixed Chimney Kilns by June, 2002.

26. Accordingly, the brick kilns across Delhi-NCR were converted from Moving Chimney BTK to Fixed Chimney BTK (FCBTK). This conversion not only helped in the reduction in SPM emissions but also resulted in fuel savings and increased production and quality.

27. However, FCBTK also suffered from incomplete combustion of fuel, indicated by high co-concentration in fuel gas (PPM), black smoke and unburnt coal deposition at floor of kiln. In view thereof, to ensure lower PM emissions and to have effective control over the air-pollution caused by FCBTK, several directions for conversion of the brick kilns from FCBTK to Zig-Zag Brick Kilns were passed by the Ministry of Environment, Forest and Climate Change, the EPCA and the CPCB, as follows :

(a) On 29.12.2015, the CPCB, in order to tackle the issue of air pollution, directed all brick kilns in Delhi-NCR to convert from Natural Draft Brick Kilns to Induced Draft Brick Kilns within 90 days.

(b) Thereafter, in November, 2016, CPCB passed an order directing the State Pollution Control Boards of UP, Rajasthan and Haryana to shut down those brick kilns which had not converted from Natural to Induced Draft (with rectangular shape and zig-zag brick setting) by 31.03.2017.

(c) Even the EPCA, in May, 2017, ordered all brick kilns in Delhi-NCR to shift to rectangular zig-zag, with entrepreneurs having the option to choose between Natural or Induced Draft. The deadline and schedule of 30.09.2017 as given by different CPCBs remained.

(d) Meanwhile, on 27.06.2017, the CPCB sought the status of conversion of Natural Draft to Induced Draft Brick Kilns (with rectangular shape ad zig-zag brick setting) from all SPCBs.

(e) On 24.10.2017, the CPCB issued directions under Section 5 of the Environment (Protection) Act, 1986 to SPCBs, whereby the SPCBs were directed that the Brick Kilns that have not converted to zig-zag kilns from fixed chimney bulls trench kiln (FCBTK) by 30.09.2017 should not be allowed to operate. Even the EPCA, in October, 2017, directed that the brick kilns which have not converted to zig-zag kilns by 30.09.2017 should not be allowed to operate in the winter season (till March 15, 2018).

(f) In fact, even the Hon'ble Supreme Court had directed the notification of the Comprehensive Action Plan for Delhi and NCR (CAP). The CPCB, accordingly issued directions under Section 3 and 5 of the Environment (Protection) Act, 1986 regarding the CAP in Delhi and NCR on 22.06.2018. CAP directs all NCR State Pollution Control Boards to ensure that only brick kilns which have converted to zig-zag technology and have been certified by the SPCB will be allowed to operate during winter 2017-2018.

28. The brick kilns associated with the applicant duly complied with the aforesaid directions and orders issued by the respective regulatory bodies and the Hon'ble Supreme Court and adopted the Zig-Zag Technology, by incurring huge costs.

29. Thus, in terms of the aforesaid directions, the brick kilns associated with the applicant shifted from the use of agricultural residue waste as in FCBTK kilns, to use of cleaner fuels like coal in zig-zag brick kilns.

30. The benefits of these changes are immense, and can be summarized as follows :

    (a) Improved heat transfer and greater efficiency, due to zig-zag setting of bricks.

    (b) Better mixing of air and fuel allowing complete combustion, reducing coal consumption to about 20 percent.

    (c) Uniform distribution of heat, increasing the share of Class I bricks to about 90 percent, which reduces emissions considerably,

    Resulting in major reductions in emissions and improvements in air quality. These improvements far exceed the improvements required by brick-kilns under the existing regulatory regime.

31. Even the EPCA, in its Special Report No. 92 on NCR Air Pollution, published on 25.10.2018, specifically mentioned that conversion of the existing brick kilns to an alternative technology, called zig-zag technology, is widely understood as the most cost-effective and feasible method to reduce pollution in this sector. It was also stated that the range of the particulate emission from the zig-zag brick kiln is less than 250 mg/Nm^3 while that of FCBTK is 250-1250 mg/Nm^3. Furthermore, it was also mentioned that at the meeting of EPCA held on 14.09.2018, EPCA noted that the advantage with zig-zag converted brick kilns is that the quality of combustion material is better – including the use of crushed or briquettes of agricultural residues – and this reduces pollution substantially. True Copy of Special Report No. 92 dated 25.10.2018 is annexed herewith as **ANNEXURE-A-9.**

32. Under such circumstances, wherein the brick kilns associated with the applicant have made huge investments in adopting the zig-zag technology for the purpose of reducing the emissions and for effective control of the air pollution within Delhi-NCR, the recommendations for issuance of directions for closure of the brick kilns in Sonipat in Delhi-NCR from October to February is clearly arbitrary and violative of Article 14 of the Constitution.

33. It is respectfully submitted that the reliance placed by this Hon'ble Tribunal on the judgments namely M.C. Mehta v. Union of India (1998) 9 SCC 149, M.C. Mehta v. Union of India (2000) 7 SCC 422, M.C. Mehta v. Union of India (2002) 4 SCC 378, in O.A. No. 1088/2018 titled Dinesh Chahal & Ors vs. Union of India is misplaced in the present context because at the time of passing of the said judgments, the brick kilns in Delhi-NCR were operating on primitive technology and there were no emission standards for brick kilns to follow. However, at present, the brick kilns are using cleaner technologies and fuels. In fact, there are regulatory bodies which monitor the emissions of the brick kilns and ensure that they are within the prescribed norms.

FAILURE ON THE PART OF CPCB TO CONDUCT A STUDY ON CLEANER FUELS

34. In addition to the above, it is respectfully submitted that the CPCB has failed to conduct a study on cleaner fuels, as directed by this Hon'ble Tribunal.

35. It is respectfully submitted that the CPCB was obliged to conduct a study on cleaner fuels like PNG in the manufacturing of brick kilns. However, no such study has been conducted by CPCB. Rather, it has sought to shy away from its duties by suggesting that a techno-economic feasibility study made be conducted by an expert agency for making an assessment with respect to use of PNG and other cleaner fuels such as internal fuels.

36. It is respectfully submitted that the proposal for use of fuels like PNG, etc are not the same as proposals for adoption of zig-zag technology from FCBTK technology. While such a conversion/change was possible through modifications of existing brick-kilns, the proposal for use of PNG cannot be implemented by changing existing infrastructure. In addition to the development of new technology, it will require the setting up of a completely new infrastructure as well.

37. If the brick kilns associated with the applicant were to adopt the use of cleaner fuels like PNG, the same would cause heavy losses to them. In fact, many brick kilns would be coerced to shut down on account of a direction to that effect.

38. Thus, in view of the above, it becomes clear that the aforesaid recommendations of the CPCB, if followed by this Hon'ble Tribunal, will lead to a situation wherein the particulate emission and other gases will rise beyond the current limits, thereby deteriorating the ambient air quality instead of improving the same.

39. Therefore, it is humbly prayed by the Applicant herein that this Hon'ble Tribunal may be pleased to set aside the Report dated 06.07.2020 submitted by CPCB and allow the operation of the brick kilns in Delhi-NCR in terms of the Graded Response Action Plan, after meeting the conditions of the Consent to Operate and the guidelines/directions issued by EPCA and other regulatory bodies.

[APPLICANT]

THROUGH

PLACE: NEW DELHI
FILED ON: 11.09.2020

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(ATUL AGARWAL)
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AFFIDAVIT

I, CHANDER BHAN, SON OF LATE SH. BHARAT SINGH, PRESIDENT OF THE SONEPAT DISTRICT BRICK KILN OWNERS ASSOCIATION, presently at Delhi, do hereby solemnly affirm and state as under:

1. That I am the President of the Applicant Company in the present application and am well conversant with the facts of the case. I have been duly authorized to swear and affirm the present affidavit on behalf of the applicant and thus I am competent to swear this affidavit.

2. That the contents of accompanying reply are true and correct to my knowledge and belief and nothing material has been concealed therein.

3. That the annexures annexed herewith are true copies of their respective originals.

Chander Bhan

DEPONENT

I identify the Person who has Signed/ Executed this Documents in my presence.

VERIFICATION

Verified at New Delhi on this 9th day of September, 2020 that the contents of above affidavit are true and correct to my knowledge and belief and nothing material has been concealed therefrom.

NOTARY GOVT. OF INDIA

Chander Bhan

DEPONENT

ATTESTED
NOTARY PUBLIC
DELHI (INDIA)

11 SEP 2020

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ANNEXURE - A-1

Some Observation on CPCB Reports on Brick Kilns Submitted to Hon'ble NGT during January – July 2020

Note 1: Emission Load

Sameer Maithel

(Draft 21 August 2020)

Background

During the period January to July 2020, the Central Pollution Control Board has submitted three reports concerning air pollution from brick kilns to the Hon'ble NGT. These are:

a) **Report dated 22.01.2020** in compliance of the Hon'ble NGT order dated 30.07.2020 in the matter of O.A. No 1088 of 2018. The report addressed the issue of air quality carrying capacity assessment and impact of operation of the conventional brick kilns using agri-residue.

b) **Report dated 04.03.2020** in compliance of the order of Hon'ble NGT dated 30.01.2020, in the matter of O.A. No 1088 of 2018 and O.A. No 1016 of 2019. The report addressed the issue of air quality carrying capacity assessment and impact of operation of the conventional brick kilns using agri-residue.

c) **Report dated 06.07.2020** with reference to the order of Hon'ble NGT dated 17.03.2020 in the matter of O.A. No 1016 of 2019, which addressed the following questions:
(i) how brick kilns can be allowed in NCR without damage to the air quality; (ii)conditions subject to which it may be done; (iii) number of brick kilns to be allowed and criteria for fixing such numbers.

In the context of the carrying capacity assessment and quantifying the PM emissions caused by brick kilns, Emission Load (kg of PM_{10} emitted per day as defined in the CPCB report dated 06.07.2020) is an important parameter. This note discusses the issue of Emission Load.

Emission Load (kg of PM_{10} emitted per day from one brick kiln)

CPCB Reports submitted to Hon'ble NGT

a) Page number 9 of the report dated 06.07.2020 states that "**Emission load from brick kilns having capacity of 30,000 bricks/day, considering stack PM emission of 250 mg/Nm^3 at 17% O_2 is 1000 kg/day**". In other words, on an average, a brick kiln producing 30,000 bricks/day, and which meets the revised emission standards as draft notified by MoEFCC of 250 mg/Nm^3 PM at 17% O_2, will emit approximately 1000 kg/day or 1 MT/day of PM_{10}. The Emission Load can be calculated using the following equation.

Emission Load (kg/day) = Concentration of PM in stack gases (mg/Nm^3) x Volumetric Flow Rate of Stack Gases (Nm^3/day)

In this case, Emission Load and concentration of PM in stack gases is known, so flow rate of stack gases can be calculated, which comes out as **40 lakh Nm^3/day or around 1,66,667 Nm^3/hr at 17% O_2 concentration.**

This Emission Load number is then used in the report for estimating the contribution of PM emissions from brick kilns in a district as well as in calculating the number of kilns that can be allowed to operate considering the supporting carrying capacity in a district.

b) Page number 19 of the report dated 22.01.2020 with reference to the Suratgarh district of Rajasthan states that "**total load of particulate matter (PM10) from 30 numbers brick kilns which were operational during the study is taken as 45.80 MT/day.** If we divide 45.80 MT/day by the number of brick kilns, we will get an **Emission Load of PM as 1.53 MT or 1533 kg/day/kiln.**

Previous CPCB reports and Peer Reviewed Scientific Papers

Three studies, including a past CPCB study and two peer reviewed scientific papers on the subject were reviewed to compare the estimates of the Emission Load and the stack gas flow rates in brick kilns

Reference 1: Presentation by Dr J. S. Kamyotra, Director, CPCB at Anil Agarwal Dialogue 2015: Poor in Climate Change, India Habitat Centre, New Delhi, March 11 – 12, 2015. (http://cdn.cseindia.org/userfiles/JS-kamyotra.pdf accessed on 20th August 2020 and attached as **Annexure 1).**

This presentation was based on an extensive study carried out by the Punjab State Council for Science and Technology (PSCST) for the Central Pollution Control Board (CPCB) to prepare a Comprehensive Industry Document (COINDS) for brick kilns and the basis for the revision of emission standards of brick kilns. This is the most extensive emission monitoring study to date in India and was carried out over 2-3 years and covering approximately 50 brick kilns.

Page number 18 of the presentation provides the results of the measured volumetric flow rate (Nm^3/hr), measured SPM (mg/Nm^3) and production capacity (bricks/day) for FCBTK kilns operating in North Zone. Similarly, page number 20 of the presentation provides the same results for the High Draught (or induced draft zig-zag kilns) operating in the North zone. With this data it is now possible to calculate the Emission Load using equation 1. The data referenced from the presentation along with the results of the calculations are shown in Table 1. For the calculations, average values of volumetric flow rate of flue gases and concentration of SPM in flue gases has been used.

Table 1 Calculated Emission Load based on CPCB-PSCST Measurements

	Volumetric flow rate of flue gases in Stack (Nm^3/hr) [A]			Concentration of SPM in flue gases (mg/Nm^3) [B]			Production capacity (brick per day)			Emission Load [AxB]x 24/1000	**Emission Load for 30,000 brick per day capacity**
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg.	kg/day	**kg/day**
FCBTK (North India - Biomass)	11115	16040	**13,578**	102	688	395	32000	40000	36000	129	107
FCBTK (North India-Coal)	14487	25938	**20,213**	140	374	257	36000	40000	38000	125	98
High Draft or Induced draft zig-zag kiln (North-Coal)	11377	23845	**17,611**	49	116	83	30000	60000	45000	35	23

In case of FCBTK, the Emission Load for a kiln producing 30,000 bricks per day is calculated to vary between 98-107 kg/day. For induced draft zig-zag kilns which are more efficient and less polluting, the Emission Load is only 23 kg/day. The average volumetric flow rate of flues gases in the chimney of induced draft zig-zag kiln of production capacities varying between 30,000 to 60,000 brick per day, varies between 11,377 Nm^3/hr to 23,845 Nm^3/hr. Both the reported Emission Load and the volumetric flow rate are only a fraction of that reported in the CPCB reports submitted to the Hon'ble NGT.

Reference 2: Research paper published by The Energy and Resources Institute (TERI) researchers

R Suresh, Sachin Kumar, Richa Mahtta, Sunit Sharma. Emission Factors for Continuous Fixed Chimney Bull's Trench Kiln (FCBTK) in India. International Journal of advanced Engineering, Management and Science, Vol-2, Issue-6, June- 2016, page 662-670 **(attached as Annexure 2)**

This research paper presents the results of emission monitoring of 10 FCBTKs using coal as fuel located at Varanasi. The main objective of the paper was to estimate the Emission Factor for particulate matter (g of PM/kg of fired brick) for FCBTK. The paper concludes that for the monitored FCBTKs, the Emission Factor for PM emissions derived per kg of fired brick ranged between 0.81- 1.18 g of PM/kg of fired brick. The Emission Factor can be used to calculate the Emission Load and is shown in Table 2.

Emission Load (kg/day) = Emission Factor (g of PM/kg of brick) x Number of bricks produced per day x weight of one brick (kg)/1000 – (Equation 2)

Table 2 Calculated Emission Load based on TERI paper

	Emission Factor (g of PM/kg of fired brick) [A]		Production Capacity [B]	Weight of brick [C]	Emission Load (kg/day) = [A]x[B]x[C]/1000	
	Min	Max	(brick/day)	kg	Min	Max
FCBTK (10 kilns coal fired at Varanasi)	0.81	1.18	30,000	3	72.9	106.2

The Emission Load for FCBTK ranged from 72.9 – 106.2 kg/day which is comparable to the results of the CPCB-PSCST study, but again only a fraction of that reported in the CPCB reports submitted to the Hon'ble NGT.

Reference 3: Research paper published by researchers from University of Illinois (USA), Enzen Global Solutions & Greentech Knowledge Solutions (India)

Uma Rajarathnam, Vasudev Athaly, Santhosh Ragavan, Sameer Maithel, Dheeraj Lalchandani, Sonal Kumar, Ellen Baum, Cheryl Weyant, Tami Bond. Assessment of air pollutant emissions from brick kilns, *Atmospheric Environment*, 98 (2014) 549-553 **(attached as Annexure 3)**

This research paper presents the results of emission monitoring of 17 brick kilns. Out of which there are 5 FCBTKs using coal as fuel and 3 Induced Draft zig-zag kilns. Like the TERI paper, the paper presents the results in the form of Emission Factor for particulate matter (g of PM/kg of fired brick). The paper concludes that for the monitored FCBTKs, the mean Emission Factor is 0.89 g of PM/ kg of fired brick and for the induced draft zig-zag kiln the mean Emission Factor is 0.24 g of PM/ kg of fired brick. The Emission Factors can be used to calculate the Emission Load using Equation 2 and the results are shown in Table 3.

Table 3 Calculated Emission Load based on Uma et al paper

	Emission Factor (g/kg)	Production Capacity	Weight of brick	**Emission Load (kg/day)**
FCBTK (5 numbers)	0.89	30000	3	**80.1**
Induced Draft zig-zag (3 kilns)	0.24	30000	3	**21.6**

The Emission Load for PM for FCBTK was calculated as 80.1 kg/day and for Induced draft zig-zag as 21.6 kg/day for 30,000 brick per day capacity.

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Conclusions

It is observed that the results of the earlier CPCB-PSCST study and the 2 peer reviewed scientific papers are in agreement regarding Emission Load for FCBTK and induced draft zig-zag kilns. On the other hand, the Emission Load shown in the CPCB reports submitted to the Hon'ble NGT are extremely high.

a) For FCBTK, the Emission Load as reported in the three other studies varies between 72.9 to 107 kg/day (for 30,000 bricks per day production capacity), while the Emission Load calculated for FCBTK based on the CPCB report dated 22.01.2020 is 1533 kg/day or almost 15 times that reported in other studies.

b) **For the High Draft (induced draft zig-zag kiln), which are now the new reference given that all FCBTKs in the NCR have been ordered to shift to zig-zag kiln technology, the Emission Load reported in the other two studies varies between 21.6 to 23 kg/day, while the Emission Load assumed for a kiln producing 30,000 bricks per day in the CPCB report dated 06.07.2020 is 1000 kg/day (for a kiln which is emitting 250 mg/Nm^3 at 17% O_2 level) or almost 45 times that of actual value.**

21

Brick Kilns in India

J. S. Kamyotra
Director, Central Pollution Control Board
Delhi, India

BRICK PRODUCTION IN ASIA

22

1. Very large and traditional industry in Asia
2. Mechanized and fully automated process for brick production is used by Developed countries

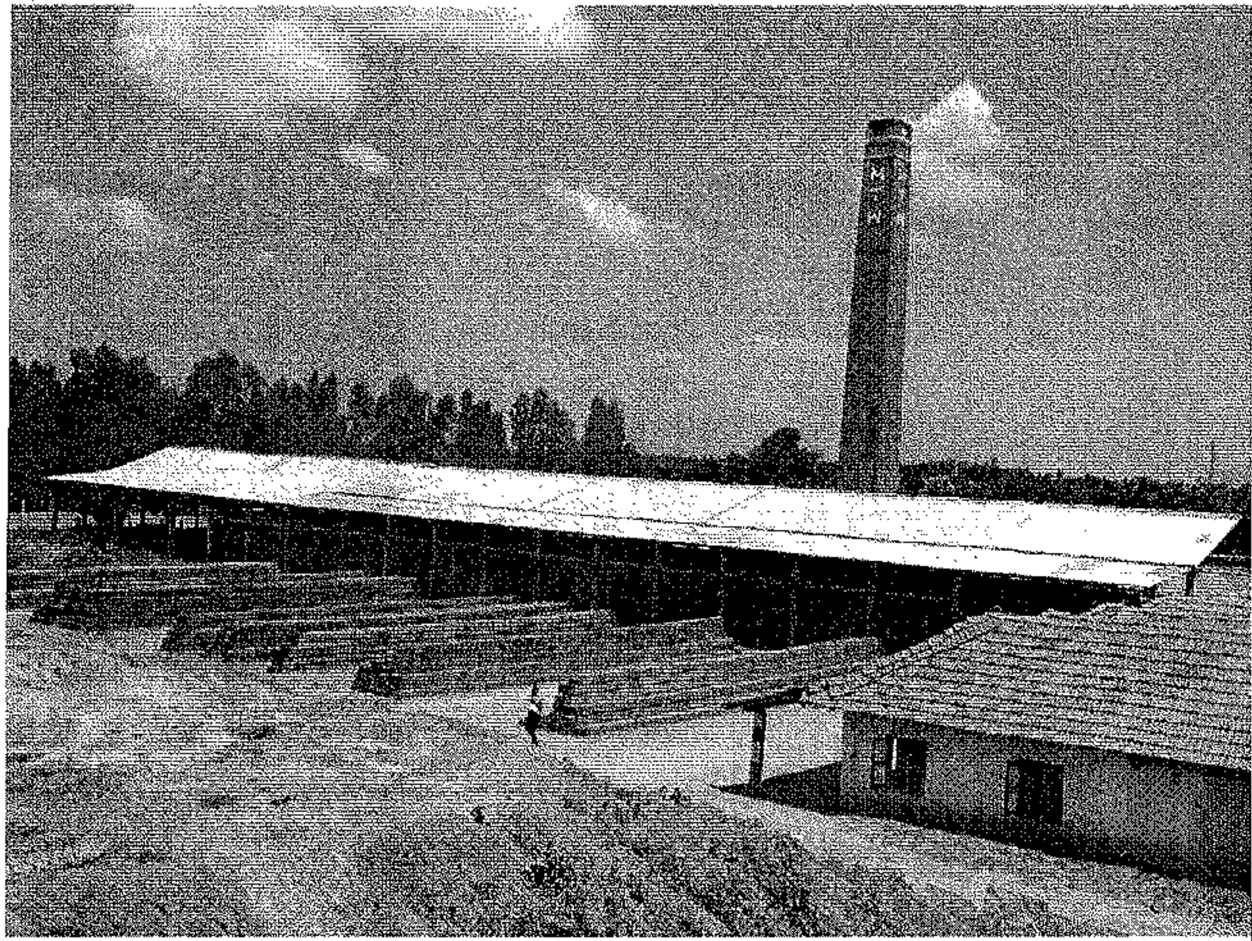
	Bangla-desh	India	Vietnam	Nepal	Pakistan	China
No. of brick units	-	1,40,000	10,000	700	>10,000	80,000
Production in billion	17.2	240-260	26.59	3.15	50	800-1000
Labor in '000	1000	9,000	NA	NA	1500	5000
Population in million	149.7	1210	176.5	18.6	176.7	1334
Brick use/ capita	115	215	151	169	283	750

INTERNATIONAL SCENARIO

INTERNATIONAL SCENARIO World over- Tunnel and Hoffman Kilns considered as environment friendly EE technology and is being promoted

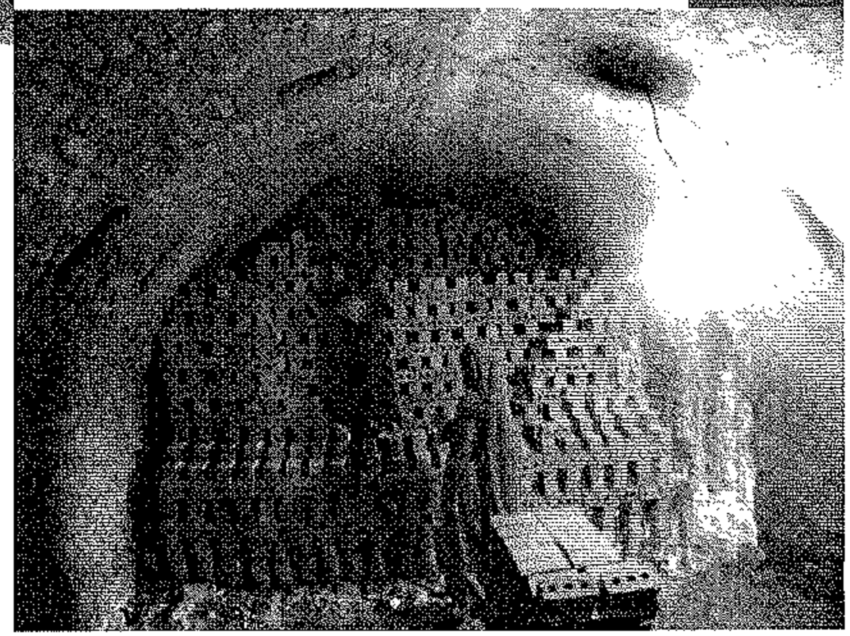
	USA/ Europe – Natural gas fired Tunnel Kilns	•High Initial cost (5-10 crores) •Lack of Know-how •Access to finance •Hot environment inside Hoffman kiln
	China – Tunnel/ Hoffman Kiln	
	Vietnam – Coal fired Tunnel Kilns	
	Bangladesh – Hybrid Hoffman Kiln/ Tunnel Kiln	

- Replacement with REBs (perforated bricks, hollow bricks, bricks with internal fuel/ flyash bricks etc).
- Mechanization for clay preparation and molding
- Min. 20-30% savings in fuel and clay.
- In China, upto 80% of total fuel requirement mixed as internal fuel and remaining 20% fuel used during firing process – *Emission reduction from kiln to a large extent.*



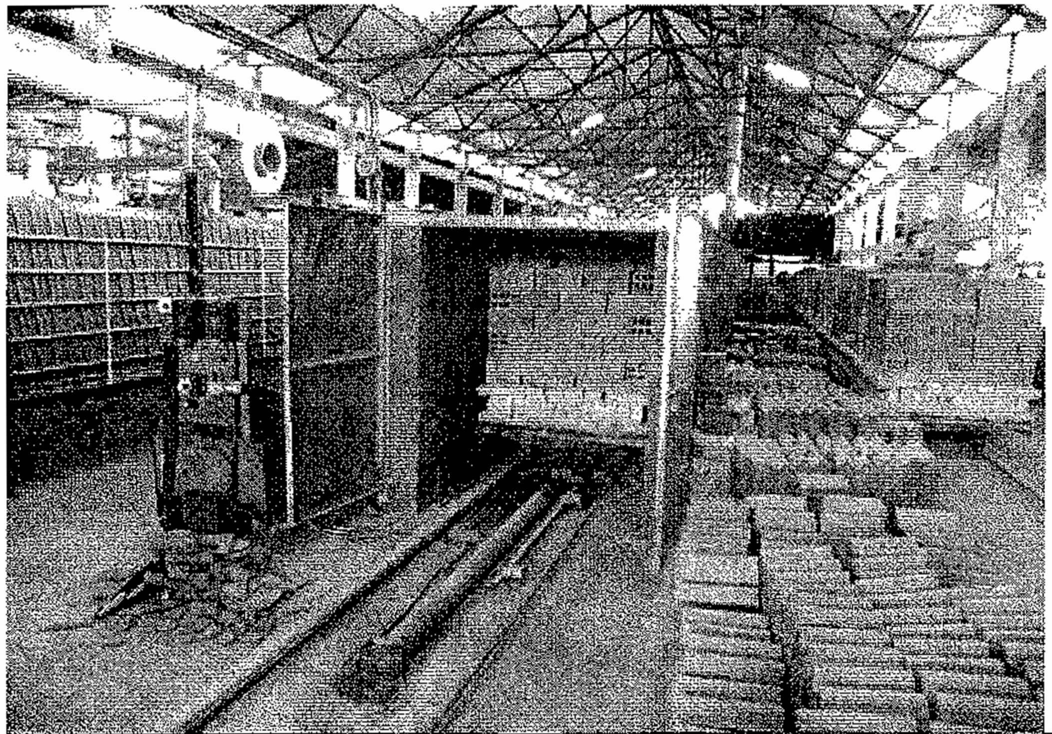
HOFFMAN KILN

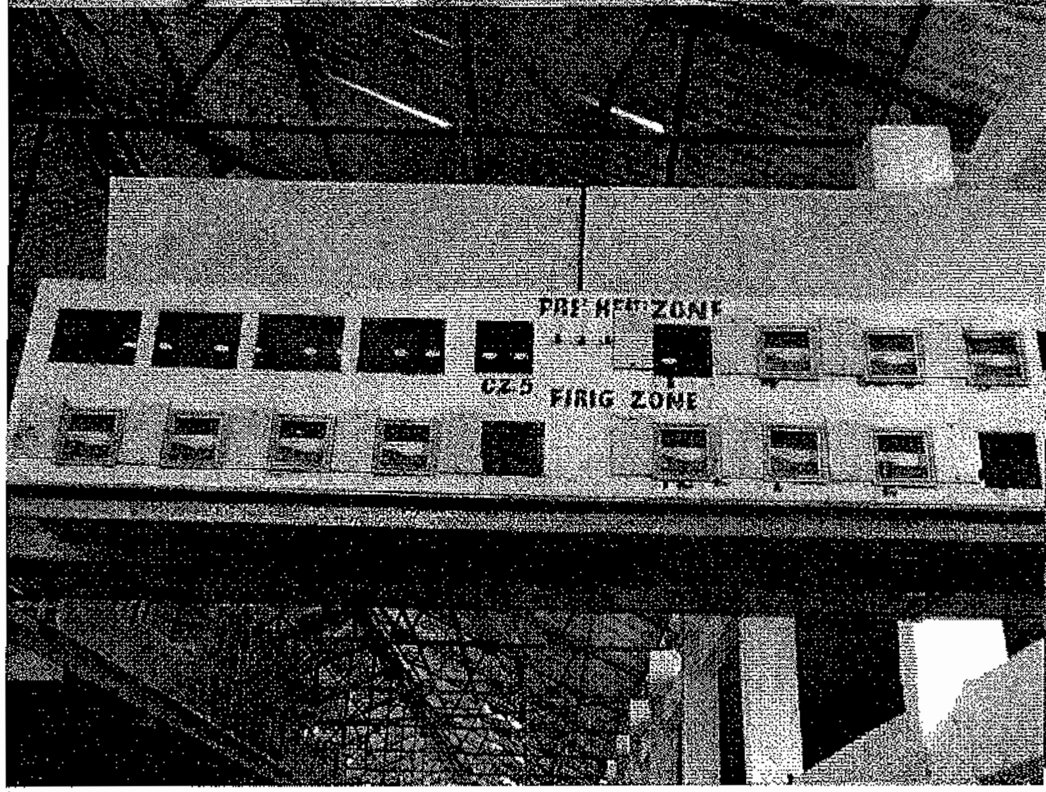
(Product Stationery and Fire Moving)

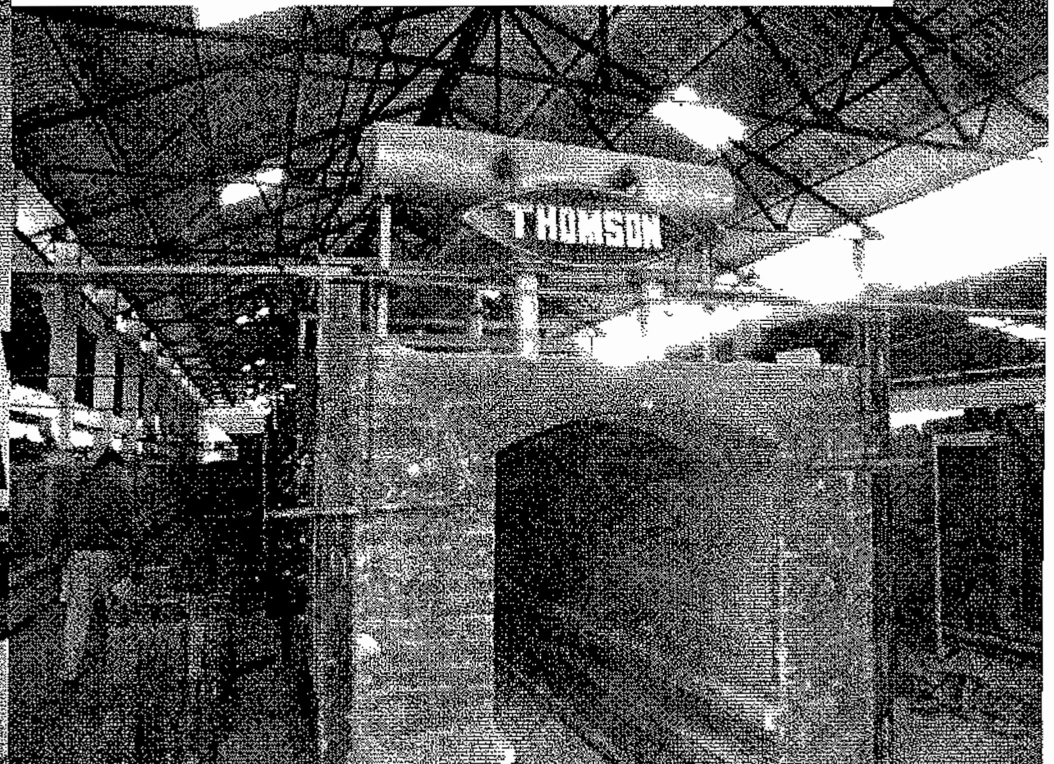


Tunnel Kiln

(Product Moving and Fire Stationary)







INDIAN BRICK INDUSTRY

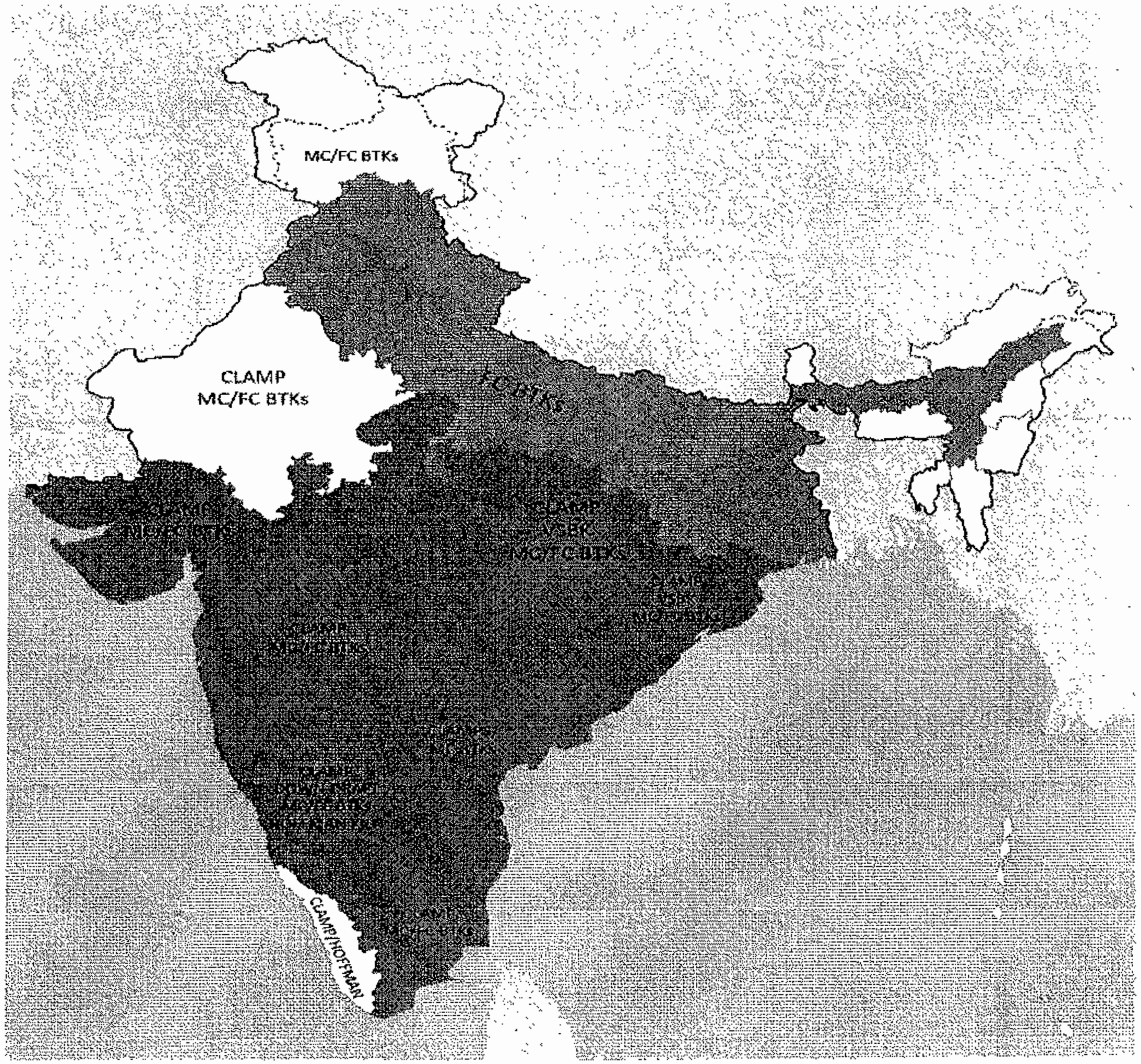
26

- Annual brick production growth: 5-10%
- 2nd largest brick producer after China.
- 74% of total production through BTKs and 21% through Clamps (100K).

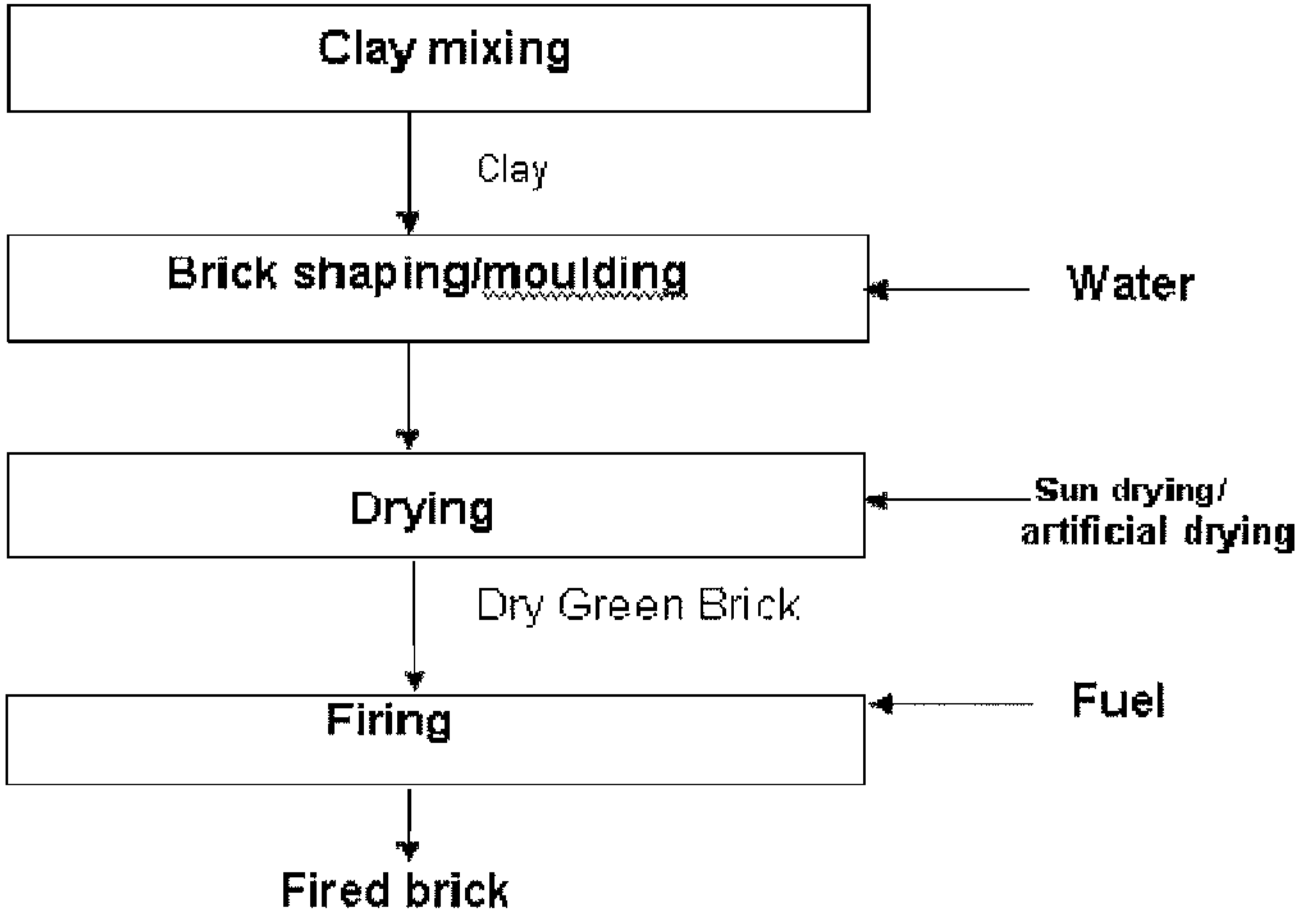
Brick-making enterprises (all types)(no.)	1,40,000
Brick-making fuel used	coal & biomass
Annual brick production	240-260 billion
Coal/biomass consumption (million tce)	35-40
CO_2 emissions (million t)	66
Clay consumption (million m^3)	500
Total employment (million employees)	9-10

Distribution of different type of kilns in India

27

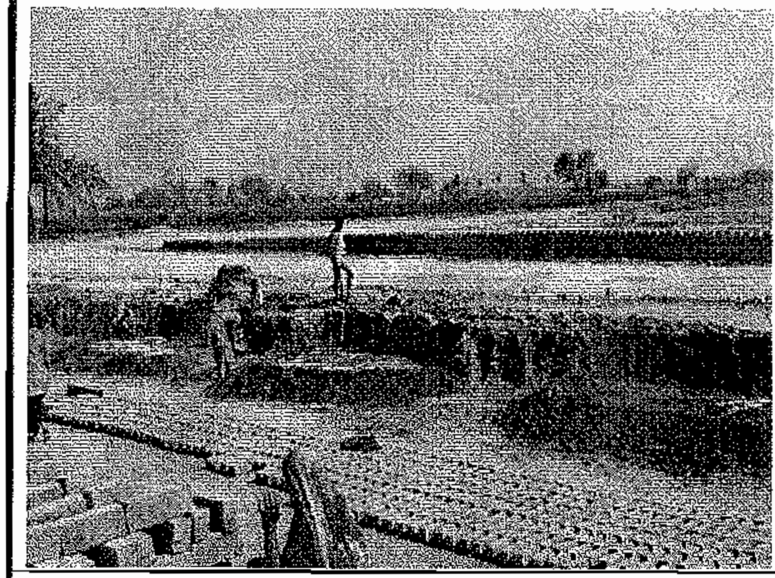


BRICK MAKING PROCESS

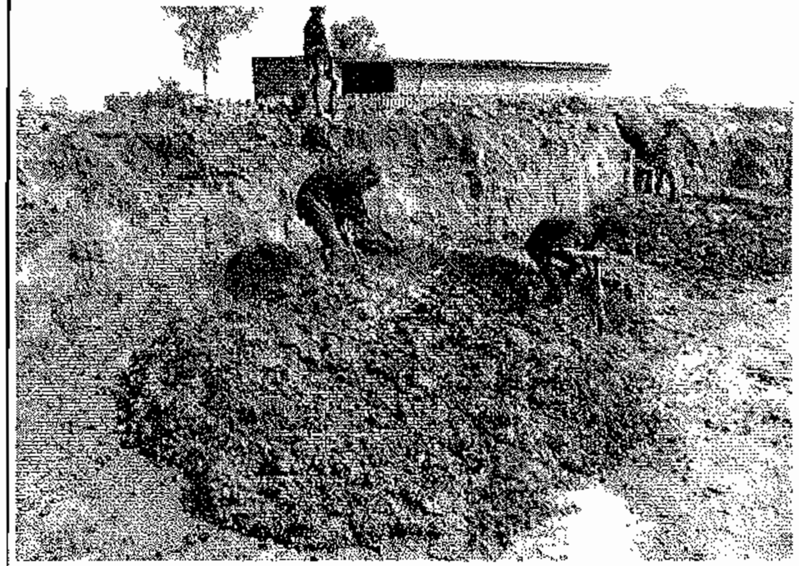


- 99% brick production through hand molding
- Use of biomass/biomass waste/flyash with low CV as internal fuel in some areas of Central/East and West zones.
- Clay preparation through pug mills/tractors with mixers in Central/west/south India.

BRICK MAKING PROCESS: MANUAL EXCAVATION & MOULDING



Manual Excavation



Preparation

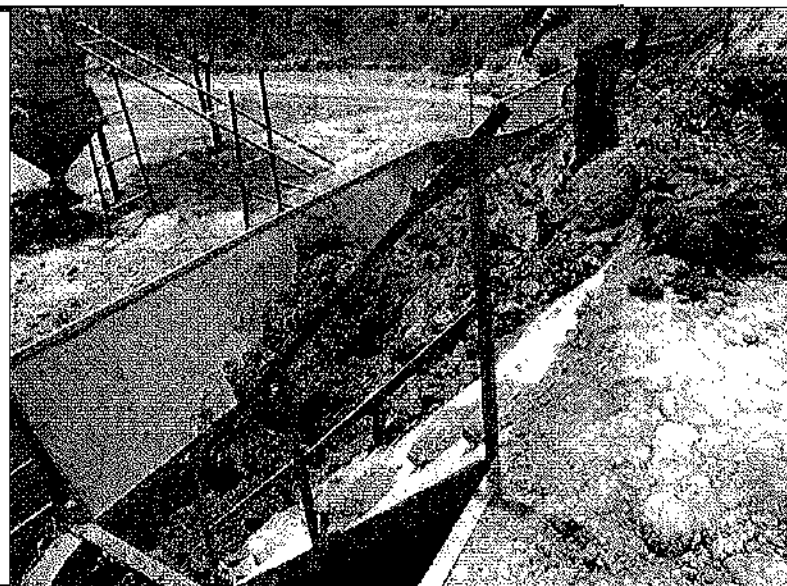
Manual Moulding

Table moulding

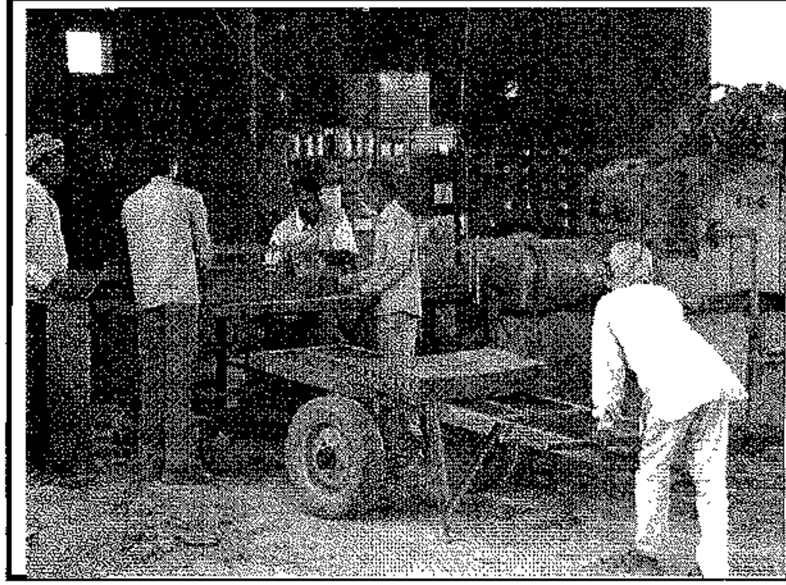
30

BRICK MAKING PROCESS: MECHANICAL

Excavation



Box feeder

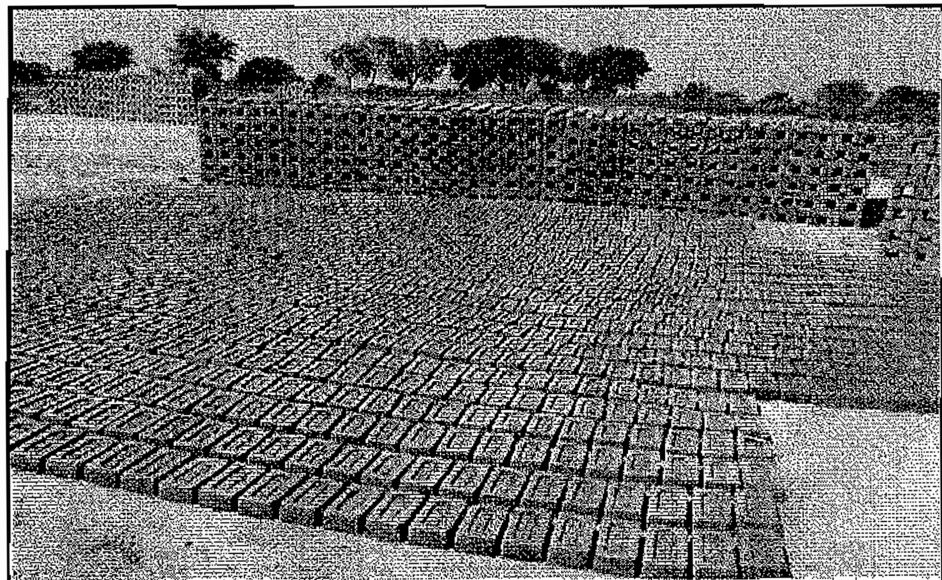


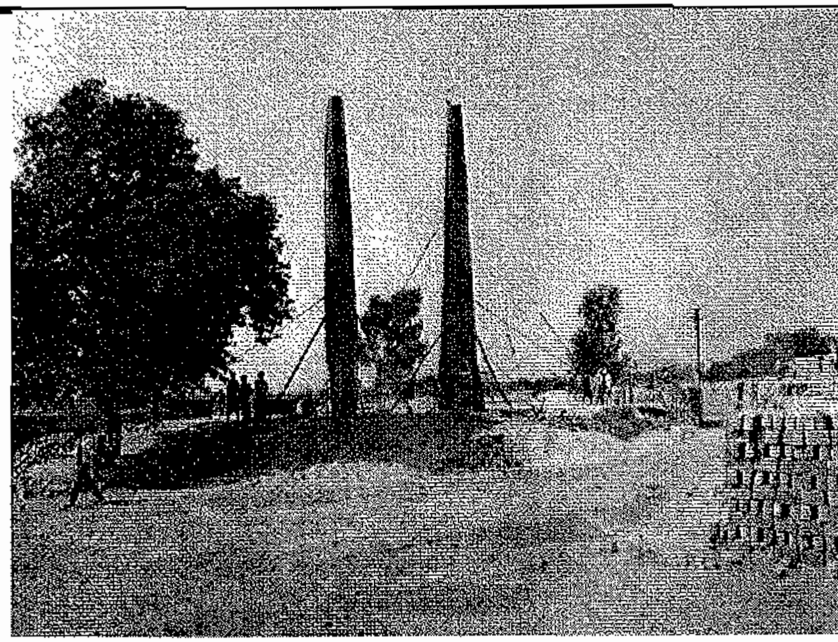
Extruders

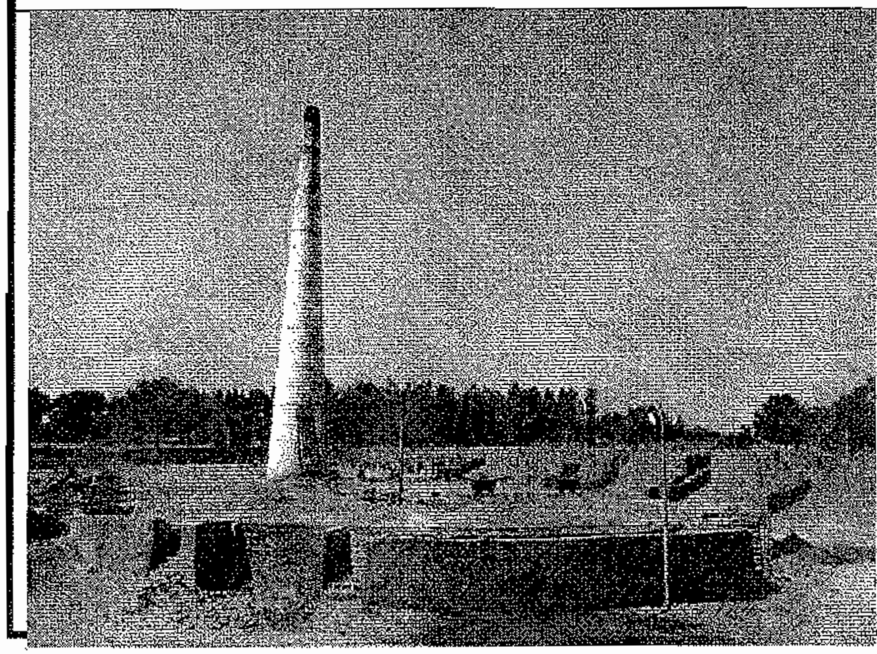
Extruders

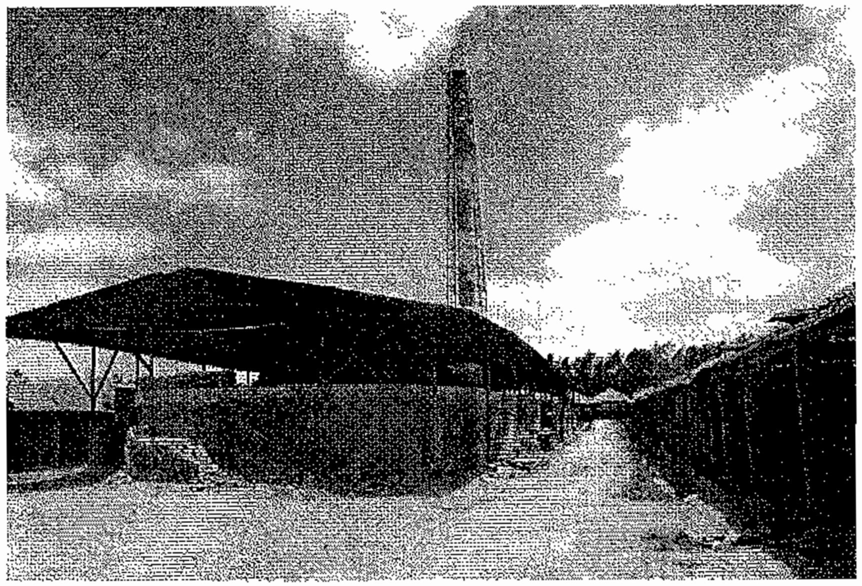
Bull's Trench Kilns

31







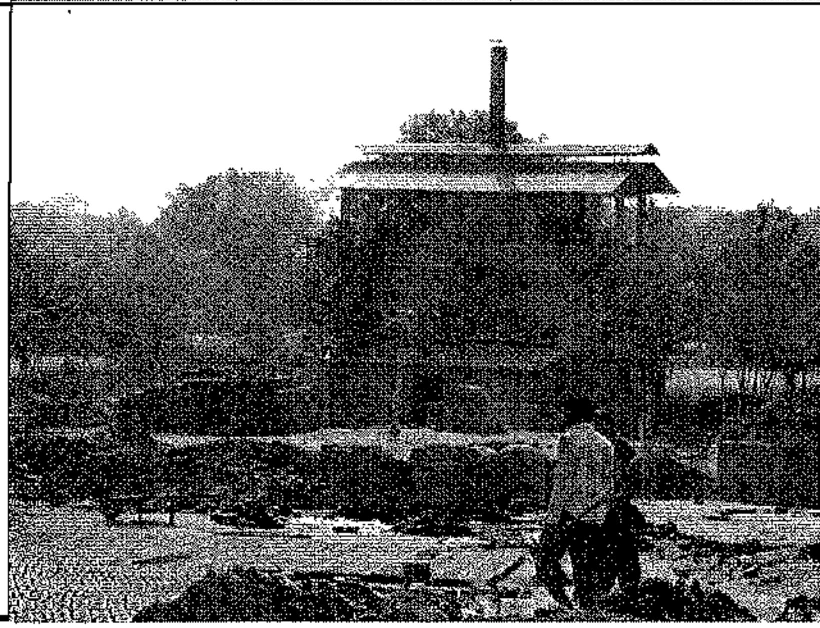


EXISTING TECHNOLOGIES

FCBTK

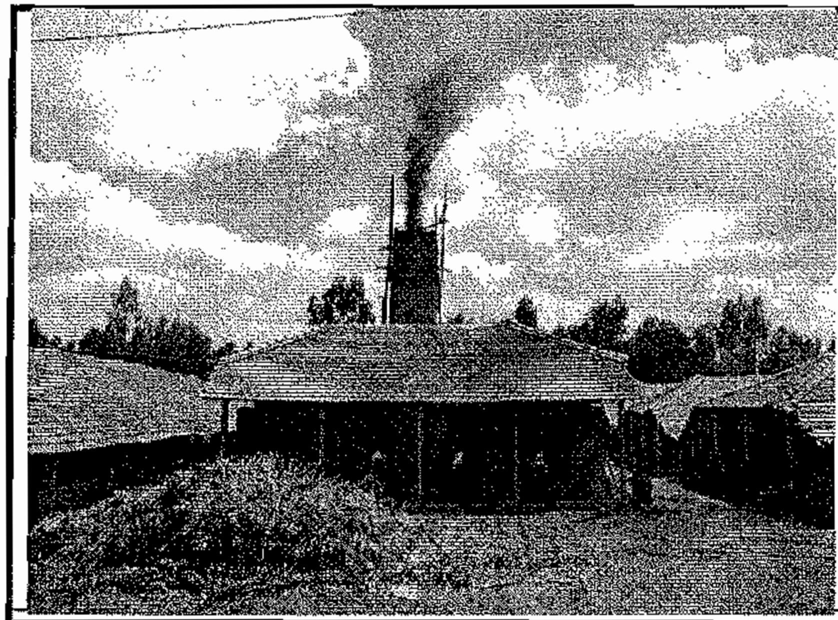
HDK

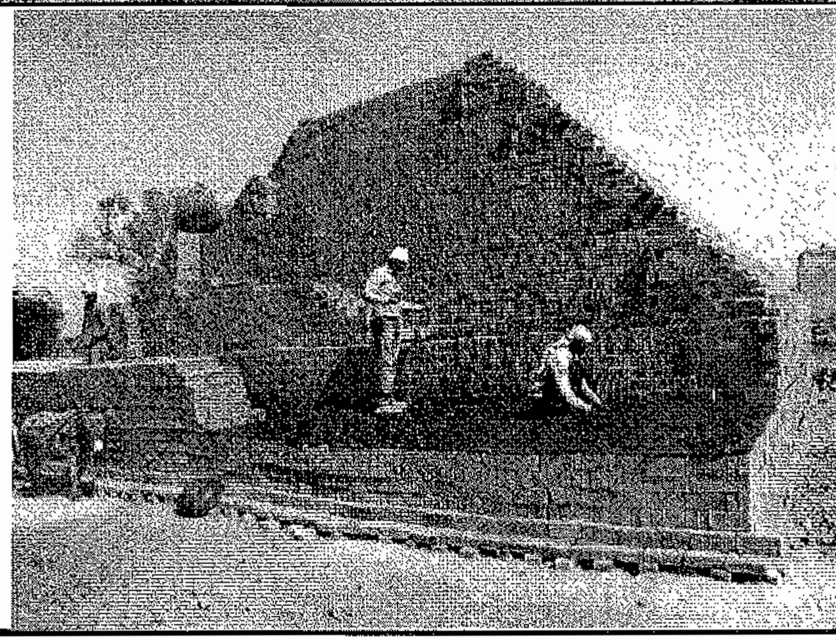
Hoffman



VSBK

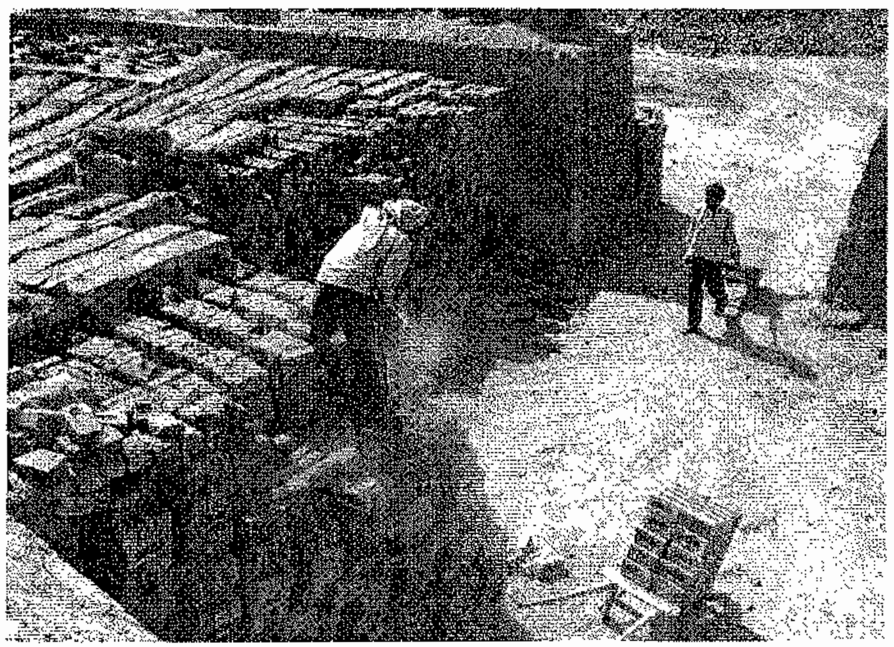
DOWNDRAFT / CLAMP KILNS

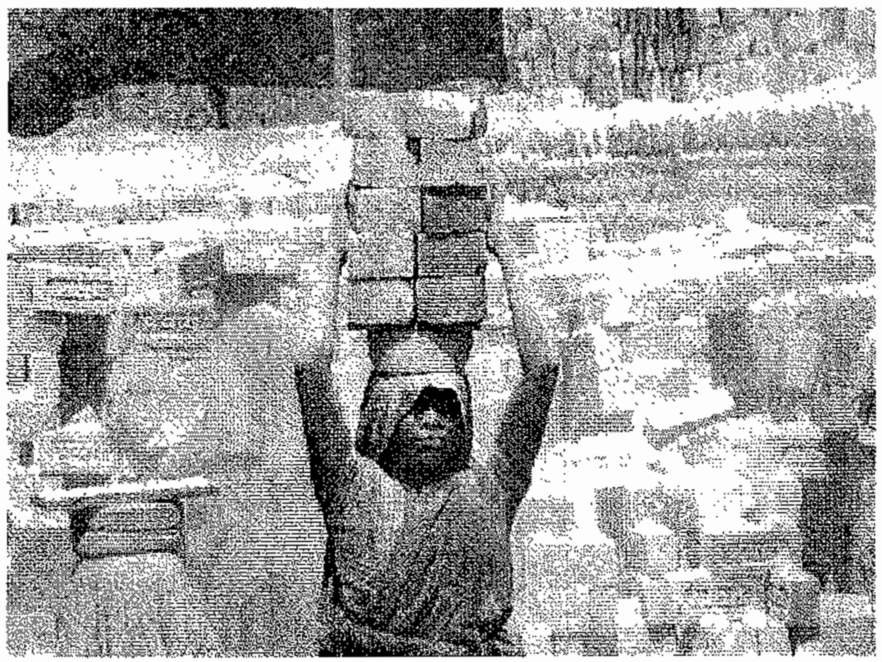




SOURCES OF EMISSIONS

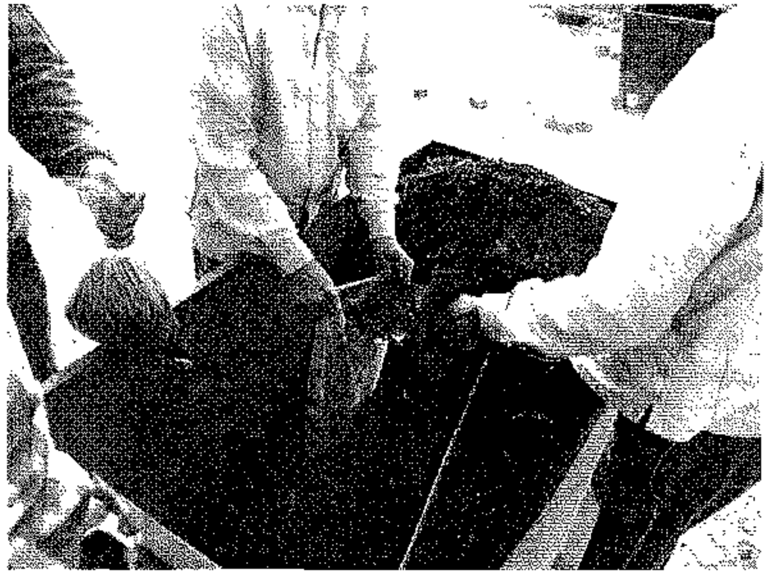
- Stack Emission
- Fugitive Emission
  - During charging of fuel
  - Crushing of coal
  - Clay excavation
  - Loading and unloading of bricks
  - Laying and removal of dust/ash layer '*keri*' over brick setting
  - Cleaning of bottom of trench/side flues
  - During high winds



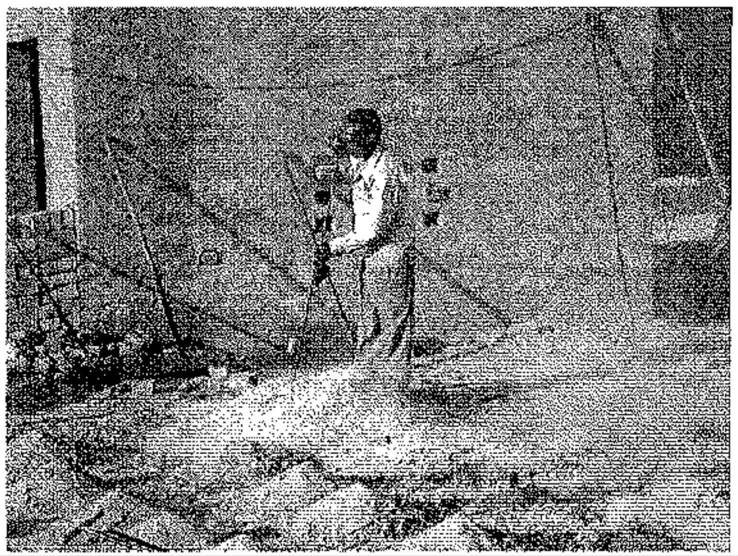


DIFFERENT TYPES OF FUELS USED

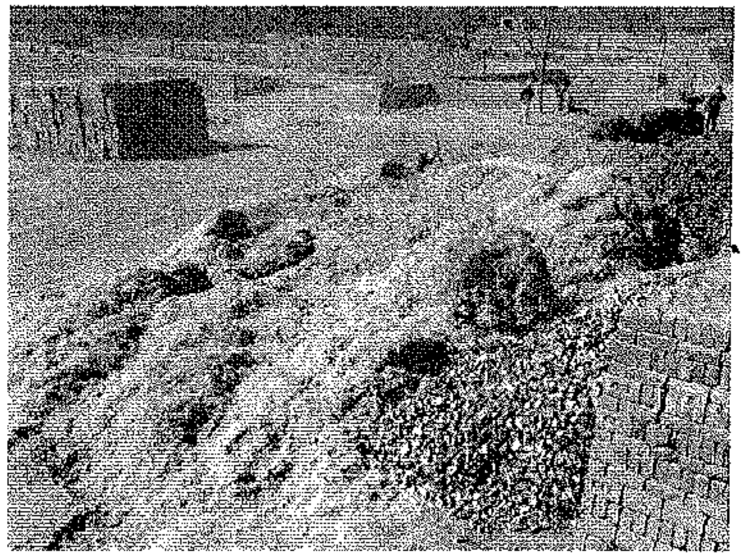
Cotton straw & wood chips



Assam coal



Mustard straw



Wooden chips, mustard & cotton

FUEL ANALYSIS

Type of Fuel	Moisture (%)	Ash (%)	Volatile (%)	Fixed Carbon (%)	GCV (Kcal/kg)
Coal					
Assam Coal	0.96-2.99	11.03-26.46	22.84-37.71	37.06-49.88	4864-5603
Chandrapura Coal	3.96-8.36	22.19-37.16	25.07-30.96	33.81-38.49	4077-4867
Indonesian Coal	13.5-16.7	2.82-15.16	42.31-46.29	28.85-35.6	5386-6316
Jharia Coal	0.31-1.48	34.47-46.89	15.83-26.85	33.78-50.06	3520-5034
Raniganj Coal	6.83-8.61	31.3-23.86	25.1-27.41	34.46-42.43	4607-5258
Biomass					
Mustard straw	5.38-9.09	3.1-6.23	70.47-73.79	16.51-17.1	3998-4306
Rice Husk	5.63-19.4	17.4-23.89	48.26-55.95	14.53-14.92	3403-3471
Cotton straw	12.18	3.77	66.75	17.3	4219
Saw Dust	30.61	5.31	53.38	10.7	3235
Internal fuel					
Katni Coal Dust	1.92	45.77	19.66	32.65	3336
Coal Rejects of thermal Power	2.43	68.5	18.09	10.98	2049

FIRING PRACTICES AND PERFORMANCE OF FCBTKS IN FIVE ZONES

Parameters	North		East Zone	Central Zone			West Zone		South Zone
Fuel	Coal	Biomass	Coal	Coal	Biomass	Coal	Coal	Biomass	Coal
No. of columns	23-31	25-27	19-23	22	21-23	19-21	19-26	20-21	12-21.
Trench width (m)	8.2-11.6	9.5-9.94	7-8	7.8	7.6-8.2	6.4-10.4	6.4-8.7	7.8-8.54	3.6-6.4
Daily production capacity	32,000-40,000	36,000-40,000	16700-32000	28,000	19,000-40,000	20,000-26,000	30,000-45,000	35,000-40,000	22,000-27,000
Firing temperature (^{0}C)	980-1050	940-1020	960-1070	880-980	900-980	960-1016	860-1016	925-973	720-850
SEC in MJ/Kg of fired brick	1.18-**1.32**	**1.33-1.95**	1.05-**1.41**	**1.29**	1.60-172	1.08-1.16	**1.13-1.82**	**1.7-1.77**	0.95-1.24
Stack Temperature (^{0}C)	60-82	52-77	63-118	116	92-95	90-128	80-172	80-90	90-119
Velocity (m/s)	1.2-3.7	1.4-1.9	1.84-2.32	1.54	2.4-2.5	1.49-1.58	2.1-3.65	2.28-2.29	2.8-5.2
Volumetric flow rate (Nm^3/hr)	11115-16040	14487-25938	7597-25938	20373	20610	9115-10600	11843-32284	24462-27984	9600-11100
SPM Charging (mg/Nm^3)	517-1375	268-382	124-865	619	294-330	500	122-422	122-147	75-364
Non-Charging	107-257	83-105	103-301	108	100-115	110-130	78-186	90	42-224
Integrated	102-688	140-374	162-742	566	169-271	357-450	90-384	96-146	55-298
SO_2 (mg/Nm^3)	10-595	5-8	34.1-563.3	10.5	7.9-3.1	13.1-23.6	5.2-943.2	18.3-52.4	0-437.5
CO (mg/Nm^3)	193-1419	2275-2952	282-1748	205	495-1311	147-238	355-3579	2622-5026	269-880
CO_2 %	**0.6-2.85**	2.4-2.6	1.2-2.4	1.2	0.7-1.7	1.7-15	1.0-2.4	1.7-2.0	1.5-2.1

Operating practice	North		East Zone	Central Zone			West Zone		South Zone
Fuel Type	Coal	Biomass	Coal	Coal	Biomass	Coal	Coal	Biomass	Coal
Size of fuel	1/2" to 2"	Chopped 1" to 2"	1/2" to 3"	1" to 6"	Chopped 1" to2" size	Same as coal fired kiln Same as coal fired kiln	1" to 6"	Chopped 1" to 2" size	coal (1" to 6")
Capacity of feeding spoon	Heavy feeding using spoon of 1.0-2.0 kg	With tokris or vehngis	Spoon size: 0.6-1.6 kg	Spoon size 1.5-2.5 kg	Tokri size: 25-30 kg & vehngi size: 45-50 kg		Spoon of size: 0.7-2.0 kg	Tokri size: 25-30 kg & vehngi size: 45-50 kg	With tokris of 25-30 kg capacity
No of rows being fed	Fuel feeding in two lines	Fuel feeding in one line	Fuel feeding in two lines	Heavy feeding in one line	Heavy feeding in one line		Fuel feeding in one or two lines	Heavy feeding in one line	fuel feeding done in two lines
Feeding frequency **Charging**	5-10 mins	Heavy 15-25 mins	7-12 mins	10-15 mins	15-25 mins		8-15 mins	15-25 mins	10-20 mins
Non-Charging	20-40 mins	20-40 mins	20-40 mins	30-50 mins	30-50 mins		30-50 mins	30-50 mins	30-50 mins
Remarks	**Thick smoke during charging period**	**High surface temperatures result in self ignition of biomass at surface only.**	**Coal crushers used in some kilns**	**Thick smoke during charging**	**High surface temperatures result in self ignition of biomass at surface only**		**Resulting in thick smoke due to charging**		**Due to feeding coal lumps the light greyish smoke emitted**

PERFORMANCE OF DESIGNS OF KILNS (OTHER THAN FCBTKs)

Parameters	FCBTK-Zig-Zag	High Draft Kiln (HDK)		VSBK	Down Draft Kiln	Hoffman Kiln
	East Zone	North Zone	East Zone	East /Central Zone	(DDK) South Zone	South Zone
No. of columns	15,000 bricks/ Chamber	18,000-20,000 bricks/ chamber	10,500-19,500 bricks/ chamber	440 bricks/ batch in 6 layers	Batch process	4,000-5,000 bricks/ chamber
Trench width (m)	5.2-6.6	10-10.4	5.2-8			2.7
Daily production capacity	20,000-30,000	30,000-60,000	15,000-28,000	6000-8800	30,000 bricks /chamber	10,000-12,000
Fuel	Coal/pet coke/ biomass	Coal/pet coke	Coal	Coal	Biomass	Coal/fired wood
Firing temperature (^0C)	970-1015	970-1020	960-1050	870-915	820-850	650-810
SEC in MJ/Kg of fired brick	**0.92-1.06**	**1.08-1.10**	**1.07-1.15**	0.9	**2.80-3.14**	**1.21-1.52**
Stack Temperature (^0C)	118-163	107-109	54-146	152-179	181-252	118-128
Velocity (m/s)	2-2.83	3.4-3.99	2.01-3.37	2.55	2.8-4.3	2.04-2.86
Volumetric flow rate (Nm^3/hr)	7390-10008	11377-23845	8971-20761	4444-9285	5036-5498	8200-8500
SPM Charging (mg/Nm^3)	155	119-147.6	145.5-432	452	150-454.5	275-353
Integrated	128-134	49-116	149-316	314-405	75-359	200-315
SO_2 (mg/Nm^3)	393-469	1045-1053	13.1-615.7	84-89	118-975	5.2-7.9
CO (mg/Nm^3)	95-158	332-1027	290-667	951-1440	4398-11309	2931-3518
CO_2 %	2-2.4	1.8-1.9	1.27-2.4	0.6-1.1	8.1-11.9	4-4.4

Parameters	FCBTK-Zig-Zag	High Draft Kiln (HDK)		VSBK	Down Draft Kiln	Hoffman Kiln
Size of fuel	Crushed coal	Crushed coal	Crushed coal	Upto 1"	For first 15-20 hrs fuel feeding rate is 30-400kg/hr whereas for last 8-10 hrs fuel feeding rate is 700-750 kg/hr	
Capacity of feeding spoon	Spoon size: 0.175-0.3 kg	Spoon size : 0.25-1.0 kg	Spoon size : 0.25-0.5 kg	NA		
No of rows being fed	6 chambers	6 chambers	2-3 chambers	Packed within the brick settings	Total firing time 24-30 hrs	3 chambers
Feeding frequency **Charging**	10-15 mins or continuous Charging	7-10 mins or continuous Charging	7-12 mins	NA	Continuous charging is done	Fire wood Charging done for 8-10 mins
Non Charging	5-15 mins	12-15 min	10-12 mins			25-30 mins
Remarks	thin smoke	Thin smoke during fuel Charging		Bloating of fired bricks due to lumps of internal fuel	Thick smoke during last 8-10 hrs of Charging	

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INFERENCES - PERFORMANCE OF KILNS IN DIFFERENT ZONES

- **FCBTKs/HDKs**
  - Trench width: 6.4-10.4 mtrs.
  - Min. Production capacity: 22,000 bricks/day

    (trench width of 3.6m in South)
- High stack emissions/ thick smoke in kilns with shorter combustion zone & poor operating practices.
- Excess Air levels of 400-1000% were observed during stack emission monitoring.
- During fuel charging period SPM levels upto 1375 mg/Nm^3 observed in kilns with poor operating practices.
- High CO levels observed in kilns using biomass as fuel.

SPECIFIC ENERGY CONSUMPTION (SEC)

IN MJ/ KG OF FIRED BRICK

FCBTKs-Coal fired	**0.95-1.82**	
FCBTK-Biomass fired	1.33 – 1.95	
HDKs/FCBTK zig-zag	0.91-1.15	Better operating practices
VSBK	0.90	Limited brick production and high initial cost
Hoffman Kiln	1.21-1.52	Produce hollow block, roof tiles
DDKs	2.8-3.14	
Clamps	1.38-1.92	

ENERGY BALANCE

Basis: 1 Ton of clay brick											
Sr. No.	**Parameters**	**FCBTK** (coal)		**FCBTK** (Biomass)		**FCBTK** (zig-zag)		**HDK**		**VSBK**	
	Heat Input										
1	Fuel (coal, biomass, etc.) consumed	in MJ	in %	in MJ	in %	in MJ	in %	in MJ	in %	in MJ	in %
		1134- 1445	100	1364-1772	100	1162	100	1038-1097	100	834	100
	Heat output										
1	Surface heat loss from kiln (Top surface & side walls)	161-424	*14-29*	288-424	*21-24*	236	*20*	150-328	*14-30*	27	*3.2*
2	Heat loss in dry flue gas	35-107	*3-7*	51-153	*3.7-8.6*	71	*6.1*	22-82	*2-7.5*	205	*24.6*
3	Heat required for removing the mechanically held water in green bricks	36-339	*3-23*	33-244	*2.4-13.8*	186	*16*	102-169	*10-15*	68	*8.2*
4	Heat loss due to hydrogen & moisture in fuel	40-80	*3-5*	98-132	*7.2-7.5*	46	*4*	33-49	*3.2-4.5*	15	*1.8*
5	Heat loss due to partial conversion of C to CO	5-28	*0.5-2*	21-75	*1.5-4.2*	4	*0.3*	23-37	*2.2-3.4*	29	*3.5*
6	Sensible heat loss in unloaded bricks	4-20	*0.3-1.4*	20-26	*0.5-1.5*	23	*2*	27-60	*2.6-5.5*	47	*5.6*
7	Other heat component*	477-960	*42-66*	442-1250	*32-70*	596	*51*	440-613	*42-56*	443	*53.1*

Heat required for irreversible chemical reaction & losses such as trench bottom, periodic heating and cooling of kiln structure & due to unburnt carbon in ash

PERFORMANCE EVALUATION OF APCD IN FCBTKs

The particulate removal efficiency of different design of Gravity Settling Chamber (GSC) generally ranged from 20-63%. The stack emission levels at inlet of GSC vary between 592-1495 mg/Nm^3.

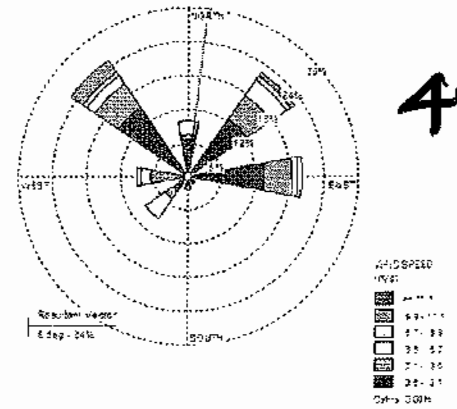
General ambient air QUALITY-brick kilns

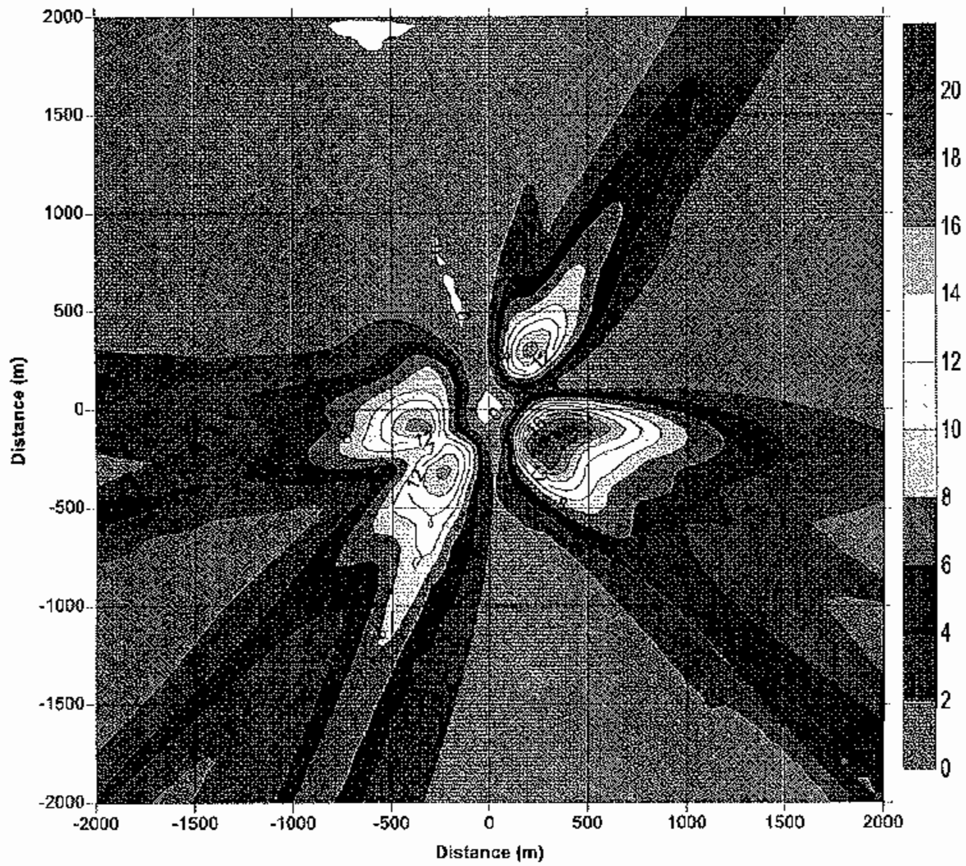
- Impacts not continuous or long term because brick kilns are seasonally operated and operations is cyclic in nature.
- Ambient SO_2 & NOx levels rarely exceeded 25 µg/m3
- The NOx emissions from kiln stacks were also very low and hence its impact on GLCs, the impact of kiln emissions would be insignificant.

AIR POLLUTANT DISPERSION MODELING

- To assess the maximum impact of stack emissions (SO_2 & SPM) on Ground Level Concentration (GLC).
- To formulate stack height guidelines for ensuring the safe impact levels in the context of prescribed Ambient Air Quality Standards.
- To recommend siting guidelines for brick kilns.

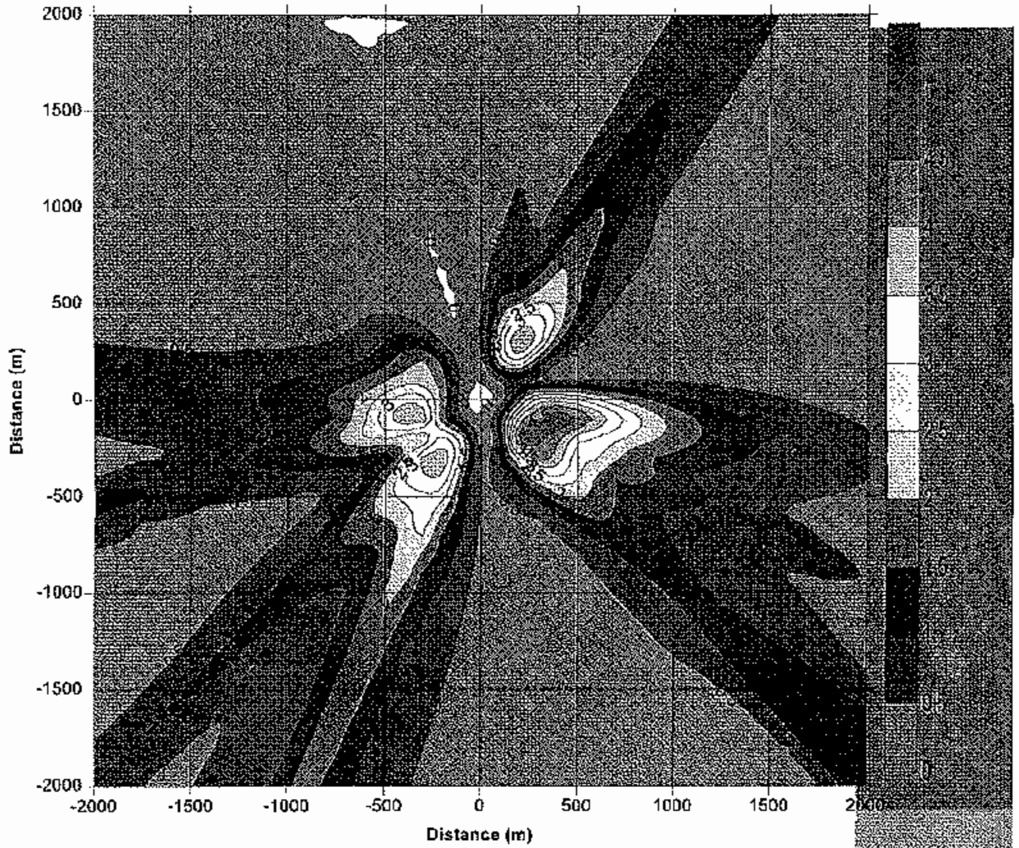
EMISSION DISTRIBUTION PATTERNS IN NORTH ZONE USING ISCST3 MODEL:





Maximum GLC- 21.94 $\mu g/m^3$,
co-ordinates (200,-200)

SPM EMISSIONS



Maximum GLC-5.13 $\mu g/m^3$,
co-ordinates (400,-200)

SO_2 EMISSIONS

Emission Factor

- The emission factor for SPM & Sulphur Dioxide is mainly due to quality of fuel and its feeding & operating practices.
- In case of coal fired brick kilns the average emission factor for SPM was in the range of 0.79 to 1.85 g/kg of fired bricks in the three zones namely North Zone, East Zone and Central Zone wherein brick firing temperature is above 950^0C.
- *Low average emission factor of 0.57g/kg observed in the South Zone which is mainly due to low firing temperature (around 850^0C) and feeding of big lumps of coal after longer intervals. Moreover the quality of brick is also comparatively inferior to the bricks produced in North, East and Central Zones.*
- FCBTK using biomass has lesser emission factors as compared to coal fired FCBTKs (SPM emission factor in the range of 0.78 to 1.19 g/kg of fired bricks).
- The average emission factor for SPM in FCBTK with zigzag firing was 0.37 g/kg of fired bricks due to longer combustion zone in comparison to conventional FCBTKs and good combustion practices adopted in the process. The emission factor is almost comparable with High Draft Kiln.

Ctd...

- The emission factor for SPM in High Draft Kiln were in the range of 0.21 to 1.12g/kg of fired brick due to efficient burning of fuel by adopting good firing practices.
- The emission factors for SPM in VSBK was 1.86 to 2.6 g/kg of fired bricks.
- The biomass fired DDK and Hoffman Kiln in South Zone has emission factor of 0.38 to 1.82g/kg of fired bricks.
- Emission factor for SO2 were mainly due to sulphur content in the fuels used. Low emission factors of 0.03 to 0.23g/kg of fired bricks were observed in biomass fired brick kilns. Whereas, in case of coal fired kilns it varied from 0.04 to 0.67 g/kg of fired bricks.
- The average emission factor for NOx were generally low and was found in the range of 0.03 to 0.32g/kg of fired bricks.

PROPOSED ACTION PLAN

- Two Fold Strategy proposed:
  1. Long Term Measures
  2. Short term Measures

PROPOSED ACTION PLAN

1. Long Term Measure:

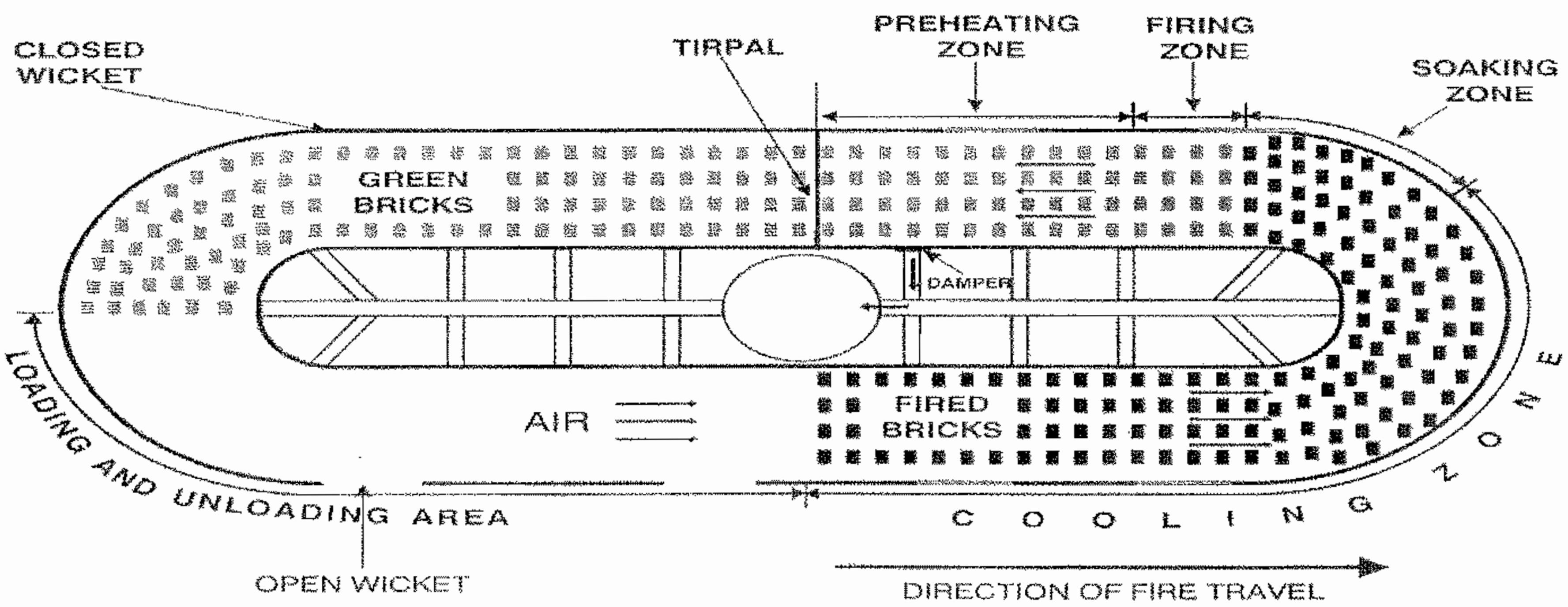
- Effective policies and regulations required for implementing energy efficient technologies like Tunnel Kiln, Hoffman Kilns etc.
- Need for establishing the demand/market for resource efficient products like hollow and perforated bricks, and limiting the production of solid bricks in phases.
- The technologies being capital intensive, requires mechanism for financial support before its replication on large scale.

Short Term Measures

a) Adoption of improved feeding, firing and operating practices in existing FCBTKs

b) Retrofitting of kiln and converting into High Draft Kiln/ Fixed Chimney Bull's Trench Kiln with zig-zag firing.

c) Extensive Capacity Building Program for 'a' above.



ZONES IN BULL'S TRENCH KILN

TECHNOLOGY SELECTION

- Need for initiatives for promotion of EE technologies while framing new Regulations for:
  - Reducing the emissions from brick making process
  - Conserving resource materials and
  - Reducing carbon footprint.
- FCBTK is the most prevailing technology, producing 74% of the country's brick production.
- Need based changes have been incorporated in brick production technology which has improved its EE.
- Use of locally available biomass in FCBTKs has also picked up especially in North and Central Zone.

TECHNOLOGY SELECTION.. Inferences

- However, the smoke emission from the kiln stack, especially during charging time is a cause of concern which can be reduced by only adopting better feeding, firing & operating practices.
- In India, High Draft Kilns (HDKs) and Vertical Shaft Brick Kilns (VSBKs) are comparatively more energy efficient technologies. constraints are
  - need for electricity/power back up in case of HDKs and
  - high initial cost/ low production & non availability of skilled manpower in case of VSBK, these technologies has not been replicated on large scale

Existing Standards for Brick Kilns

Sr. No.	Industry	Parameter	Standards
1	2	3	4
74	Brick Kilns	**i. Bull's Trench Kiln (BTK) Category***	Limiting concentration in mg/Nm3
		Particular matter	
		Small	1000
		Medium	750
		Large	750
		Stack height	minimum (metre)
		Small	22 or induced draft fan operating with minimum draft of 50 mm WG with 12 metre stack height.
		Medium	27 or induced draft fan operating with minimum draft of 50 mm WG with 15 metre stack height.
		Large	30 or induced draft fan operating with minimum draft 50 mm WG with 17 metre stack height.
		*Category Trench width (m)	Production (bricks/day)
		Small BTK <4.50	Less than 15,000
		Medium BTK 4.50-6.75	15000-30000
		Large BTK above 6.75	Above 30000

74	Brick Kilns	**(ii) Down-Draft Kiln (DDK) Category****	Limiting concentration in mg/Nm3
		Particular matter small/medium/large	1200
		Stack height	minimum (metre)
		Small	12
		Medium	15
		Large	18
		**Category Production (bricks/day) Small DDK Less than 15000 Medium DDK 15,000-30,000 Large DDK Above 30,000	

74	Brick Kilns	**(iii) Vertical Shaft Kiln (VSK)**	
		Category**	Limiting concentration in mg/Nm3
		Particular matter small/medium/large	250
		Stack height	minimum (metre)
		Small	11 (at least 5.5 m from loading platform)
		Medium	14 (at least 7.5 m from loading platform)
		large	16 (at least 8.5 m from loading platform)
		**Category No. of shafts	Production (bricks/day)
		Small VSK 1-3	Less than 15000
		Medium VSK 4-6	15,000- 30,000
		Large VSK 7 or more	Above 30000

1. Gravitational Settling Chamber along with fixed chimney of appropriate height shall be provided for all Bull's for all Bull's Trench kilns.
2. One chimney per shaft in Vertical Shaft Kiln shall be provided. The two chimneys emanating from a shaft shall either be joined (at the loading platform in case of brick chimney or at appropriate level in case of metal chimney) to form a single chimney.
3. The above standards shall be applicable for different kilns if coal, firewood and / or agricultural residues are used as fuel."

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PROPOSED EMISSION STANDARDS

FIXED CHIMNEY BULL's TRENCH KILN (FCBTK), HIGH DRAFT KILN (HDK) & HOFFMAN KILN

Guidelines for better fuel charging & operating practices in and siting of Bull's Trench Kilns and Clamp Kilns

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IMPROVED FUEL CHARGING & OPERATING PRACTICES

(For improving the combustion efficiency and reduce emissions)

- The coal charging in Bull's Trench Kilns should be properly graded and maximum size of coal charged should be limited to 20 mm.
- Fuel charging in Bull's Trench Kilns should be done in minimum 3 rows of brick setting at a time in case of coal and in minimum 2 rows of brick setting at a time in case of firewood and agricultural residues.
- Minimum 3 fuel charging shall be done every hour in Bull's Trench Kilns.
- Internal fuel, such as powdered coal, flyash etc. should be used by mixing with clay during brick making in Bull's Trench Kilns and clamp brick kilns.

PROCESS EMISSION CONTROL

- Crushing of coal should be done in enclosed equipment/ area to avoid process emissions.
- Following measures be adopted to control dust emissions due to airborne ash from the top of brick settings:
  - Raising a 2 feet wind breaker wall along the outer trench wall of bull's trench kilns.
  - Covering of the top ash layer in the preheating zone with sheet in bull's trench kilns.
- The approach road and the road around brick kiln should be paved/stabilized.
- Water should be sprinkled frequently over roads around brick kiln and over the ash layer before its removal and transfer.
- Two or three rows of trees should be planted along the outer periphery of kiln area.

PROCESS IMPROVEMENT

- Use of Temperature gauge in firing zone, flue duct and chimney to monitor and control combustion process.
- Use of double walled insulated feedhole covers packed with insulation material such as ceramic or asbestos fibers to prevent heat loss from fuel charging holes bull's trench kilns.
- Double walled wicket with kiln ash filled in between Bull's Trench Kilns instead of conventional single brick wicket wall with brick on edge which results in leakage.
- Closing of side flue ducts with brick wall (1 ½ brick thick) plastered with a mix of sand clay and cow dung bull's trench kilns or alternatively, shunt system should be used for transferring the gas from side flues to central flue, connected with chimney.
- Minimum 7 inch thick brick kiln ash layer over the brick setting bull's trench kilns to provide heat insulation.
- Placement of fuel in multi-layers during brick stacking in clamp kilns to reduce emissions and to produce better quality bricks

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NORMALISATION OF EMISSION STANDARDS IN FCBTK/HDK

- The air supply in a (FCBTK) drawn through the cooling/ fired brick withdrawal zone has following role:
  - Assist in the combustion of the fuel
  - In addition to the combustion, air is needed to carry forward the heat through different zones for transferring the heat (i.e. cooling of hot fired bricks and drying/ pre-heating freshly set green bricks before combustion)

Normalisation of Emission Standards in FCBTK/HDK

Therefore, in addition to air required for combustion, excess air is required for transferring of heat to different zones. Various authors have indicated the total quantity of air as:

- 6-7 times the quantity of air required for the combustion of fuel (Alfred B. Searle, 1956)
- 500% excess air is required in a continuous kiln (Tim Jones, 1996)

Better practices

- Fuel Storage
- Size of Coal
- Fuel quality
- Fuel feeding
- Kiln Maintenance
- Use of internal fuel
- Fugitive Emissions
- Monitoring
- Protection to workers health

Fuel Storage

- The coal should be stacked on a raised platform with pucca flooring and proper drainage arrangements.
- Coal should preferably be stored under shed with proper ventilation
- The height of coal stack should not be more than 1.5 meter otherwise it will loose its heat value due to self ignition under intense heat and pressure.

Size of Coal

- The size of coal should be such that the coal should either be completely burnt or atleast should have caught fire before the next round of feeding. Hence the coal size should be between powder to ¾ inch i.e. properly graded coal. This would help in uniform brick quality as the powdered coal ignites immediately on feeding thereby releasing heat to the top layer of brick setting. Whereas large sized coal particles release heat at the bottom of brick setting.
- Small sized coal improves air-fuel mixing thus accelerating the rate of combustion. Appropriate size of coal can be obtained by screening/ crushing of large sized coal.
- The crushing of coal leads to fugitive emissions. It is advised that coal crushing should be done in enclosed area with high walls so as to avoid cross currents.

Fuel quality

- Use of coal with high ash content will not only lead to high stack emission but will also pose a problem of handling of ash. It is, therefore, recommended that coal with ash content more than 35% should be avoided.
- Coal with high sulphur content (more than 2%) should not be allowed to use in brick kilns especially in the areas in the vicinity of orchards or flower bearing crops.

Fuel feeding

- Feeding of fuel in more number of lines would increase the length of firing zone and would result in more efficient combustion thereby reduction in stack emissions. Besides this the SEC of brick kiln would also improve.

Kiln Maintenance

- Constructing double walled wicket with rapish/keri in between. The conventional practice of single brick wicket wall with brick on edge results in leakage and hence should be avoided.
- Closing side flues with brick wall (1 ½ brick thick) plastered with a mix of sand clay and cow dung.
- Using double walled insulated feedhole covers. The existing feed hole covers are made of single layer steel plate. The insulated feed hole covers consists of double walled steel plates packed with insulation material such as ceramic or asbestos fibres.
- Providing a minimum ash/keri thickness of 7 inch over the brick setting.

- It is also observed that the kiln structure is partially/fully below the ground level in many States. And even the side walls/base of the kiln is unlined. During rainy season, the trench of brick kiln use to be filled with water. As a result, during first cycle of firing, additional fuel to the extent of 40-50% is consumed in order to evaporate the excess moisture present in the kiln structure, thereby emitting dark smoke from the kiln chimney. Besides this the quality of bricks is also severely affected during first cycle. It is, therefore, recommended that:
  - The kiln should always be above the ground level with proper drainage facility.
  - The kiln structure should preferable be covered by providing a shed over the kiln portion. Provision of shed over kiln would save at least 20-30 tons of coal every first cycle. The shed will have a payback period of around 4-5 years depending upon the weather of particular location.
  - Providing shed over the kiln would also improve the ambience of the area and provide shade to the workers working in the kiln.

Use of internal fuel

- Internal fuel such as ash with carbon, powdered coal or other waste with fuel value should be used in clay. Better mixing of fuel in clays can be achieved using mechanical means. Use of internal fuel will reduce the feeding requirement thus leading to reduced emissions.

Fugitive Emissions

- During summer winds/ storms, the ash layer over the top of brick settings, become airborne resulting in fugitive emissions. To minimise this, wind breakers should be raised along the outer trench wall of brick kiln by constructing two feet high brick wall.
- Provision of shed over the kiln structure will also reduce the fugitive emissions.
- Water should be sprinkled over the keri/ ash layer before its removal and transfer.
- The coal crusher should be installed in an enclosed area with minimum 6' high walls.
- Brick paved/earthen stabilized roads shall be constructed along the outer periphery of brick kiln and approach roads. The water should be sprinkled frequently over these roads.
- Two or three rows of trees with thin leaves should be planted along the outer periphery of kiln area.
- The ash layer in the preheating zone can be covered with plastic sheet/tirpal.

Monitoring

- Since the process of loading, unloading and firing system is totally manual and its performance and efficiency depends on the efficiency and skill of the workers, it is utmost important to monitor the activities, especially the feeding and operating practices in the kiln by using instrumentation, installing monitoring gadgets.
  - It should be made mandatory for a kiln owner to employee a supervisor with minimum 10+2 qualification who will keep the log of temperature in the firing zone, in the side flue and chimney.
  - A temperature gauge shall be installed in the kiln chimney to monitor the temperature of flue gas.

Protection to workers health

- Covering of the kiln top with a continuous layer of bricks or tiles.
- A full face mask is to be provided to workers to protect their eyes, ears and nose.
- Hand gloves are to be provided to workers to protect their hands from ill effects of coal handling and also from hot flue gases coming out of fire hole during the charging.
- Special coat/apron and shoes are to be provided to the workers for their protection against these hazards.

Thanks

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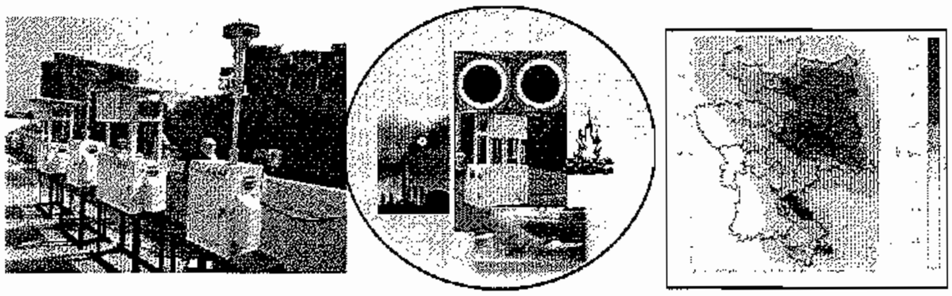
ANNEXURE-A-2

Report No. ARAI/16-17/DHI-SA-NCR/Final Report
August 2018

Final Report

Source Apportionment of $PM_{2.5}$ & PM_{10} of Delhi NCR for Identification of Major Sources



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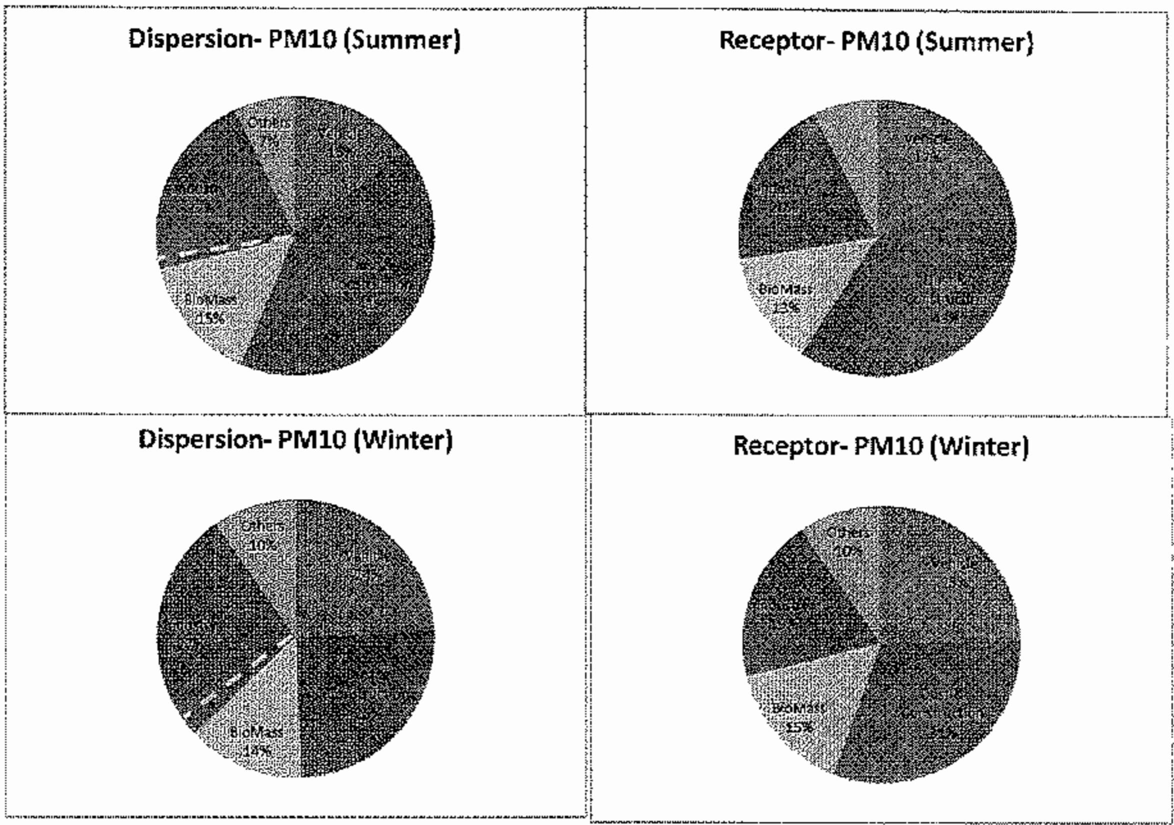

Figure 5.21 : Comparison of results of dispersion and receptor modelling assessment for PM_{10} in Delhi for the two seasons

* Green dotted line shows that some industries in NCR, (which contribute to Delhi's air quality) also use biomass

5.7 Sub-sectoral contributions to PM_{10} and $PM_{2.5}$ concentrations in Delhi

While the broad sectoral shares have been described in the previous section, this section shows contribution of different sub-sectors towards $PM_{2.5}$ and PM_{10} concentrations in Delhi.

5.7.1 Winters

Table 5.3 and 5.4 show the sub-sectoral contributions towards ambient $PM_{2.5}$ and PM_{10} concentrations in Delhi during winters, respectively. It is evident that within the residential sector, biomass fuel is the dominant factor contributing to $PM_{2.5}$ and PM_{10} concentrations. It contributes to 9% in $PM_{2.5}$ and 8% in PM_{10} concentrations in winters. Within the industrial sector, which has a contribution of about 30% in $PM_{2.5}$ concentrations, 8% is contributed by the brick kiln sector, 6% by power stations, 2% by stone crushers and other industries using coal, biomass, pet-coke, and FO contributed to about 14%. Later, in 2017, the use of pet-coke and FO were banned in the region. In the other category, (within the overall contribution of 11%), DG sets because of high PM and NOx emissions contribute significantly (5%), followed by refuse burning (3%), and the other sources contribute to less than 1% each, towards $PM_{2.5}$ concentrations. In the dust category, road dust contributes to 4%, and construction 1% to the $PM_{2.5}$ concentrations. Within the transport sector in Delhi, trucks have the

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highest share of 8%, followed by two-wheelers (7%), and three-wheelers (5%). This is due to their higher shares in either or both $PM_{2.5}$ and NOx emissions.

In PM_{10}, the shares for different sub-sectors almost remain the same as $PM_{2.5}$. However, the shares of dust increase considerably, with road dust and construction contributing to 8% and 6%, respectively in Delhi's PM_{10} concentrations.

Table 5.3 : Sub-sectoral contribution to $PM_{2.5}$ in Delhi in winter 2016

[illegible]	[illegible]	Delhi
Residential		10%
	Biomass	9%
	Kerosene	1%
	LPG	0.1%
Agricultural burning	Biomass	4%
Industry		30%
	Power plant	6%
	Bricks	8%
	Stone crushers	2%
	Other industries	14%
Others		11%
	DG sets	5%
	Refuse burning	3%
	Crematoria	0.2%
	Restaurant	1%
	Airport	1%
	Waste incinerators	1%
	Landfill fires	0.4%
Dust		17%
	Road dust	4%
	Construction	1%
	Others	12%
Transport		28%
	Truck	8%
	Tractor	1%
	Bus	3%
	Cars	3%
	2 wheelers	7%
	3 wheelers	5%
	LCVs	1%

Table 5.4 : Sub-sectoral contribution to PM_{10} in Delhi in winter 2016

Sectors	Sub-sectors	Delhi
Residential		9%
	Biomass burning in kitchen	8%
	Kerosene	1%
	LPG	0%
Agricultural burning	Biomass	4%
Industry		27%
	Power plant	5%
	Bricks	7%
	Stone crushers	3%
	Other industries	12%
Others		10%
	DG sets	4%
	Refuse burning	4%
	Crematoria	0.3%
	Restaurant	0.6%
	Airport	0.4%
	Waste incinerators	0.6%
	Landfill fires	0.4%
Dust		25%
	Road dust	8%
	Construction	6%
	Others	11%
Transport		24%
	Truck	7%
	Tractor	1%
	Bus	2%
	Cars	3%
	2 wheelers	6%
	3 wheelers	4%
	LCVs	1%

5.7.2 Summers

During summers, contribution of different sectors varies due to increased wind speeds and increased natural dust contributions (**Table 5.5** and **Table 5.6**). Within the sectors, biomass fuel use in residential sector is the dominant factor contributing to $PM_{2.5}$ and PM_{10} concentrations. It contributes to 7-8% in $PM_{2.5}$ and PM_{10} concentrations in summers. Within the industrial sector, contribution of about 22% in $PM_{2.5}$ concentrations in Delhi, 5% is contributed by the brick kiln sector, 7% by power stations, 1% by stone crushers and other industries using coal, biomass, pet-coke, and FO contributed to about 8%. In the others category, the share of DG sets falls to 2% due to reduced nitrate formation in summers. Refuse burning contributes significantly (4%), and rest other sources contribute to less than 1% each, towards $PM_{2.5}$ concentrations. In the dust category, road dusts contribute to 3%, and construction 2% to the PM2.5 concentrations. Within the transport sector in Delhi, trucks have the highest share of 5%, followed by two-wheelers (4%), and three-wheelers (3%). This is due to their higher shares in either or both $PM_{2.5}$ and NOx emissions. The share of cars remains at 2% in $PM_{2.5}$ concentrations in Delhi during summers.

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In PM_{10}, the shares for different sub-sectors almost remain same as $PM_{2.5}$. However, the shares of dust increase considerably, with road dust and construction contributing to 10% and 4% in PM_{10} concentrations in Delhi.

Table 5.5 : Sub-sectoral contribution to $PM_{2.5}$ in Delhi in summers 2016

Sectors	Sub-sectors	Delhi
Residential		8%
	Biomass burning in kitchen	7%
	Kerosene	1%
	LPG	0.1%
Agricultural biomass burning	Biomass	7%
Industry		22%
	Power plant	7%
	Bricks	5%
	Stone crushers	1%
	Other industries	8%
Others		8%
	DG sets	2%
	Refuse burning	4%
	Crematoria	0.2%
	Restaurant	0.4%
	Airport	0.2%
	Waste incinerators	0.3%
	Landfill fires	0.5%
Dust		38%
	Road dust	3%
	Construction	2%
	Others	33%
Transport		17%
	Truck	5%
	Tractor	1%
	Bus	1%
	Cars	2%
	2 wheelers	4%
	3 wheelers	3%
	LCVs	1%

Table 5.6 : Sub-sectoral contribution to PM_{10} in Delhi in summers 2016

Sectors	Sub-sectors	Delhi
Residential		8%
	Biomass	8%
	Kerosene	0.5%
	LPG	0.1%
Agri. Burning	Biomass	7%
Industry		22%
	Power plant	7%
	Bricks	5%
	Stone crushers	2%
	Other industries	8%
Others		7%
	DG sets	2%
	Refuse burning	4%
	Crematoria	0.3%
	Restaurant	0.5%
	Airport	0.1%
	Waste incinerators	0.3%
	Landfill fires	0.4%
Dust		43%
	Road dust	10%
	Construction	4%
	Others	28%
Transport		15%
	Truck	5%
	Tractor	1%
	Bus	1%
	Cars	2%
	2 wheelers	4%
	3 wheelers	3%
	LCVs	0.5%

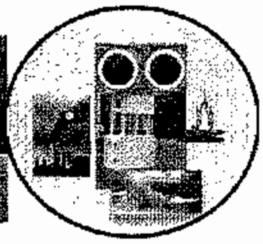
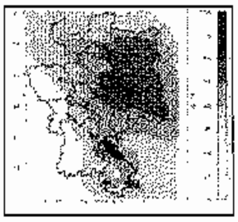
5.8 Sub-category-wise contribution of different vehicles in $PM_{2.5}$ concentrations

The share of cars in winter and summer $PM_{2.5}$ concentrations is about 3.4% and 2%, respectively (**Table5.7**). However, within this, the share of older cars on road is much higher than the newer ones. The table shows the category-wise distribution of the share of cars to $PM_{2.5}$ concentrations, which shows that older cars (BS-II and before) contribute about 31%-50%, while BS-III cars contribute about 19%-22%. BS-IV cars contribute to 50% and 28% in the overall car contribution to $PM_{2.5}$ in Delhi and NCR,

Report No. ARAI/16-17/DHI-SA-NCR/Exec_Summ
August 2018

Executive Summary

Source Apportionment of $PM_{2.5}$ & PM_{10} of Delhi NCR for Identification of Major Sources

Prepared for

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Ministry of Heavy Industries and Public Enterprises, New Delhi

Prepared by

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August 2018

Disclaimer Notice

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The inferences, analysis and projections made in this report are based on the data gathered physically at the identified locations in National Capital Region (NCR) during April 2016 to February 2017 period. Due care has been taken to validate the authenticity and correctness of the information.

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The report has also been reviewed by the Technical Committee setup for the project.

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- National Institute For Environmental Studies, Japan
- Indian Institute Of Technology, Delhi

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IMPORTANT ABBREVIATIONS

Al	:	Aluminium
As	:	Arsenic
BHG	:	Bahadurgrah
Br	:	Bromine
Br^-	:	Bromide Ion
Ca	:	Calcium
Ca^{++}	:	Calcium Ion
CHN	:	Chandani Chowk
Cl	:	Chlorine
Cl^-	:	Chloride Ion
CO	:	Carbon Monoxide
Co	:	Cobalt
Cu	:	Copper
C.V.	:	Coefficient of Variance
EC	:	Elemental Carbon
ED-XRF	:	Energy Dispersive X-ray fluorescence
F^-	:	Fluoride Ion
FBD-1	:	Faridabad 1 Sector 21 d
FBD-2	:	Faridabad 2 Near DAV College
Fe	:	Iron
GHZ-1	:	Lohia Nagar, Ghaziabad 1
GHZ-2	:	Ghaziabad 2, Industrial Sector
GRG-1	:	Huda sector 43, Gurgaon 1
GRG-2	:	Palam Vihar, Gurgaon 2
IC	:	Ion Chromatograph
ITO	:	ITO square
JNP	:	Janakpuri
K^+	:	Potassium Ion
LPM	:	Litre per Minute
Mg^{++}	:	Magnesium ion
Mn	:	Manganese
MYR	:	Mayurvihar, Phase 1
Na^+	:	Sodium Ion
NCR	:	National Capital Region
$NH4^+$	:	Ammonium Ion
Ni	:	Nickel
$NO2^-$	:	Nitrite ion
$NO3^-$	:	Nitrate Ion
NOI-1	:	Noida Industrial Site, sector 6
NOI-2	:	Noida sector 1, UPPCB office
NOx	:	Oxides of Nitrogen
NRN	:	Naraiana Industrial Sector
OC	:	Organic Carbon
P	:	Phosphorus
PM	:	Particulate Matter
PM_{10}	:	Particulate Matter below 10 micron size
$PM_{2.5}$	:	Particulate Matter below 2.5 micron size
PNP	:	Panipat
PPM	:	Parts Per Million
RHN	:	Rohini, Sector 6
RKP	:	R. K .Puram, Sector 2
S	:	Sulphur
S.D.	:	Standard Deviation
SHD	:	East Arjun Nagar, Shahdara
Si	:	Silicon
SNP	:	Sonipat
SO_2	:	Sulphur Dioxide
SO_4^{--}	:	Sulphate ion
TC	:	Total Carbon
Ti	:	Titanium
TOR	:	Thermal/Optical Reflectance
TOT	:	Thermal/Optical Transmission
V	:	Vanadium
WZP	:	Wazirpur Industrial Sector
Zn	.	Zinc

Executive Summary

E1. Introduction

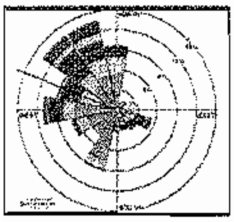
This study carried out source apportionment of $PM_{2.5}$ and PM_{10} concentrations in Delhi-National capital region (NCR) using two modelling-based approaches. The first approach relied upon monitoring and chemical characterization of $PM_{2.5}$ and PM_{10} samples. The chemically speciated samples along with source profiles were fed into the receptor model to derive source contributions. In the second approach, source-wise emission inventory, along with meteorological inputs and boundary conditions were fed into a dispersion model to simulate PM_{10} and $PM_{2.5}$ concentrations. The modelled concentrations were compared with actual observations for validation. The validated model has been used to carry out source sensitivity to derive source contributions and future projections of $PM_{2.5}$ and PM_{10} concentrations. Finally, various interventions have been tested which can reduce the pollutant concentrations in future years.

Independently derived source contributions from the two approaches (receptor and dispersion) for the year 2016 are compared to judge their mutual consistency. This will help the policy makers to take informed decisions and eventually the validated dispersion model can be used for future projection or intervention analysis. The results of the two approaches not only show consistency with each other but also with the previous study (IITK, 2015) in deriving source contributions. In comparison to the IITK (2015), this study has different monitoring locations and is based on different meteorological conditions prevailing in the year 2016. Moreover, this study has used newly developed emission factors, source profiles for some sources and also covered a wider study domain of NCR. Additionally, a chemical transport model has been used to account for chemical reactivity and long range transport of pollutants. This builds confidence in the estimates which may be used to formulate strategies for control of air pollution in Delhi-NCR.

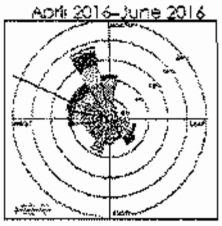
Some major findings of air quality monitoring, receptor modelling, emission inventory, dispersion modelling, and future projections are summarized in subsequent paragraphs

E2. Air Quality Monitoring

- A comprehensive exercise of air quality monitoring was carried out for a period of two seasons in one year at 20 representative locations (9 in Delhi City, 4 in Uttar Pradesh, 7 in Haryana) in the NCR including kerbside, industrial, commercial, residential, and reference sites, which has different land use pattern and sources of activity (**Figure E.1**).
- Twenty monitoring sites as given below were distributed in Delhi-NCR based on land use type and prominent wind direction to capture air quality levels under different activity profiles.



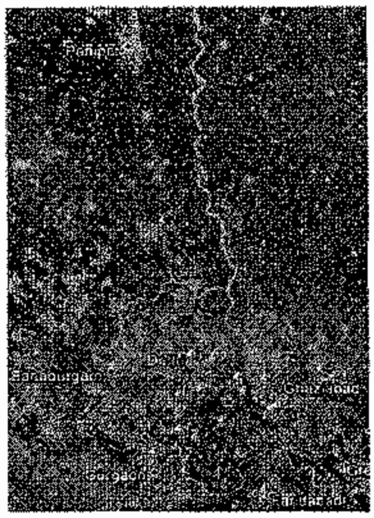
Windroses - Summer Season April 2016–June 2016



Windroses - Winter Season November 2016–Feb 2017

Site No.	Location	Site ID
1	ITO square	ITO
2	R. K. Puram, Sector 2	RKP
3	Bahadurgrah	BHG
4	Shahdara	SHD
5	Mayurvihar, Phase 1	MYR
6	Janakpuri	JNP
7	Chandani Chowk	CHN
8	Panipat	PNP
9	Naraiana Industrial Sector	NRN
10	Wazirpur Industrial Sector	WZP
11	Rohini, Sector 6	RHN
12	Sonipat	SNP
13	Ghaziabad 1	GHZ-1
14	Ghazabad 2	GHZ-2
15	Noida, Sector 6	NOI-1
16	Noida- Sector 1	NOI-2
17	Huda sector, Gurgaon 1	GRG-1
18	Palam Vihar, Gurgaon 2	GRG-2
19	Faridabad 1	FBD-1
20	Faridabad 2	FBD-2

WIND SPEED (m/s)



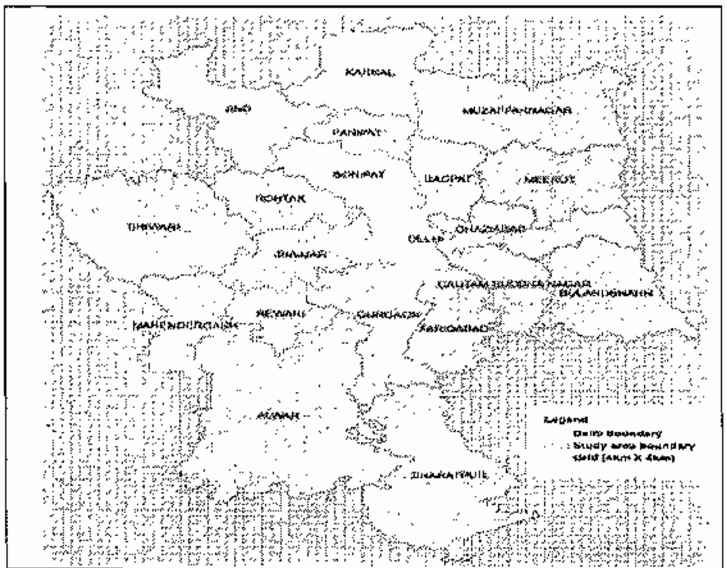


Figure E.1 : Details of locations of air quality monitoring sites and the study domain

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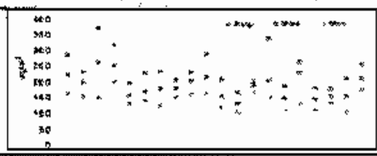
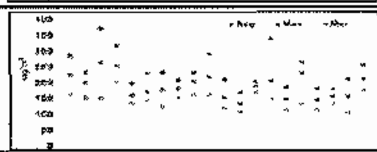
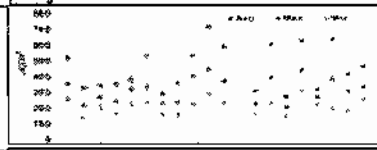
Parameter	All Site Average, µg/m³	Sitewise (Avg., Min., Max.), µg/m³
Summer PM_{10} (µg/m³)	263 188 131	
Summer $PM_{2.5}$ (µg/m³)	130 90 65	
Winter PM_{10} (µg/m³)	441 314 201	
Winter $PM_{2.5}$ (µg/m³)	254 168 92	
	● Max ● Mean ● Min	

Figure E.2: Average PM_{10} and $PM_{2.5}$ mass concentration (µg/m³) at respective monitoring sites in summer and winter season

- Site-wise variation in concentrations of PM_{10} and $PM_{2.5}$ in summer and winter seasons is presented in **Figure E.2**. In summer season, average concentration of PM_{10} at all monitoring sites across Delhi-NCR was 188 ± 37 µg/m³. Concentration of PM_{10} varied from 131 to 263 µg/m³. Similarly, average concentration of $PM_{2.5}$ in summer season was 90±17 µg/m³ varying from 65 to 130 µg/m³.
- Both PM_{10} and $PM_{2.5}$ average concentrations were found to be more than the prescribed standard limit by the Central Pollution Control Board (CPCB).
- In winter season, average concentration of PM_{10} across all monitoring sites in Delhi-NCR was 314±77 µg/m³. Average maximum concentration was 441 µg/m³ while minimum average concentration was 201µg/m³. Similarly in $PM_{2.5}$, average concentration was 168±45 µg/m³ varying from 92 to 254 µg/m³.

E3. Chemical analysis of samples

Chemical speciation of particulate matter samples collected on filter paper can be separated into the three most common categories: elements, ions (sulphates, nitrates, ammonium, etc.) and carbon fractions. **Figure E.3** depicts the overall scheme of chemical speciation of particulate samples.

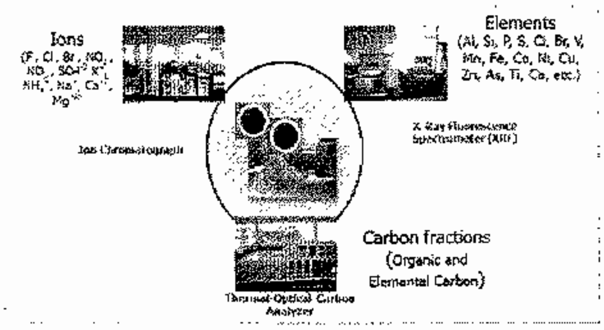


Figure E.3 : Chemical speciation of particulate matter samples

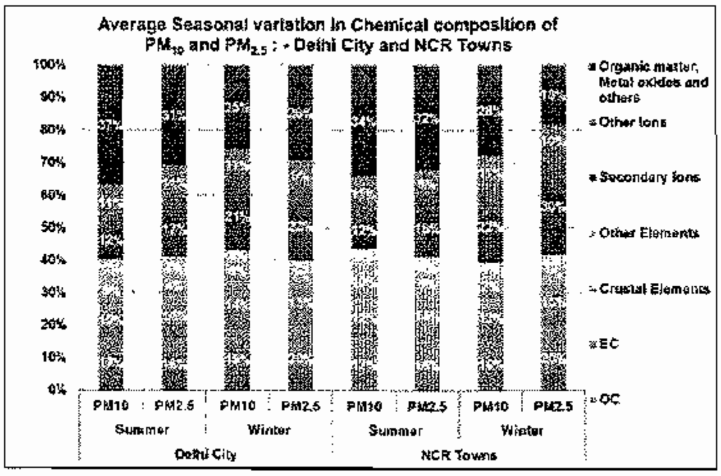


Figure E.4: Average chemical composition of PM_{10} and $PM_{2.5}$ in NCR Towns (Panipat, Sonipat, Ghaziabad, Gurgaon, Noida, Faridabad and Bahadurgarh) and Delhi-city in summer and winter seasons

Seasonal variation in average chemical composition of PM_{10} and $PM_{2.5}$ for Delhi-city and NCR Towns is presented in **Figure E.4.**

Average chemical composition of PM_{10} and $PM_{2.5}$ at Delhi-city and NCR Towns in summer season;

- **PM_{10}:** OC (organic carbon) was similar (~17%) at Delhi-city and NCR Towns. EC (elemental carbon) was found to be slightly higher at NCR Towns (~12%) compared to Delhi-city (~10%). Contribution of crustal elements in Delhi City was 9% and in NCR Towns it was about 10%. Other elements contributed to about 5% in Delhi city as well as NCR Towns. Secondary ions (~12%) and other ions (~11%) were found to be similar in both Delhi city and NCR Towns. Remaining constituents of organic matter, metal oxides, and others were higher in Delhi-city (~37%) compared to NCR Towns (~34%).

- $PM_{2.5}$: Average chemical composition was found to be similar in both Delhi-city and NCR Towns. Both OC (~16%) and EC (~14%) were found to be similar. Both crustal elements (~4%–5%) and other elements (~6%–7%) were found to be similar. Secondary ions was found to be similar in NCR Towns (~17%–18%), whereas other ions were found to be higher in Delhi-city (~11%) compared to ~9% in NCR Towns. Remaining constituents of organic matter, metal oxides, and others were found to be similar (~31%–32%).

Average chemical composition of PM_{10} and $PM_{2.5}$ at Delhi-city and NCR Towns in winter season:

- **PM_{10}**: OC was found to be higher in Delhi-city, that is, ~19% compared to ~16% in NCR Towns. EC was found to be higher in Delhi-city (~14%) compared to ~12% in NCR Towns. Both crustal elements (~6%–7%) and other elements (~3%–4%) were found to be similar. Contribution of secondary ions was found to be significant with about 21% in Delhi city and about 22% in NCR Towns. Other ions contributed to about 11% in Delhi city and NCR Towns. Remaining constituents of organic matter, metal oxides, and others were higher in NCR Towns, that is, ~28% compared to ~25% in Delhi-city.
- **$PM_{2.5}$**: Contribution of OC was found to be about 20% in both Delhi city and NCR Towns. Similarly contribution of EC was about 15%. Contribution of crustal elements was found to be lower i.e. about 2% in Delhi city and about 3% in NCR Towns. Other elements (~3%–4%) were also found to be similar. Secondary ions were found to be higher (~30%) in NCR Towns compared to ~22% in Delhi-city whereas other ions were found to be similar i.e. about9% in Delhi city and about 10% in NCR Towns. Remaining constituents of organic matter, metal oxides, and others were found to be higher in Delhi-city (~29%) as compared to ~18% in NCR Towns.

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E4. Receptor modelling

The fundamental principle of receptor models is that mass conservation can be assumed and a mass balance analysis carried out to identify and apportion sources of airborne particulate matter in the atmosphere. The approach to obtain a data set for receptor modelling is to determine a large number of chemical constituents, such as elemental concentrations in a number of samples. Receptor models use monitored pollutant concentration and some information about the chemical composition of air pollution sources (profiles) to estimate the relative influence of these sources on pollutant concentrations at any single monitoring location.

The following approach was used for receptor modelling using USEPA's CMB model:

- Identification of probable contributing sources to the monitoring sites
- Selection of chemical species : Following species were analysed from the PM_{10} and $PM_{2.5}$ samples collected at respective sites in summer and winter seasons.
    - Carbon fractions based on temperature (organic carbon and elemental carbon) using Thermal Optical Reflectance (TOR) Carbon Analyser,
    - Ions (anions—fluoride, chloride, bromide, sulphate, nitrate; and cations—sodium, ammonium, potassium, magnesium, and calcium) using Ion chromatography
    - Elements (Al, Si, K, Ca, Ti, V, Fe, Co, Ni, Cu, Zn, As, Se, Zr, Mo, Pd, Cd, Ce and Pb) using Energy Dispersive X-Ray Fluorescence Spectrometer (ED-XRF)
- Selection of representative source profiles, based on the source activities around the sites and considering sources that will impact the receptor locations based on wind direction, with the fraction of each of the chemical species and uncertainty.
- Site-specific wind trajectories during monitoring period were taken from website of Air Resource Laboratory, HYSPLIT, URL: *https://www.arl.noaa.gov/ready/hysplit4.html*
- Fire data was collected for the monitoring period from NASA, Earth data, Fire Information for Resource Management Systems (FIRMS), URL: *https://firms.modaps.eosdis.nasa.gov/firemap/*. This data was collected to assess magnitude and spread of fire activity in the upwind direction.

- A few study specific profiles were developed under this project and used. Details of source profiles selected are as follows:
    - Vehicular sources:
        a) New composite profiles of different fuel types developed for newer technology vehicles (post-2005) under this study and
        b) Earlier profiles of pre-2005 vehicle technology. (CPCB, 2009, Vehicle Source Profiling report)
    - Non-vehicular sources: Indigenous profiles developed by IIT-Bombay (CPCB, 2009, Stationary Source Profiling report)
    - Site-specific profiles developed under this study are:
        a) Refuse burning,
        b) Agri-waste (sugarcane) combustion,
        c) Agri-waste (rice) combustion,
        d) Agri-waste (wheat) combustion,
        e) Road and soil dust (composite of Delhi and NCR Towns).
- Estimation of both the ambient concentrations and uncertainty of selected chemical species from the particulate matter collected at respective sites; and
- Solution of the chemical mass balance equations was obtained through CMB-8.2 receptor model by using the chemical composition results of 24 hour daily samples collected in summers and winter season in 2016/17 at all sites and source profiles of applicable sources at respective sites as an input.
- Contributing sources were identified by averaging the contribution from sources observed based on daily samples across the monitoring period.

- Based on availability of source profiles and due to similar nature of source profiles leading to difficulty in resolving the CMB equation due to their collinearity, identified sources are categorized into dust and construction, biomass burning, vehicles, industry and others. Dust and construction source includes natural sources, such as soil dust and anthropogenic sources, such as paved and un-paved road dust and dust generated due to construction activity. Biomass burning includes agri-waste (sugarcane, wheat, and rice) burning and residential biomass burning. Vehicles include contribution from all categories of vehicles and all fuel-types. Distribution of contribution based on vehicle-type and fuel-type can be obtained from dispersion modelling results based on emission inventory presented in subsequent sections. Similarly detailed distribution of dust, biomass, and industrial sources is presented in dispersion modelling results.

Results of receptor modelling for summer and winter season:

- Average contribution of different sources towards PM_{10} and $PM_{2.5}$ in summer and winter seasons for sites in Delhi-city and NCR Towns is presented in **Figure E.5**.

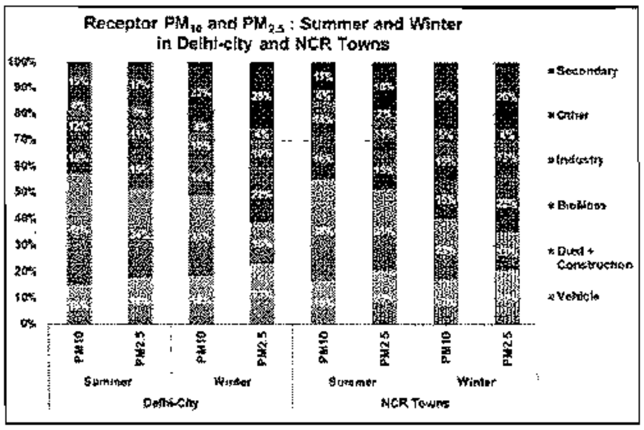

Figure E.5: Average source contribution to PM_{10} and $PM_{2.5}$ samples at representative sites in summer and winter season in Delhi-city and NCR Towns (Panipat, Sonipat, Ghaziabad, Gurgaon, Noida, Faridabad and Bahadurgarh)

*These are primary contribution from different sectors and secondary particulates are shown seperately, which are later allocated to the sectors using dispersion modeling.

Seasonal variation of different sources of $PM_{2.5}$ and PM_{10}, obtained as an out of receptor modelling, in terms of percentage contribution is shown in **Figure E.5** for Delhi-city and NCR Towns.

E4.1 PM_{10}

Seasonal variation of PM_{10} shows higher contribution of dusty sources in summer (38%–42%) as compared to winter in Delhi-city as well as NCR Towns. This can be attributed to dry conditions and higher wind velocities resulting in entrainment of dust. However, contribution of dusty sources (e.g. road, construction and soil dust) was also significant in winter season (23%–31%). Contribution of vehicles to PM_{10} was slightly higher in winter (17%–18%) in Delhi-city and NCR Towns than in summer (15%–16%). Biomass burning contribution was slightly higher in winter in Delhi-city (14%) than in summer (12%), whereas in NCR Towns the contribution was similar in both the seasons (15%–16%). Contribution from industrial sources was similar in both summer and winter seasons in Delhi-city (10%–12%) and NCR Towns (14%–15%). Contribution in NCR Towns was higher as compared to Delhi-city due to the presence of industries in the proximity. There are several types of industries operating in NCR Towns including bricks, sugar, paper, dyeing, rubber, chemical ceramics, iron & steel, textile, fertilizer, stone crushers, and casting & forging etc. Other sources, which include DG sets showed similar contribution of about 4%–5%. Contribution of secondary ions to PM_{10} is significantly higher in winter (23%–25%) than in summer (11%–15%) in both Delhi-city and NCR Towns.

E4.2 $PM_{2.5}$

Seasonal variation of $PM_{2.5}$ shows significantly higher contribution of dusty sources in summer (31%–34%) as compared to winter (15%) in Delhi-city as well as NCR Towns. Higher contribution of dusty sources even in $PM_{2.5}$ can be attributed to dry conditions and higher wind velocities in summers resulting in contribution from far-off sources. Primary contribution of vehicles to $PM_{2.5}$ was higher in winter (20%–23%) in Delhi city and NCR Towns than in summer (18%–20%). Biomass burning contribution was significantly higher in winter in Delhi-city and NCR Towns (22%) than in summer (15%). Contribution from industrial sources was similar in both summer and winter seasons in Delhi city (10%–11%) and NCR Towns (13%). Contribution in NCR Towns was higher as compared to Delhi-city due to the presence of industries in the proximity. Other sources, which include DG sets showed contribution of less than 5%. Contribution of secondary ions to $PM_{2.5}$ was higher in winter (26%) than in summer (17%–18%) in both Delhi-city and NCR Towns.

- Significantly higher contribution of dust in PM_{10} and also in $PM_{2.5}$ particularly in summer season may be attributed to the transboundary contribution. Wind back-trajectories HYSPLIT for 48 hours for the monitoring days at the sites particularly in summer shows wind flows from far-off regions.
- Variation in the contribution of sources, such as vehicles (15%–23%), biomass burning (12%–22%), and dust (15%–42%) may be attributed to the variation in activities at local level and meteorology.
- Secondary particulates were found to contribute significantly to both PM_{10} and $PM_{2.5}$ in winter season.
- Contribution from sources outside Delhi, such as residential cooking, agricultural waste burning, industries (tall stacks) and dust particles are likely due to winds carrying pollution with the incoming air to Delhi-city and NCR Towns.

E5. Emissions Inventory

Source-wise multi-pollutants inventories of air pollutants have been prepared for the year 2016, at a high resolution of 4x4 km^2. Along with PM, inventories of sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon monoxide (CO), and non-methane volatile organic compounds (NMVOCs) have also been prepared to account for secondary particulates formation. The major sectors which have been covered in the analysis are: 1)Residential, 2)Open agricultural residue burning, 3)Transport—tailpipe emissions , 4)Construction, 5)Industries (including bricks and stone crushers), 6)Power plants- stacks, coal handling units and fly-ash ponds, 7)Road dust, 8)Diesel generators, 9)Refuse burning, 10)Crematoria, 11)Restaurants, 12)Airports, 13)Landfills, 14)Waste incinerators, 15) Solvents, 16) Ammonia emission sources, etc.

Emissions estimates were based on activity type, emissions factors, pollution abatement technology used, and the efficiency of control. Activity data was collected from both primary and secondary sources. The newly developed database of vehicular emissions factors developed by the Automotive Research Association of India (ARAI) has been used for vehicular sources. Emissions estimated from various sectors have been allocated over the study domain as per area, line, and point source categories. ARCGIS software was used for estimation of gridded emissions (4x4 km^2) for different pollutants across the NCR.

The emissions inventory for Delhi and the NCR is shown in **Table E.1**. The estimates presented are the annual totals for different sectors, however, there are seasonal variations in emissions from different sectors, which have been accounted for during simulations. The total emissions of PM_{10}, $PM_{2.5}$, NO_x, SO_2, CO, and NMVOC are estimated for Delhi and NCR. The percentage share of sectors in overall inventory of PM_{10}, $PM_{2.5}$, NO_x, and SO_2 emissions are shown in **Figure E.6**. Amongst the sources within Delhi, the share of the transport sector is significant (39%) in $PM_{2.5}$ emissions. This reduces to 19% in PM_{10} emissions in Delhi, due to the presence of other major sources, such as road dust and construction, which emit more particles in the coarser range of PM. With the closure of some of the coal based power generating units, Transport now has a dominant share (81%) in the NO_x emissions amongst the sources within Delhi. SO_2 emissions within the city of Delhi are small and are mainly contributed by Badarpur coal-based power plant. Sectoral shares are significantly different, when the entire NCR is considered. Industries (28%), road dust (13%), residential (20%), and agricultural burning (17%) are the main contributors to PM_{10} emissions in NCR. For $PM_{2.5}$, industries (24%), residential (25%), agricultural burning (19%), and transport (13%) are the major contributors in NCR. Despite dominant use of LPG within Delhi city, the residential sector contributes significantly mainly due to biomass fuel used in about 3 million households in NCR. The share of transport in NCR reduces to 60% for NO_x emissions, considering other sources, such as power plants, DG sets, and industries in NCR. SO_2 emissions in NCR are about 27 times higher than Delhi, mainly due to the presence of industrial sources and power plants. Standards for control of NO_x and SO_2 in industrial setups have not yet been implemented, and hence these emissions have remained uncontrolled. Use of petcoke and FO (which are very high sulphur fuels) was a significant source of industrial SO_2 emissions in NCR during 2016, before they were banned. Emissions of ammonia were taken from IIASA's GAINS ASIA database for India.

It is evident that the emission share of different sectors is significantly different in Delhi and NCR. The air quality in Delhi is impacted by both local and outside sources, and hence, a simulations exercise is a pre-requisite to understand the contributions of different sectors lying within or outside the city of Delhi in the NCR. Other than emissions, meteorology also plays an important role in defining pollutant concentrations and source contributions.

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TableE.1 : Annual emission inventory of pollutants (kt/yr) in Delhi city and NCR (including Delhi) for 2016

SECTOR	DELHI						NCR					
	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	NMVOC	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	NMVOC
TRANSPORT*	12.8	12.4	126.9	1.1	501.1	342.1	68.6	66.5	528.9	4.4	1750.9	886.5
INDUSTRIES	1.3	1.1	1.6	4.6	0.2	0.0	288.3	127.4	85.2	556.2	620.0	27.0
POWER PLANTS	6.1	3.5	11.2	23.6	3.5	0.9	73.7	41.1	132.5	297.1	13.4	9.4
RESIDENTIAL	2.9	2.0	3.7	0.2	61.1	12.7	204.3	131.5	38.0	16.8	1700.3	374.1
AGRICULTURAL BURNING	0.5	0.4	0.1	0.0	2.7	0.3	174.1	102.2	30.6	9.0	781.1	209.2
ROAD DUST	24.0	5.8	0.0	0.0	0.0	0.0	137.2	30.6	0.0	0.0	0.0	0.0
CONSTRUCTION	14.2	2.7					43.7	7.8				
DG SETS	0.1	0.0	0.7	0.0	0.2	0.1	3.7	3.2	53.0	3.5	11.4	4.3
REFUSE BURNING	1.4	1.2	0.5	0.1	4.6	2.7	17.5	14.4	5.5	0.7	56.0	33.3
CREMATORIA	0.4	0.2	0.1	0.0	2.2	1.2	1.5	0.8	0.2	0.0	7.7	4.3
RESTAURANT	1.4	0.8	0.4	1.3	2.5	0.4	1.7	1.0	0.5	1.6	2.9	0.4
AIRPORT	0.1	0.1	6.6	0.5	13.6	7.0	0.1	0.1	6.6	0.5	13.6	7.0
WASTE INCINERATORS	0.5	0.3	4.1	1.6	0.9	0.0	0.5	0.3	4.1	1.6	0.9	0.0
LANDFILL FIRES	1.8	1.5	0.6	0.1	5.8	2.2	1.9	1.6	0.6	0.1	6.1	2.3
SOLVENTS						57.3						112.8
TOTAL	68	32	156	33	598	427	1017	528	886	892	4,964	1671

Note: These are annual totals for emissions from different sectors. However, there are monthly variations in emissions from various sectors, which have been taken into account during simulations. Real world emissions have also been accounted for certain sectors. Power plants include stack, flyash ponds and coal handling emissions

*Including high emitters

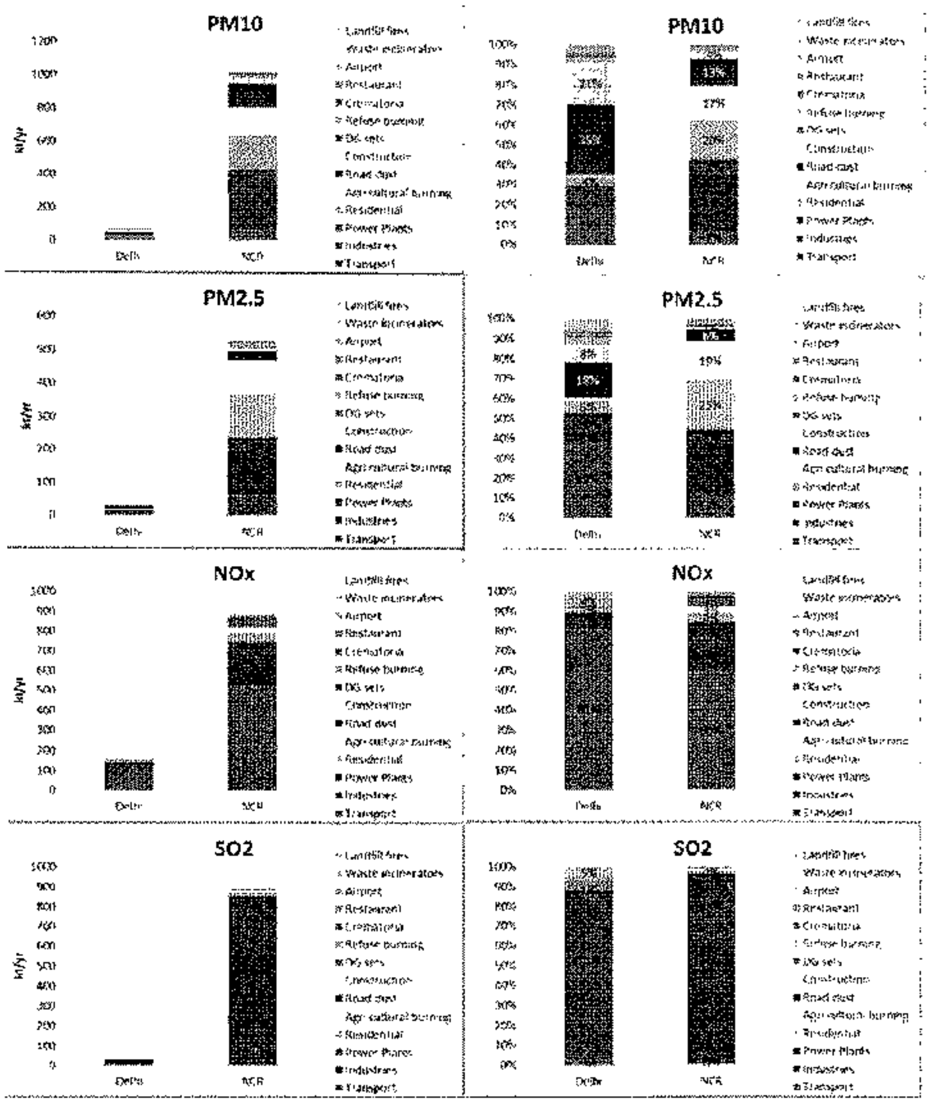

Figure E.6 : Absolute and percentage share of different sectors in overall inventory in NCR (including Delhi) and Delhi city

Note: These shares are based on annual totals for emissions from different sectors. However, there are monthly variations in emissions from various sectors, which have been taken into account during simulations. The sources showing less than 1% of contributions are not labelled in the above Figure.

E6. Simulation of air quality: dispersion modelling

Ambient PM_{10} and $PM_{2.5}$ concentrations were simulated in this study using the WRF-CMAQ model combination. WRF model runs have been carried out to generate 3-dimensional meteorological fields over the study domain which acts as input to the CMAQ model along with emission inventories. To account for contributions from outside NCR, India scale simulation runs have been carried out for the year 2016 using India-scale emissions inventory. In order to account for transport of pollutants from outside India, international boundary conditions have been adopted from global air quality products. Simulations have been performed for India and then for the NCR for the year 2016 to predict PM_{10} and $PM_{2.5}$ concentrations in NCR. The modelled concentrations were compared with the actual observations taken by ARAI for specific locations.

Evidently, the concentrations are significantly higher during winter than in summer, due to adverse meteorological conditions. Reduction in wind speed and boundary layer height during winter reduces the dispersive capacity of the atmosphere and leads to higher concentrations of pollutants near the ground.

Modelled $PM_{2.5}$ and PM_{10} concentrations were compared with the actual values for model validation. While the model captured seasonal variations quite well, the magnitude of PM concentrations was somewhat underestimated. The average ratio of modelled to observed $PM_{2.5}$ concentrations was 0.82–0.87. This performance of the model appears to be satisfactory, when compared with several previous studies (e.g. IITK (2015)). The small shortfall in the model estimates may be attributed to some unaccounted emissions from natural sources. Other than the overall mass, the share of different constituent species of $PM_{2.5}$ is also satisfactorily reproduced by the CMAQ model. The validated model was used for estimating source contributions using source-sensitivity method.

6.1 Source apportionment in Delhi

Table E.2 shows the contributions of various sectors in $PM_{2.5}$ and PM_{10} concentrations, estimated using dispersion modelling for winter and summer seasons at 20 locations in Delhi-NCR. The results show source contributions in base case for the year 2016. It is to be noted that the contribution of agricultural burning is not fully accounted for in this study as the monitoring and modelling periods did not include the month of October, when the burning activities are generally at their maximum. Moreover, the sectoral contributions are averaged for the whole modelling/monitoring period, and hence, do not highlight the contribution of agricultural burning, which happens during a certain number of days and cause episodically high pollutant concentrations.

In $PM_{2.5}$ concentrations during winter, the average share of the transport sector varies from 28% in Delhi. Industries contribute to 30%, while fuel (mainly biomass) burning (in residences and agricultural fields) contributes 14%. Dust (soil, road, and construction) have a share of 17%. In $PM_{2.5}$ concentrations during summer, the share of the transport sector is about 17% in Delhi. Industries contribute 22%, while biomass burning in residences and agricultural fields contribute 15%. Dust (soil, road, and construction) have a share of 38% in summers. Significantly high contributions from outside of India have been observed during summer season. High contributions from international boundaries to India have also been reported by other studies (HEI, 2018; IITM 2017). Other sources contribute to 11% in winters and 8% in summer season.

In PM_{10} concentrations during winter, the average share of the transport sector is 24% in Delhi. Industries contribute to 27%, while fuel (mainly biomass) burning in residences and agricultural fields contributes 13%. Dust has a considerably higher share in PM_{10} concentrations (25%). During summer, the share of the transport sector is observed to be 15%. Industries contribute to 22%, while biomass burning (in residences and agricultural fields) contributes to 15%. Dust has a significantly higher share of 42% in PM_{10} fractions. Other sectors contribute to 10% PM10 concentrations in winters and 7% in summer season.

Table E.2 : Average sectoral contributions in $PM_{2.5}$ and PM_{10} concentrations in Delhi estimated using dispersion modelling during winters and summers

$PM_{2.5}$		
Sectors	**Winters**	**Summers**
Residential	10%	8%
Agri. Burning	4%	7%
Industry	30%	22%
Dust (soil, road, const.)	17%	38%
Transport	28%	17%
Others	11%	8%
PM_{10}		
Sectors	**Winters**	**Summers**
Residential	9%	8%
Agri. Burning	4%	7%
Industry	27%	22%
Dust (soil, road, const.)	25%	42%
Transport	24%	15%
Others	10%	7%

Note: Industries include power plants (stacks, flyash ponds and coal handling units) , brick manufacturing, stone crushers, and other industries. Others include DG sets, refuse burning, crematoria, airport, restaurants, incinerators, landfills, etc. Dust includes sources of natural and anthropogenic origin (soil, road dust re-suspension, and construction activities). Dust is also contributed through trans-boundary atmospheric transport from international boundaries.

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E7. Comparison of receptor and dispersion modelling results

A comparison of sectoral contributions obtained from receptor modelling using CMB8.2 and dispersion modelling is presented in subsequent sections. The results of both the approaches are compared at the locations of air quality monitoring.

E7.1 $PM_{2.5}$

The results of receptor modelling are compared with the dispersion modelling outputs in **Figure E.7**. The receptor modelling results show primary sectoral contributions, and secondary particulates separately. It is to be noted that secondary particulates are also contributed by gaseous emissions from different sectors. The dispersion model was used to assess the contribution of different sectors to secondary particulates. The secondary particulates in the results of receptor modelling were accordingly allocated to different sectors to assess total sectoral contributions (primary and secondary).

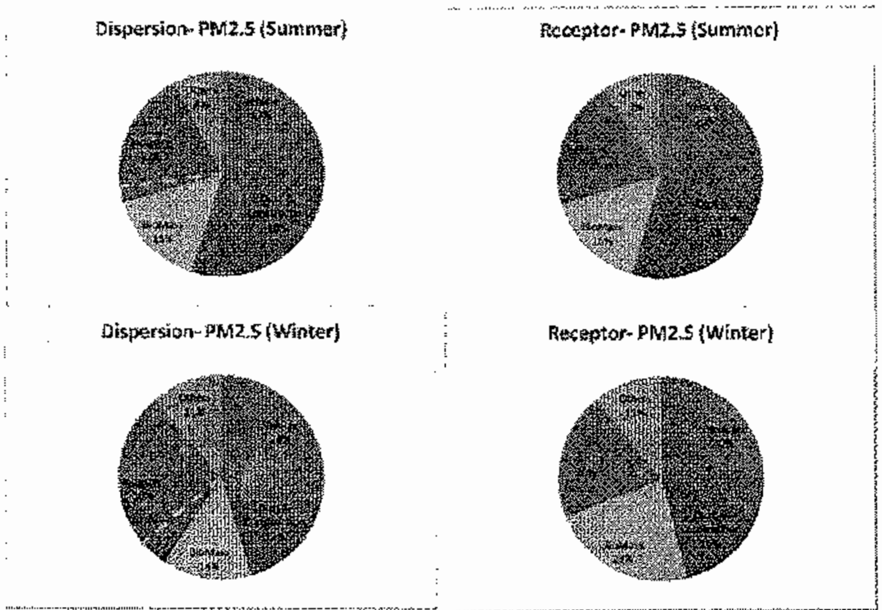

Figure E.7: Comparison of results of dispersion and receptor modelling assessment for $PM_{2.5}$ in Delhi

* Green dotted line shows that some industries in NCR (which contribute to Delhi's air quality) also use biomass

Figure E.7 shows that the results of the two approaches are close for most sectors. It is to be noted that in the dispersion modelling approach, the industrial sector (which seems to be overestimated) includes biomass as an industrial fuel. Dust includes contributions from road dust re-suspension, construction activities, and trans-boundary international contributions. Based on the assessment of species, it may be concluded that in summers, trans-boundary contributions are mainly composed of dust. However in winters, there are also some trans-boundary contributions from sectors, such as biomass burning and industries also.

Overall, the results of source apportionment seem to be consistent for most sectors in both the approaches, in the two seasons, the dispersion model shows contributions of transport sector as 17%–28%, in comparison to the receptor model estimations of 20%–30%. These findings are higher than the contributions of transport sector reported in IITK (2015) report, because in this study we included secondary particulates along with the primary contributions.

E7.2 PM_{10}

Comparison of results of dispersion modeling with receptor modelling for PM_{10} is shown in **Figure E.8**. The results complement each other. Receptor modelling shows dust contributions of 31%–43%, which are shown to be in the range of 25%–41% by the dispersion modelling approach in the two seasons. The range of estimates for the transport sector is 15%–24% as per dispersion model runs in different seasons, while it is 17%–25% using the receptor model. Biomass burning consistently shows contributions in the range of 13%–15%. The two approaches show slight variation in industrial sector contributions, which ranges from 19%–27%.

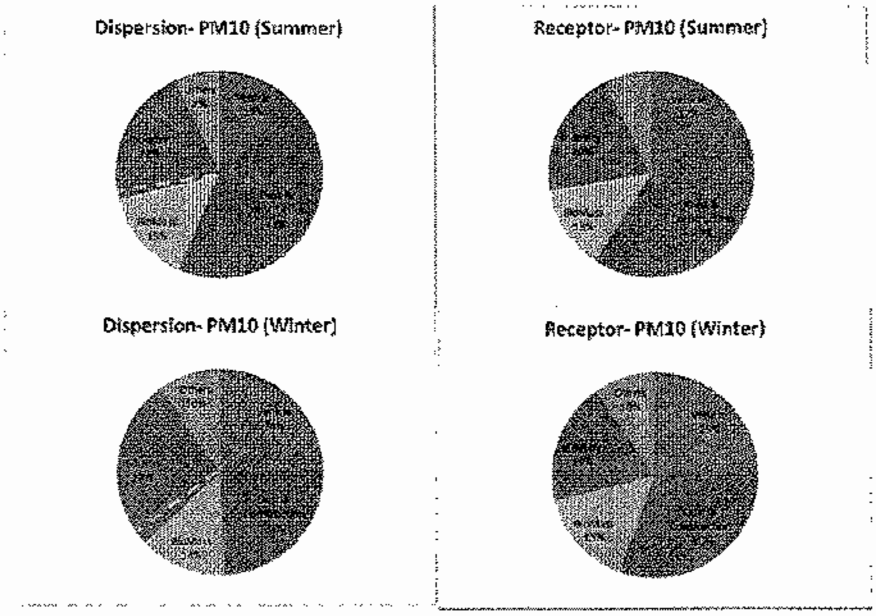

Figure E.8 : Comparison of results of dispersion and receptor modelling assessment for PM_{10} in Delhi for the two seasons

* Green dotted line shows that some industries in NCR (which contribute to Delhi's air quality) also use biomass

E7.3 Sub-sectoral contributions to PM_{10} and $PM_{2.5}$ concentrations in Delhi and NCR

While, the broad sectoral shares have been shown in the previous section, this section shows the contribution of different sub-sectors towards $PM_{2.5}$ and PM_{10} concentrations in Delhi and NCR.

In the residential sector, biomass fuel is the dominant factor contributing to $PM_{2.5}$ and PM_{10} concentrations. It contributes to 8%–10% in $PM_{2.5}$ and 8%–9% in PM_{10} concentrations in the two seasons. Within the 30% contribution of the industrial sector in $PM_{2.5}$ concentrations (winter) in Delhi, 8% is contributed by bricks sector, 6% by power stations, 2% by stone crushers, while other industries (using coal, biomass, pet-coke, and furnace oil) contributed to about 14%. Later, in 2017, petcoke and furnace oil (FO) use were banned in the region. In the others category (within the overall contribution of 11% in winters $PM_{2.5}$ concentrations), DG sets (because of high PM and NOx emissions) contribute significantly (5%), followed by refuse burning (3%), and the rest other sources contributed to less than 1% each, towards winters $PM_{2.5}$ concentrations. In the dust category, road dust and construction sectors have 4% and 1% contributions in $PM_{2.5}$ concentrations, respectively. Within the transport sector in Delhi, trucks have the highest share of 8%, followed by two-wheelers (7%), and three-wheelers (5%). This is due to their higher shares in either or both $PM_{2.5}$ and NO_x emissions. The share of two-wheelers falls to 4% at NCR level, with increase in shares of buses (diesel buses) and tractors. The share of cars in winter and summer $PM_{2.5}$ concentrations is about 3.4% and 2%, respectively. Within this, the share of older cars on road is much higher than the newer ones. Older cars (BS-II and earlier) contribute to about 31%–50%, while BS-III cars have a contribution of 19%–22% in Delhi and NCR. BS-IV cars contributed to 50% and 28% in the overall car contributions to $PM_{2.5}$ in Delhi and NCR, respectively. The fuel-wise distribution shows that diesel has a major contribution of 67%–74% in the share of cars, followed by CNG (13%–20%), and petrol (13%–14%) cars. Although, CNG cars contribute minimally to primary PM emissions, they have some secondary nitrate contributions through NO_x to nitrate conversions. Considering 2.0%–3.4% overall share of cars in $PM_{2.5}$ concentrations in two seasons, and a 19%–27% contribution of BS-IV diesel cars within this, the overall share of all BS-IV diesel cars in $PM_{2.5}$ concentrations is estimated to be about 0.5%–0.9% in Delhi and 0.3%–0.5% in NCR. Within the heavy duty segment (buses and trucks), vehicles registered after 2010 have an emission share of 30%–60% in Delhi and 30%–42% in NCR, while the older vehicles with inferior emission norms have the remaining shares. Similarly, in case of two-wheelers, post 2010 vehicles have a share of 34%–35%, while the older vehicles with inferior emission norms have higher shares. It is to be noted that these are the shares of vehicles in 2016, and with fleet turn-over, the share of BS-IV vehicles will increase and the contribution of older vehicles will gradually decline, although, the absolute quantity emissions from BS-IV vehicles will be much lower than pre BS-IV vehicles due to improved technologies. In PM_{10}, the shares for different sub-sectors almost remain same as $PM_{2.5}$. However, the share of dust increases considerably, with road dust and construction contributing to 8% and 6% in Delhi's PM_{10} concentrations. Their share increases to 10% and 7%, respectively in NCR during winters.

E8. Sectoral shares in other towns

The sectoral shares in PM_{10} and $PM_{2.5}$ concentrations have been shown in **Table E.3** based on both dispersion as well as receptor modelling techniques. There are stark variations across different towns due to different monitoring schedules (and corresponding modelling results) in the NCR Towns. There are also some variations in the estimates of sectoral shares between the two approaches, which could be attributed to limitations in monitoring (only 1 or 2 stations in each city) and spatial allocations of emissions. However, directionally the results are similar. In $PM_{2.5}$ the contribution of combustion based sources, such as vehicles, industries, biomass is higher, while dust (road, construction, and ex-NCR) contributes dominantly in PM_{10} concentrations. Summers show higher dust contributions from international boundaries (mainly of natural origin) due to higher wind speeds.

Table E.3: Sectoral shares estimated by dispersion and receptor modelling for various towns in NCR

NCR-Towns	Season	Parameter	Dispersion Modelling					Receptor Modelling				
			Vehicle	Dust	Biomass	Industries	Others	Vehicle	Dust	Biomass	Industries	Others
Bahadurgarh	Summer	PM_{10}	17%	49%	13%	16%	5%	14%	31%	24%	19%	12%
		$PM_{2.5}$	22%	39%	15%	19%	5%	20%	32%	21%	17%	10%
	Winter	PM_{10}	21%	40%	11%	22%	6%	20%	28%	13%	25%	14%
		$PM_{2.5}$	28%	26%	12%	27%	7%	24%	19%	23%	24%	10%
Panipat	Summer	PM_{10}	21%	31%	18%	25%	5%	10%	37%	21%	18%	14%
		$PM_{2.5}$	22%	33%	17%	23%	5%	20%	34%	18%	15%	13%
	Winter	PM_{10}	22%	25%	16%	31%	6%	18%	26%	16%	28%	14%
		$PM_{2.5}$	27%	12%	18%	35%	8%	29%	8%	16%	32%	15%
Ghaziabad	Summer	PM_{10}	8%	41%	12%	35%	4%	18%	42%	16%	17%	7%
		$PM_{2.5}$	10%	37%	14%	34%	5%	21%	36%	12%	23%	8%
	Winter	PM_{10}	13%	31%	16%	35%	5%	22%	27%	16%	24%	11%
		$PM_{2.5}$	18%	19%	18%	39%	6%	26%	16%	29%	18%	11%
Noida	Summer	PM_{10}	13%	47%	12%	22%	6%	15%	44%	10%	23%	8%
		$PM_{2.5}$	15%	46%	13%	20%	6%	20%	31%	12%	26%	11%
	Winter	PM_{10}	25%	29%	12%	25%	9%	21%	23%	12%	26%	18%
		$PM_{2.5}$	30%	20%	12%	28%	10%	23%	10%	22%	24%	21%
Gurgaon	Summer	PM_{10}	14%	52%	13%	13%	8%	19%	32%	19%	24%	6%
		$PM_{2.5}$	16%	49%	14%	13%	8%	26%	29%	16%	19%	10%
	Winter	PM_{10}	23%	30%	14%	26%	7%	16%	23%	20%	26%	15%
		$PM_{2.5}$	27%	20%	15%	30%	8%	26%	15%	27%	17%	15%
Faridabad	Summer	PM_{10}	9%	46%	18%	18%	9%	21%	42%	14%	16%	8%
		$PM_{2.5}$	10%	46%	18%	17%	9%	19%	41%	12%	21%	7%
	Winter	PM_{10}	21%	19%	18%	32%	10%	18%	23%	17%	24%	19%
		$PM_{2.5}$	24%	13%	18%	34%	11%	27%	23%	19%	18%	14%

Note: Share of sources vary across cities because of sources and also because of changing meteorology as the period monitoring varied across three months within a season.

E9. Geographical contributions

This study also estimated the contribution of various regions towards $PM_{2.5}$ and PM_{10} concentrations in Delhi and NCR Towns. The average contribution of Delhi's own emissions in Delhi's $PM_{2.5}$ concentrations was found to be 36% in winters and 26% in summers. However, there are variations across different places in the city (**Figure E.9**). This finding is in-line with other recent studies for Delhi (Marrapu et al., 2014; IITK, 2015; Kiesewetter et al., 2017). In summers, the contribution of outside sources is higher on account of higher wind speeds and enhanced atmospheric transport of pollutants. In the NCR Towns, the contribution of emissions from Delhi city varies as per their location with respect to Delhi and prevailing wind directions. NOIDA city which is downwind of Delhi receives 28% and 40% of its $PM_{2.5}$ concentrations from Delhi-based sources, in summer and winter seasons, respectively. On the other hand, Panipat which is upwind of Delhi receives only 1% contribution from Delhi, and shows 56%–70% contribution from the remaining NCR regions. Ghaziabad also receives its major (61%–70%) contribution from NCR only.

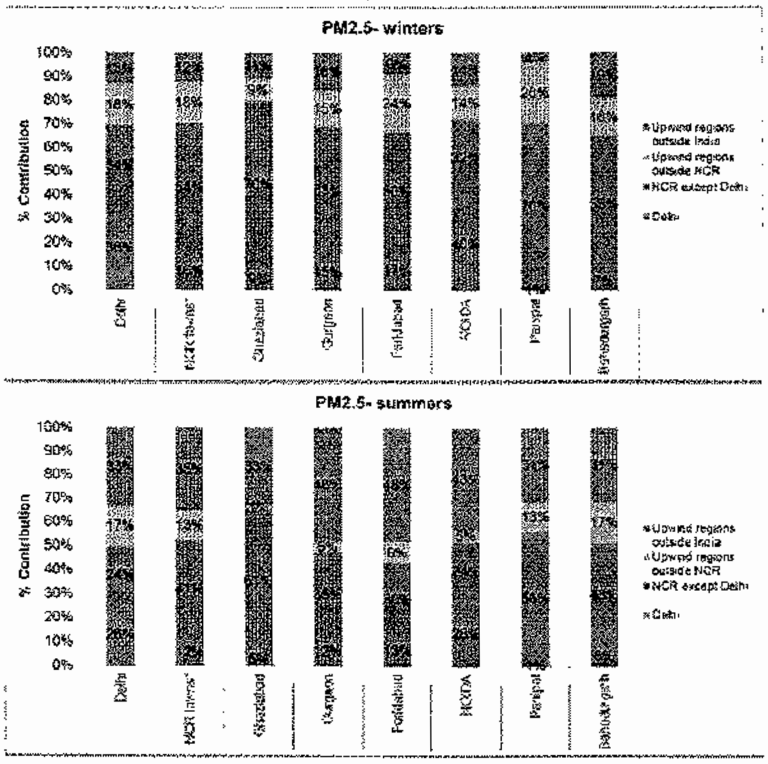

Figure E.9: Contribution of various geographical regions in $PM_{2.5}$ concentrations in different towns during winter and summer seasons

Note: Share of different regions vary across different cities because of sources and also because of changing meteorology as the period monitoring varied across three months within a season.

* Average of NCR towns excluding Delhi. The contribution of nearby districts like Gurgaon, Faridabad, Noida, Ghaziabad, Jhajjar, and Sonipat in Delhi's $PM_{2.5}$ concentration was 23%-24%.

E10. Future projections

In order to understand the growth in different sectors contributing to air pollution in the region, future scenario analysis was also carried out. In this regard, possible future growth scenarios have been prepared for the year 2025 (medium term) and 2030 (long term). A Business as usual (BAU) scenario has been developed which takes into account the growth trajectories in various sectors and also the policies and interventions which have already been notified for control of pollution. A No-Further-Control (NFR) scenario has been analysed, in which impacts of these already planned interventions have been discounted. In order to assess the potential of various strategies for control of PM_{10} and $PM_{2.5}$ concentrations, about 27 interventions in different sectors have been tested on the model. Strategies which could provide significant air quality benefits have been identified and by combing them an alternative scenario (ALT) has been developed with the aim of meeting the prescribed air quality standards.

The BAU scenario shows that the total PM_{10} emissions will increase from 1,017 to 1,549 kt/yr during 2016–2030 (+54%). $PM_{2.5}$ emissions will grow from 528 to 791 kt/yr, by 50%. NO_x emissions will stabilize to about 913 kt/yr and SO_2 emissions will decrease from 892 kt/yr to 430 kt/yr. The increase in total PM emissions can be attributed to increase in industrial emissions which are projected to double and in the road dust and construction sector where the increase is 69%–82% by 2030. Emissions of NO_x are expected to stabilize during 2016 and 2030, mainly due to introduction of BS-VI emission norms in the vehicles sector, stringent NO_x and SO_2 standards in industries, and reduced usage of DG sets by 2030. The emissions of SO_2 are projected to decrease mainly due to banning of petcoke and FO (which are high sulphur fuels), and introduction of stringent standards for industries and power plants. With introduction of BS-VI norms, the PM emissions from the vehicle sector are expected to be 49% lower in 2030. Despite introduction of some controls, the industrial sector, due to its growth, will become the major sector contributing to $PM_{2.5}$ emissions in NCR. Contribution of residential sector in emissions reduces due to penetration of LPG and elimination of kerosene use for lighting. The share of agriculture residue burning in emissions is expected to reduce slightly considering the present focus on technologies and strategies for control. On the other hand, the contribution of road dust and construction activities in emissions is projected to increase in the BAU scenario.

Feeding the projected emissions for different sectors in the model, the BAU scenario still depicts an increase in PM_{10} concentrations (two season average) from 134 µg/m³ in 2016 to 156 and 165 µg/m³ in 2025 and 2030, respectively in NCR including Delhi. The $PM_{2.5}$ concentrations will increase from 109 µg/m³ in 2016 to 114 and 118 µg/m³ in 2025 and 2030 respectively. The increase could have been higher if the emissions control strategies (like BS-VI norms) envisaged in BAU are not implemented. These strategies are expected to contribute significantly towards reducing (30%) concentration of PM_{10} and $PM_{2.5}$ by the year 2030. Despite this, the BAU scenario shows slightly more pollutant concentrations in future than present, and hence, additional strategies will be required for control. In order to construct an alternative future scenario, intervention analysis is performed to estimate the emissions and concentrations reduction potential of different control strategies in transport biomass, industries, road and construction dust and others sectors. The share of transport, industries, biomass , dust and others in $PM_{2.5}$ concentrations (winters) in 2030 is found to be 16%, 44%, 13%, 19%, and 8%, respectively.

The reductions have been estimated for various strategies across different sectors for the winter season (**Table E.4**). In the biomass burning sector, it was found that a 6%–7% reduction in ambient concentration of $PM_{2.5}$ and PM_{10}, respectively in 2030 may be achieved by using agricultural residues as pellets in households. However, when agricultural residues are burnt in power plants by replacing coal, it leads to a reduction of 7%–8% in PM_{10} and $PM_{2.5}$ concentrations. The main reduction is by eliminating the agricultural burning activity. Additional benefits of pelleting in households (improved cooking efficiency) and reduced use of sulphur-based coal in power plants have also been accounted for. LPG penetration leads to a reduction of 6% in $PM_{2.5}$ and PM_{10} concentrations in 2030.

As the projected share of transport in 2030 is low (16% in winter season), the impact of strategies in this sector is found to be somewhat lower than other sectors. Higher penetration of electric vehicles in transport such as 2-wheelers, buses and cars shows the reduction of 5%–6% in $PM_{2.5}$ and PM10 concentrations in 2025-2030. Reducing real world emissions by congestion management can lead to 4%–3% reduction in $PM_{2.5}$ and PM_{10} concentrations in 2030. Fleet modernization leads to 8%–6% reduction in 2025 and 3%–2% reduction in $PM_{2.5}$ and PM_{10} concentrations in 2030.

On the other hand, the projected share of industries is high (44% in winters) in 2030, and hence the impact of strategies on PM concentrations is found to be higher than other sectors. Fuel switch to gaseous fuels can lead to a massive reduction of 12% in PM_{10} and $PM_{2.5}$ concentrations in 2025. The reduction grows to 23% in 2030. Alternatively, the implementation of a stringent standard for $PM_{2.5}$/PM_{10} in industries can lead to 8%–10% reductions in PM concentrations in 2025, and 11%–12% in 2030. Better enforcement with continuous monitoring of industrial emissions will result in lower industrial emissions and a reduction of 9%–10% may be achieved in PM concentrations in 2025 and 2030. The impact of other strategies, such as zig-zag technology in brick kilns, and introduction of standards for gaseous pollutants is found to be less than 4%.

The share of dust in PM_{10} concentrations in 2030 is high, that is, 20% from road and construction activities. The strategy of enhanced vacuum cleaning of roads results in 6% and 2% reduction in PM_{10} and $PM_{2.5}$ concentrations, respectively in winters. Control of dust from C& D activities can reduce 2% and 1% of PM_{10} and $PM_{2.5}$ concentrations, respectively in NCR in 2030. Banning of open refuse burning and using it in waste to energy (WTE) plants reduces PM_{10} and $PM_{2.5}$ concentrations by 3% and 4%, respectively, in 2030. Supply of 24x7 electricity may reduce $PM_{2.5}$ concentrations by 2% in 2030 by reducing DG set usage. The rest of the strategies in others category having different reduction potentials are shown in **Table E.4**.

Table E.4 : Concentration reduction potential of various strategies (winter seasons) in 2025 and 2030.

S.NO	Strategies	2025		2030	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
	Biomass				
1	Increase in LPG penetration in residential sectors in NCR by 75% in 2025- 100% in 2030	-6%	-6%	-6%	-6%
2	Supply and use of improved biomass cook-stoves 75% in 2025 and 100% in 2030 to households using biomass	-6%	-6%	-4%	-4%
3	Supply and use of improved induction cook-stoves 75% in 2025 and 100% in 2030 to households using biomass	-6%	-6%	-6%	-6%
4	Use of agricultural residues in WTE (With adequate tail-pipe controls) *	-4%	-5%	-4%	-4%
5	Use of agricultural residues in power plants *	-8%	-8%	-8%	-7%
6	Use of agricultural residues pellets in local households *	-7%	-7%	-6%	-6%
	Transport				
7	Electrification of vehicular fleet (Bus (25-50%), two (20-40%) and three wheelers (100%), and cars (20-40%)	-6%	-5%	-6%	-5%
7a	Public transportation -25% and 50% electric buses in 2025 and 2030	-1%	-1%	-1%	-1%
7b	Private electric vehicles- 20% in 2025 and 40% in 2030 electric two-wheelers, and 100% three-wheelers	-4.7%	-3.5%	-3.9%	-2.8%
7c	Private electric vehicles- 20% in 2025 and 40% in 2030 electric cars	-0.24%	-0.17%	-1.4%	-1%
8	Fleet modernization - Restricted entry/movement of pre-BS-VI vehicles	-8%	-6%	-3%	-2%
9	Banning entry of pre BS-IV trucks and buses - to be modernized/retrofitted to be BS-VI equivalent	-3%	-2%	-1%	-1%
10	Improved inspection and maintenance system- High emitters go down from 5% to 2% (2025) and 1% in 2030	-2%	-1%	-1%	-1%

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S.NO	Strategies	2025		2030	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
11	Reducing real world emissions from vehicles by 50% through congestion management	-5%	-4%	-4%	-3%
12	Shift of 50% cars and 2-w users to shared commuter transport (public/private) (based on EVs)	-2%	-1%	-1%	-1%
13	Increase penetration of biodiesel to 12% by 2025 and 20% by 2030	-0.5%	-0.3%	-0.7%	-0.5%
14	Increased penetration of hybrid and EV cars: 35% hybrid and 15% EV cars by 2025 and 70% hybrid and 30% EV by 2030	-0.7%	-0.5%	-2.1%	-1.5%
	Industries				
15	Power plant controls -implement stricter NO_x and SO_2 standards with continuous monitoring	-4%	-3%	-4%	-3%
16	Stricter enforcement of standards in industries through continuous monitoring and other mechanisms	-9%	-10%	-9%	-10%
17	Enforcement of SO_2/NO_x standards in industries 50% and 100% in 2025 and 2030	-1%	-1%	-2%	-2%
18	Enforcement (75-100%) of zig-zag brick kiln technology in 2025 and	-4%	-4%	-4%	-3%
19	100% fuel switch from solid to gaseous fuels	-12%	-12%	-23%	-23%
20	Stricter dust control on stone crushers	-0.1%	-1%	-0.1%	-2%
21	Introduce and implement stringent PM_{10} and $PM_{2.5}$ norms in industries	-8%	-10%	-11%	-12%
	Road dust and construction				
22	Vacuum cleaning of roads - silt load reduction of 25% and 50% in 2025	-0.3%	-2%	-2%	-6%
23	Wall to wall paving- silt load reduction of 25% and 50% in 2025 and 2030	-0.3%	-2%	-2%	-6%
24	Control of dust from construction activities- barriers and fogging based controls -30% and 60% in 2025 and 2030.	-0.3%	-1%	-1%	-2%

S.NO	Strategies	2025		2030	
		$PM_{2.5}$	PM_{10}	$PM_{2.5}$	PM_{10}
	Others				
25	Full ban on refuse burning activities and combustion in WTE	-4%	-3%	-4%	-3%
26	Landfill fire control	-0.1%	-0.2%	-0.5%	-0.4%
27	Stricter standards for DG sets using innovative PM and NO_x emissions control technologies	-2%	-2%	-1%	-1%
28	Supply 24x7 electricity leading to 90–95% reduction in DG set usage by 2025 and 2030.	-2%	-2%	-2%	-1%

The table shows the reduction potential of different strategies and detailed techno-economic feasibility studies will be required for some of the strategies before actual implementation.

* This only shows the average effect over the whole season but in addition it will also help in reducing the peak of pollution during post-harvesting season.

After conducting the intervention analysis, a set of interventions, which are most feasible to implement and also have substantial impact on PM concentrations are selected for constructing the alternative scenario. **Figure E.10** shows the change in concentrations of $PM_{2.5}$ and PM_{10} in BAU and alternative scenario. In alternative scenario, in 2030, $PM_{2.5}$ emissions have reduced by 72% and PM_{10} emissions have reduced by 77% and the corresponding reduction in average concentration (of both seasons) was 58% in $PM_{2.5}$ and 61% in PM_{10}. The alternative scenario envisages meeting the prescribed daily standards in the winter season and hence, it may be safely assumed that annual average standards may be met considering lower concentrations during other seasons.

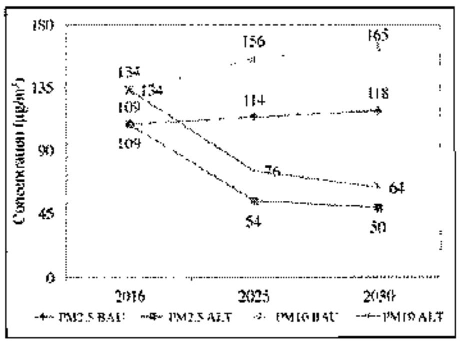

Figure E.10: Average of two seasons (winter and summer) PM_{10} and $PM_{2.5}$ concentrations in Delhi-NCR in seasons in BAU and ALT scenarios

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E11. Proposed Action Plan

An action plan including all the selected strategies in the alternative scenario has been presented in **Table E.5**. The time frames and possible implementing agencies of these strategies are also suggested.

Table E.5.: Action plans with the list of interventions selected for reduction of pollutant concentrations in Delhi-NCR

S.No.	Strategies	Description	Desired Time frame	Suggested implementation agencies
	Biomass Burning ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 14% and 10%, respectively.)			
1	Increase in LPG penetration in NCR by 75% in 2025- 100% in 2030	Convert 75% and 100% biomass to LPG in 2025 and 2030, respectively	100% LPG penetration by 2026	MoPNG
2	Use of agricultural residues as briquettes in power plants	Zero-open burning and use of residue briquettes in power plants	Agricultural residue to be used in power plants by 2020	MoP, MoA
	Transport ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 9% and 7%, respectively.)			
3	Public transportation system on electric vehicles; followed by private vehicles	25% and 50% electric buses in 2025 and 2030, respectively	25% and 50% electric buses in 2025 and 2030, respectively	State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)
4	Improved inspection and maintenance system	Setting up OBD/remote sensing based and advanced I&M centres. High emitter emissions go down from 25% to 10% (in 2025) and 25% to 5% in 2030	15 advanced I&M centres in NCR by 2021 and 30 by 2025. To support, existing PUCs to be upgraded for OBD-based testing.	MoRTH, State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)
5	Fleet modernization	All vehicles to be BS-VI	Fleet modernisation mechanisms along with scrappage centres by 2025	MoRTH, State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)

S.No.	Strategies	Description	Desired Time frame	Suggested Implementation agencies
6	Reducing real world emissions from vehicles by congestion management	Reduce real world emissions by 50% by congestions management strategies	Introduce congestion pricing schemes in Delhi by 2019 and expand to NCR by 2021to shift from private to public modes of transportation*	MoUD and states urban development and transport departments
7	Shift of 50% cars and 2-w to shared commuter transport	Shift 50% of personal transport on shared taxis in 2025 and 2030	Promote private players to enhance shared transport modes by 2019	State transport departments-NCR(Delhi, UP, Haryana, Rajasthan)
	Industries ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 32% and 31%, respectively.)			
8	Power plant controls with continuous monitoring	Implement stricter NO_x and SO_2 standards	Install tailpipe control devices by 2020.	Power plant companies, MoP, SPCBs, and CPCB
9	Introduction and enforcement of new SO_2 and NO_x standards	75% and 100% enforcement of SO_2/NO_x standards in industries in 2025 and 2030, respectively	Install tailpipe control devices in 75% of industries by 2021 and 100% by 2026	Industries, SPCBs, and CPCB
10	Enforcement of zig-zag brick kiln technology	75% and 100% enforcement of zig-zag brick kiln technology in 2025 and 2030, respectively	75% and 100% enforcement of zig-zag brick kiln technology in 2021 and 2026, respectively	SPCBs and CPCB
11	Fuel switch to gas from solid fuels	50% and 100% fuel switch to gas from solid fuels in 2025 and 2030, respectively	Fuel switch to gas from solid fuels in 50% and 100% industries in 2025 and 2030, respectively	MoPNG, State Industrial departments
	Road dust and Construction ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 4% and 11%, respectively.)			
12	Vacuum cleaning of roads	Silt load reduction 25% and 50% in 2025 and 2030, respectively	Mechanized road cleaning of 25% and 50% roads in 2025 and 2030, respectively	Municipal corporations

S.No.	Strategies	Description	Desired Time frame	Suggested implementation agencies
13	Wall to wall paving of roads	Silt load reduction 25% and 50% in 2025 and 2030, respectively	Wall to wall paving of 25% and 50% roads in 2025 and 2030, respectively	PWD
14	Control of dust from construction activities	Barriers and water controls (30% and 60% control on PM emissions in 2025 and 2030, respectively)	Mandatory implementation of barriers and water controls in major construction sites by 2021 and all by 2026.	PWD, NHAI, Municipal bodies, PCBs
	Others ($PM_{2.5}$ and PM_{10} concentration reduction in 2030 winter season: 6% and 6%, respectively.)			
15	Use of refuse in WTE	Reduced emissions from refuse burning in WTE plants fitted with controls	Immediate market mechanism for collection and transportation of refuse to WTE	Municipal corporations and panchayats
16	Supply 24x7 electricity	Supply 24x7 electricity, DG set emissions to reduce to 10% and 5% in 2025 and 2030, respectively	Immediate arrangements for regulatory and tariff structure to make use of the power surplus situation and thereby ensuring 24x7 power supply	State electricity departments

The table shows the reduction potential of different strategies and detailed techno-economic feasibility studies will be required for some of the strategies before actual implementation.

*The revenues collected from congestion pricing scheme should mandatorily be used for enhancement of public transport.

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E12. Conclusions

- Air pollution levels are extremely high in Delhi and NCR, especially in winters.
- The assessment of both the scientific approaches reveals that transport, biomass burning, and industries are the three major contributors to $PM_{2.5}$ concentration in Delhi NCR during winter. In summer, the contributions of dust from inside and outside of India eclipses the shares of these three major sectors in the $PM_{2.5}$ concentrations, however, the contributions still remain significant.
- The assessment for PM_{10} shows that other than transport, biomass burning, and industries, road dust and construction dust also contribute significantly to concentrations. Like $PM_{2.5}$, during summers, the contributions of dust from outside of India reduce the shares of these local sectors in the PM_{10} concentrations.
- The study has quantified the contributions of different sources at present and in future time-frames (2025–2030). The $PM_{2.5}$ concentrations are expected to increase by 5% in 2025 and by 8% in 2030 with respect to 2016, in a BAU scenario. The PM_{10} concentrations are expected to increase by 16 and 23% in 2025 and 2030, respectively, in a BAU scenario. This is after accounting for growth in different sectors and also taking into account the possible enforcement of the interventions which have already been notified for control of air pollution. Discounting these planned interventions, the growth in $PM_{2.5}$ concentrations could be 30% higher in 2030.
- The study analysed various interventions and estimated their possible impacts over $PM_{2.5}$ and PM_{10} concentrations in Delhi and NCR. An alternative scenario has been developed considering the interventions which can provide maximum air quality benefits. The alternative scenario results in a reduction of 58% and 61% in $PM_{2.5}$ and PM_{10} concentrations in 2030, with respect to the BAU scenario, and achieves the daily ambient air quality standards for PM_{10} and $PM_{2.5}$.
- The interventions which have identified as the ones with highest impact on PM concentrations in 2030 are:
  - Complete phase out of biomass use in NCR by enhanced LPG penetration in rural households
  - Use of agricultural residues in power plants and other industries to replace high ash coal and open burning in fields
  - Introduction of gaseous fuels and enforcement of new and stringent SO_2/NO_x/$PM_{2.5}$ standards for industries using solid fuels
  - Strict implementation of BS-VI norms
  - Improvement and strengthening of inspection and maintenance system for vehicles
  - Fleet modernization and retro-fitment programmes with control devices
  - Enhanced penetration of electric and hybrid vehicles
  - Reducing real world emissions by congestion management
  - Stricter enforcement of standards in large industries through continuous monitoring
  - Full enforcement of zig-zag brick technology in brick kilns
  - Vacuum cleaning of roads, wall to wall paving of roads
  - Control of dust from construction activities using enclosures, fogging machines, and barriers
  - Elimination of DG set usage by provision of 24x7 electricity and control by innovative tail-pipe control technologies

—

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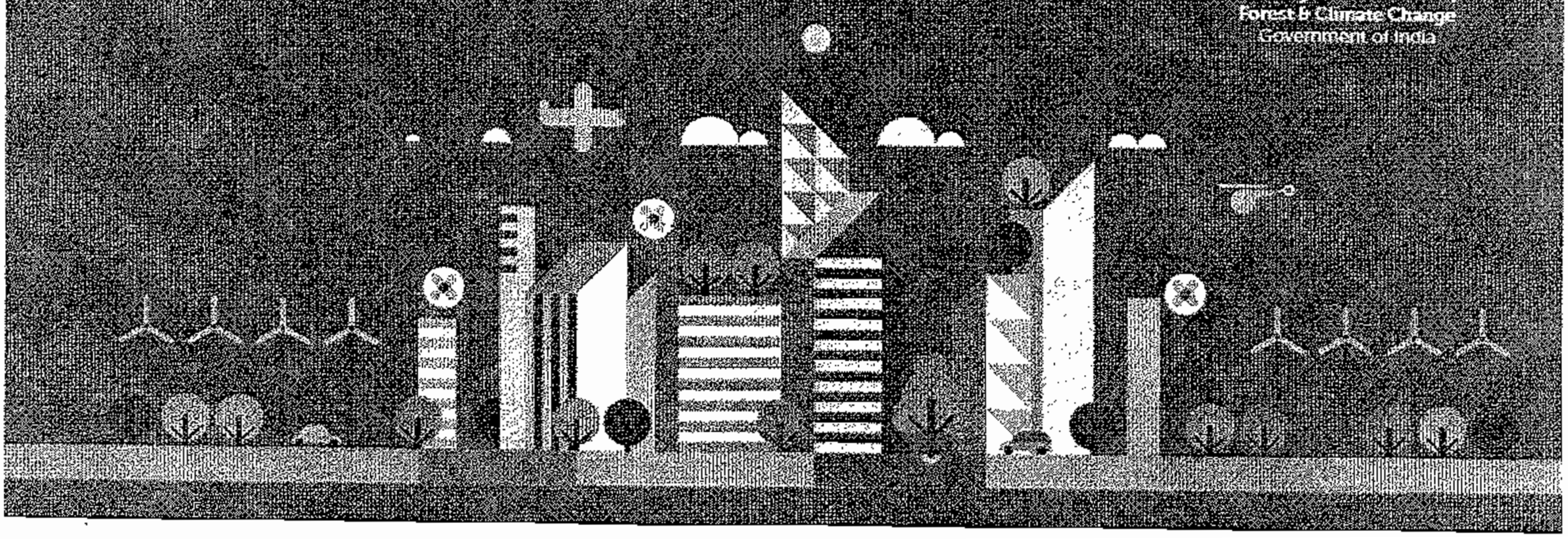
ANNEXURE- A-3

सत्यमेव जयते

NCAP
NATIONAL CLEAN AIR PROGRAMME

Ministry of Environment, Forest & Climate Change
Government of India



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सत्यमेव जयते

NCAP
NATIONAL CLEAN AIR PROGRAMME

Ministry of Environment,
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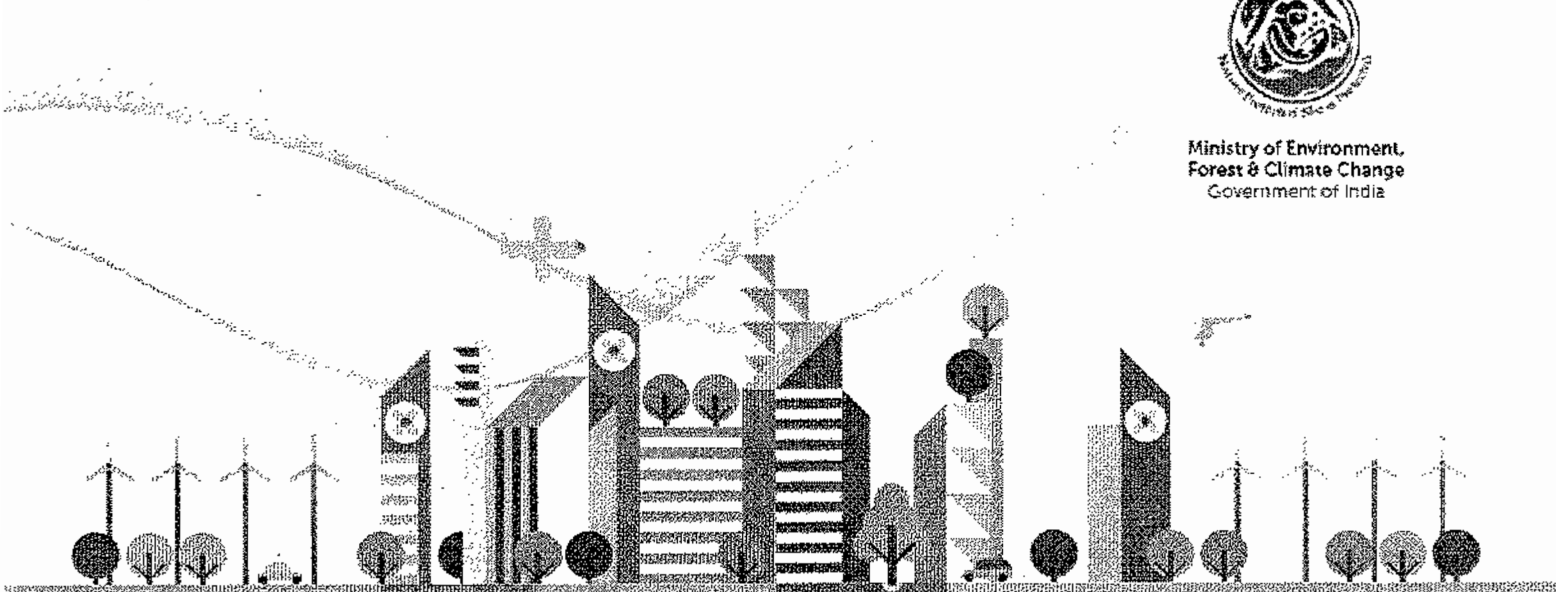

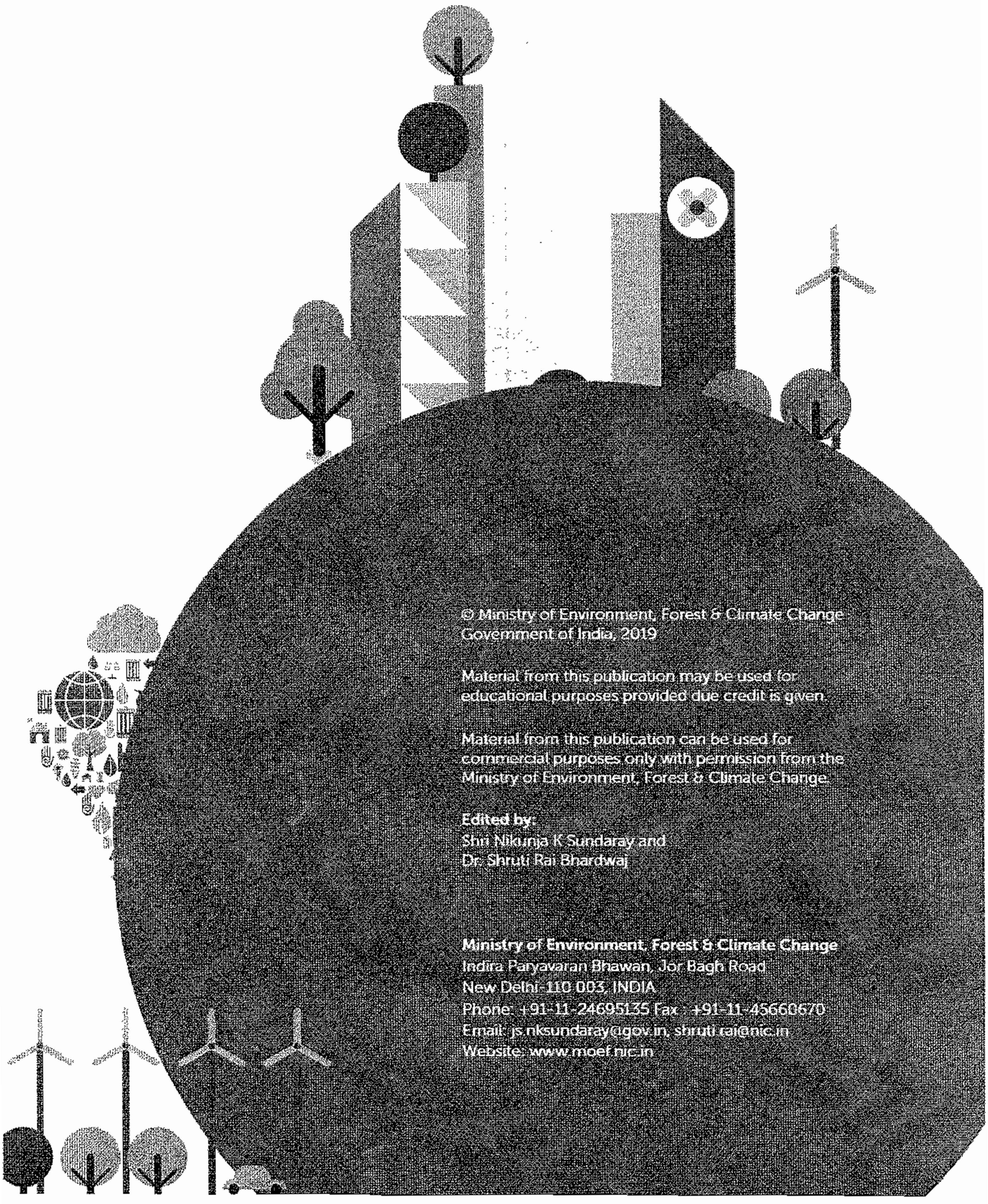

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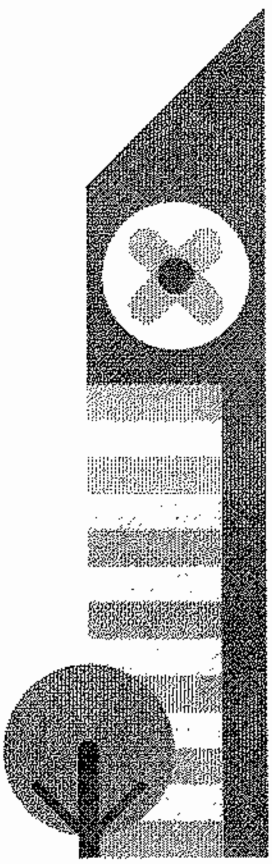

LIST OF ABBREVIATIONS

AAQFS	Ambient Air Quality Forecasting System
AOD	Aerosol Optical Depth
AQI	Air Quality index
ARAI	Automotive Research Association of India
BEE	Bureau of Energy Efficiency
BS	Bharat Stage
C&D	Construction and demolition
CAAQMS	Continuous Ambient Air Quality Monitoring Stations
CAAQMS	Continuous Ambient Air Quality Monitoring Stations
CAMPA	Compensatory Afforestation Management and Planning Authority
CEPI	Comprehensive Environmental Pollution Index
CNG	Compressed Natural Gas
CPAs	Critically Polluted Areas
CPCB	Central Pollution Control Board
CSIR	Centre for Scientific and Industrial Research
DST	Directorate of Science and Technology
EPA	Environmental Protection Agency
EPCA	Environment Pollution Prevention and Control Authority
EV	Electric Vehicles
FGD	Flue Gas Desulfurization
GAIL	Gas Authority of India Limited
GHG	Greenhouse Gas
GRAP	Graded Response Action Plan
GTAP	Graded Response Action Plan
HDV	Heavy-Duty Vehicles
ICMR	Indian Council of Medical Research
IIFM	Institutes as Indian Institute of Forest Management
IITM	Indian Institute of Tropical Meteorology
IMD	India Meteorological Department
INDC	Intended Nationally Determined Contribution
ISRO	Indian Space Research Organisation
LPG	Liquid Petroleum Gas
MHCV	Medium & Heavy Commercial Vehicles
MNRE	Ministry of New and Renewable Energy
MoA	Ministry of Agriculture
MoEF&CC	Ministry of Environment, Forest and Climate Change
MoPNG	Ministry of Petroleum & Natural Gas
MoRTH	Ministry of Road Transport and Highways
MSW	Municipal Solid Waste
NAAQS	National Ambient Air Quality Standards
NAMP	National Air Quality Monitoring Programme
NAPCC	National Action Plan on Climate Change
NAPCC	National Action Plan on Climate Change

NCAP	National Clean Air Programme
NCR	National Capital Region
NEERI	National Environmental Engineering Research Institute
NEMMP	National Mission for Electric Mobility
NICB	NPL-India certification body
NMHC	Non-methane hydrocarbons
NPMCR	National Policy for Management of Crop Residues
OCEMS	Online Continuous Emission Monitoring System
PAHs	Polycyclic Aromatic Hydrocarbons
PMUY	Pradhan Mantri Ujjwala Yojana
PNGRB	Petroleum and Natural Gas Regulatory Board
PUC	Pollution under Control
PWD	Public Works Department
SACEP	South Asia Co-operative Environment Programme
SAFAR	System of Air Quality and Weather Forecasting and Research
SDGs	Sustainable Development Goals
SOP	Standard Operating Procedure.
SPAs	Severely Polluted Areas
SPCB	State Pollution Control Board
TERI	The Energy and Resources Institute
TPP	Thermal Power Plants
UNCCD	United Nations Convention to Combat Desertification
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
VVMP	Voluntary Vehicle Fleet Modernization Programme
WHO	World Health Organization

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MESSAGE

Air Quality failing to meet the prescribed national air quality standards is recognized for causing adverse health impact on human health, agricultural production and ecosystem. Rapidly expanding economy and migration of people to urban centers in India is a significant factor for the deterioration of ambient air quality, particularly in metropolitan areas in the country. In order to combat the challenge of unhealthy air quality in regional and urban areas in India, Government has taken number of significant positive measures which inter-alia include setting and revising of national ambient air quality and industrial emission standards, establishment of National Air Quality Monitoring Programme, stringent regulation of vehicular emissions and introducing fuel quality norms, enhanced penetration of LPG etc. to name a few. These measures are expected to curb the escalating pollution levels to an extent. However, with the availability of monitoring data from increasing number of non-attainment cities, the need was felt to intensify the efforts for well-planned technological actions and solutions for improving the air quality in the country.

Moving forward in this direction, the Ministry of Environment, Forest and Climate Change, Government of India has come up with this National Clean Air Program (NCAP) as a national-level strategy document prescribing the actions for reducing the levels of air pollution at city and regional levels in India. Acknowledging the Trans boundary impact of air pollution, actions are also proposed for evolving effective regional and global coordination mechanism.

Effective air pollution reduction plan will be formulated on the basis of source apportionment studies for 102 non-attainment cities of the country and will be implemented through a stringent enforcement mechanism. Collaborative, multi-scale, inter-sate and cross-sectoral coordination between the relevant central ministries, state governments and bodies forms the crux of the programme. NCAP incorporates several measures for effective monitoring, assessment and control of air pollution in India. The approach for expediting implementation under NCAP is through mainstreaming and integration into the existing policies and programmes of the Government of India.

I commend all those who have put intensive efforts in formulation of this national programme.

Date: 31.12.2018

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ENVIRONMENT, FOREST AND CLIMATE CHANGE
GOVERNMENT OF INDIA

MESSAGE

Clean air is an essential component for ensuring healthy lives and ecosystem. India, through its journey of rapid economic growth to meet the needs of burgeoning population, is now dealing with the menace of air pollution. There is a whole range of pollutants which can detrimentally impact the human health and equally varied are the sources from which these are emitted. It is utmost important to effectively monitor and assess the sources of air pollution, in order to draft adequate strategies for its control. Government of India has taken many initiatives and the efforts started way back in 1981 with coming into existence of Air (Prevention and Control of Pollution) Act, 1981 followed by Environment (Protection) Act, 1986. In fact, Indian constitution is foundation stone of environmental jurisprudence in India. Right to clean environment and pollution free air and water is one of the fundamental right and duty to protect the environment is fundamental duty under the constitution.

However, the need of the hour is to intensify efforts towards control of air pollution at pan India level so as to ensure its decoupling with the rapidly growing economy. Working towards this endeavor, the National Clean Air Program (NCAP) has been formulated with aim to improve the air quality in India. It is a national-level response to reduce the levels of air pollution at both the regional and urban scales in the country. The NCAP emphasis on comprehensive mitigation actions not limited to cities but extended to rural areas while also focusing on actions for transboundary pollution sources. It also envisages augmenting and evolving an effective and widespread ambient air quality monitoring network across the country besides focusing on awareness and capacity building.

NCAP has been formulated through a participatory and collaborative approach involving sectoral ministries, state pollution control boards, research institutions, technical institutions, universities, other government, and non-governmental and private organizations, incorporating vast regional diversity and sectoral complexities in India. I believe the activities planned in the NCAP will be implemented with stringent timelines.

I would like to congratulate all those who have been part of evolution and finalization of this important national policy document.

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MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

MESSAGE

Air pollution is presently one of the biggest global environmental challenges with impacts now known to be not limited at local level. Far- reaching impacts due to its transport over long distance; and with geographical and meteorological conditions influencing the outcome, it has become a significant health concern for developing countries like India. As an emerging populated economy, India is going through the phase of accelerated growth. This has significance for meeting India's commitments with respect to major Sustainable Development Goals (SDGs) of no poverty, zero hunger, good health, quality education etc.

Increased demands for mobility, power, and products coupled with this economic growth has led to increase in emissions. The source apportionment studies are pointing towards dust, biomass, industries, and agricultural residues as other primary sources for pollution in Indian cities. While city-specific action plans to control air pollution are in place in some form for some of the cities, India felt the need of national scale program for prevention, control and mitigation of air. The basic premise for the national level programme arises from two important observations. Firstly, significant number of cities, where air quality monitoring is carried out in India, violate the prescribed annual ambient air quality standards. Secondly, factors influencing the air pollution are not limited to local sources but regional and trans-boundary sources have proven to be determining the outcome. This widespread violation of air quality is validated by several modelling-based studies and satellite based air quality data.

Acknowledging the issue, the Ministry of Environment, Forest and Climate Change, Government of India has now come up with National Clean Air Programme (NCAP) as national level strategy. The aim of the Programme is to gradually improve the ambient air quality and to meet the prescribed annual average ambient air quality standards at all locations in the country in stipulated time frame. For control of pollution at national scale, the NCAP emphasizes on actions distributed across mitigation, knowledgebase augmentation and institutional strengthening. The NCAP focuses on collaborative and participatory approach covering all sources of pollution and coordination between relevant Central Ministries, State Governments, local bodies and other stakeholders. International cooperation is one of the major components to garner the benefits of international experiences and also to address the issue of regional and trans-boundary sources of air pollution.

I would like to put on record great sense of appreciation for all the efforts put in by Shri A.K. Mehta, Additional Secretary, Shri Nikunja Kishore Sundaray, Joint Secretary and Dr. Shruti Rai Bhardwaj, Additional Director in this endeavour.

[C. K. Mishra]

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1 PROCESS FOR FORMULATION OF NCAP

Since collaborative and participatory approach involving relevant Central Ministries, State Governments, Local bodies and other Stakeholder with focus on all sources of pollution form crux of the Programme, extensive consultation with all the relevant stakeholders forms the foundation for formulation of NCAP. The first draft of the NCAP document formulated by the Ministry on the basis of available background information was shared with State Government, relevant Ministries and other Stakeholders. NCAP was uploaded to ministry's website for comments from stakeholders including general public and last date for receipt of comments was 17.05.2018. NCAP was shared with Resident Commissioners of all the States and UTs during the meeting held on 26.3.2018 in the Ministry.

Ministry of Environment, Forest, and Climate Change (MoEF&CC) conducted a 2-day stakeholder consultation on 19th -20th April 2018 to discuss NCAP along with State Government. Another Stakeholder consultation on NCAP involving other stakeholders in addition to State Government was held on 21st-22nd May 2018. In addition to significant inputs from State Government, various international best practices were also shared by international experts during these consultations. A thematic knowledge session on 'National Clean Air Programme' was organized on 04.06.2018 at Vigyan Bhawan, New Delhi as part of the 'State Environment Minister's Conference' under the five-day long celebration of World Environment Day, 2018 (WED-2018).

The NCAP was amended on the basis of available inputs from these consultations and meetings.Final inter-ministerial meeting involving the key ministries, States and experts was held on 9th October 2018 in the Ministry and the redrafted NCAP document was unanimously approved.

2 OVERVIEW

India is committed to create a clean environment and pollution free air and water. In fact, it is mandated in our constitution. India's commitments and obligations to environmental conservation and protection within the ambit of the targeted goals on environmental sustainability under the Sustainable Development Goals (SDGs) is manifested in the fact that several administrative and regulatory measures, including a separate statute on air and water pollution are under implementation since long. The Air (Prevention and Control of Pollution) Act, 1981, was enacted under Art. 253 of the Constitution to implement the decisions taken at the United Nations Conference on Human Environment held at Stockholm in June 1972, in which India participated. Sustainable development, in terms of enhancement of human well- being, is an integral part of India's development philosophy.

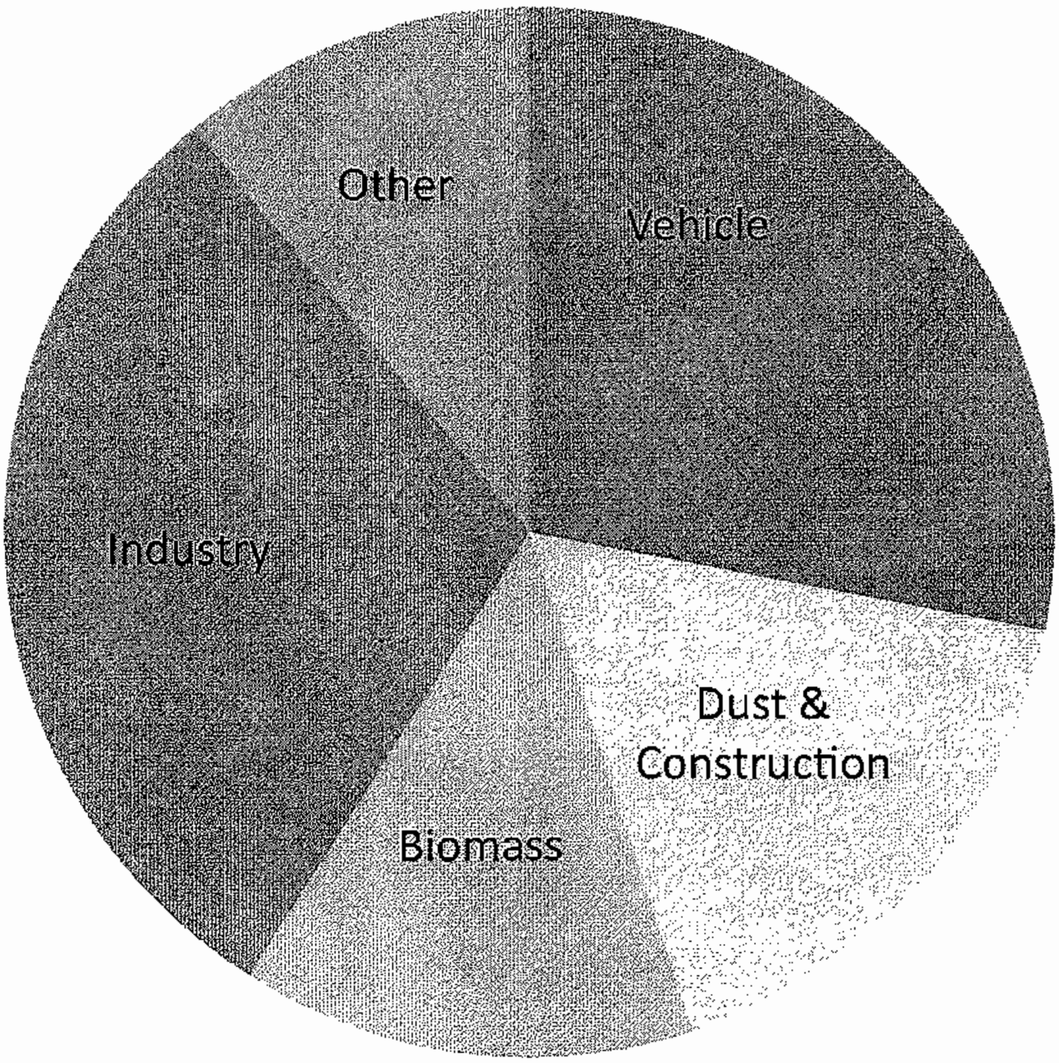
However, a vast country and an emerging economy like India, faces enormous challenges with its burgeoning population and widespread poverty, in meeting its various other significant commitments associated with poverty, and eradication of hunger under the SDGs. India has been going through a phase of accelerated industrial activities for the past three decades. The associated growth in terms of industrialization and urbanization has led to manifold increase in pollution issues, more specifically air pollution issues.

In recent years, medium and small towns and cities have also witnessed an increase in pollution, thus getting fast reflected in the non-attainment cities of India. Air pollution has increasingly become a serious concern, predominantly because of its health impacts. The reported perplexing statistics in various international reports, correlating air pollution with health impacts without the use of indigenous dose response functions, further complicates the issue by possibly creating an ambiguous public perception.

Air pollution emission issues are associated with many sectors, which inter-alia include power, transport, industry, residential, construction, and agriculture. Burning fossil fuels causes air pollution that both contributes to global climate change and also contributes to air pollution. Global climate change is caused by the overabundance of greenhouse gas (GHG) emissions in the atmosphere. The local air quality generally refers to the level of pollutants in the air that we breathe, which is typically found in the lowest part of the atmosphere, and the air quality is reduced by excess concentration of specific pollutants, namely, PM_{10}, $PM_{2.5}$, NO_x, SO_x, CO, etc. There exists a considerable quantitative literature estimating the local pollution co-benefits of climate change mitigation interventions. The sectors in which fuel combustion contributes to GHG emissions, such as energy, buildings, industry, and transport, are the ones with the most significant air quality co-benefits and the most substantial quantitative literature. In energy and industry, the largest co-benefits come from replacing coal combustion with less polluting fossil fuels, from replacing fossil fuels with renewable energy, from improving energy efficiency, and from improving the characteristics of coal via coal washing and briquetting. For buildings, the largest air quality co-benefits are typically linked to improvements in energy efficiency and modifications in cooking stoves. Transport studies typically aggregate the effects from a collection of interventions, including greater use of public transport and improving vehicle fuel efficiency, but transport-related studies also often aggregate effects on health outcomes from other non-pollution effects such as benefits from increased walking and cycling.

The impact of air pollution is not limited to health but extends to agriculture and the general well-being of humans, floral and faunal population. Furthermore, since air pollution is not a localized phenomenon, the effect is felt in cities and towns far away from the source, thus creating the need for regional-level initiatives through inter-state and inter-city coordination in addition to multi-sectoral synchronization. While the problem of air pollution is mainly urban centric, studies show the regional scale pollution, is more concentrated in the Indo-Gangetic plains and more industrialized states. Incidences of episodic air pollution during the winters in Delhi NCR in the recent years have attracted significant media attention, thus bringing the entire issue of air pollution under regular public scrutiny.

SOURCES



3 SOURCES

Data generated from National Air Quality Monitoring Programme (NAMP) over the years reveal that particulate matters (PM_{10} and $PM_{2.5}$) are the major challenge which are found to be exceeding the National Ambient Air Quality Standard (NAAQS) all across the country more specifically in urban areas of Indo-Gangetic plain. Other pollutants such as SO_x, NO_x and ozone (O_3) are mostly observed to be within the prescribed national standards. The sources of emissions in India have been estimated emissions in several research studies.

While there are some variations due to differences in methodologies and the year of estimation, however, there is broad convergence of the estimates. While vehicles, industries, rampant constructions, biomass burning, diesel gensets, commercial and domestic use of fuel, etc are major sources of pollution, the inherent disadvantages specifically of the Indo-Gangetic plain stemming from its geographical location and soil composition, compounds the air pollution woes for the region. The Indo-Gangetic plain is essentially landlocked and the Himalayas prevent polluted air from escaping to the north creating the so called "valley effect" and dry alluvial soil significantly contributes to wind-blown dust.

As per TERI's inventory (Sharma and Kumar, 2016)[1], the share in $PM_{2.5}$ emissions are dominated by the industrial (36%) and residential combustion (39%) sectors. Transport contributes to just 4% of $PM_{2.5}$ emissions at the National scale, however, these emissions are concentrated in the urban centers. Moreover, being ground-based sources, their contribution to prevailing air quality levels could be much high. Open burning of agricultural residue in rural areas contributes about 7% to the total $PM_{2.5}$ emissions. Other sectors cumulatively contribute 11% of emissions. Power plants contribute 4% of $PM_{2.5}$ emissions; however, these may contribute significantly to the pollution levels in the specific zones of influence of the power plants. The current inventories of NO_x emissions show dominance of the transport sector (35%), power plants (22%), and DG and agricultural pump sets (15%). SO_2 emissions are estimated to be generated mainly by the industry (49%) and power sectors (43%). Hydrocarbon emissions are mainly generated from biomass combustion activities in the residential sector.

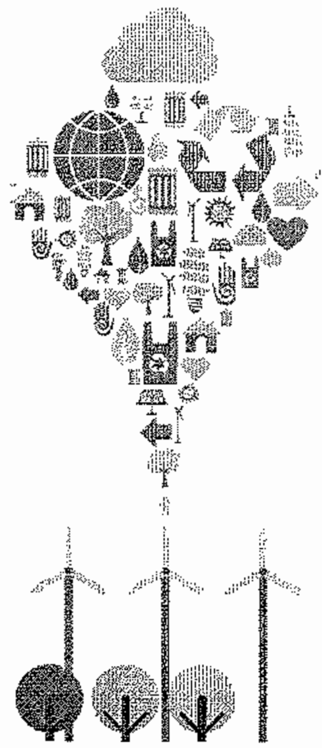
There is a drastic difference in the contribution of sources at the urban scales. CPCB, 2011, shows the results of a comprehensive source apportionment studies carried out in six cities during 2007–2010, namely, Bengaluru, Chennai, Delhi, Kanpur, Mumbai, and Pune. The results show that dust from road dust re-suspension, construction activities, and soil has the major contribution (6%–58%) to PM_{10} concentrations in these six cities. The share of the transport sector remains smaller in PM_{10} but increases significantly in $PM_{2.5}$ (finer fractions)

1 Sharma, S., Kumar, A., Datta, A., Mohan, I., Das, S., Mahtta, R., Lakshmi, C. S., Pal, S., Malik, J., (2016). Air pollutant emissions scenario for India. ISBN 978-81-7993-639-9

concentrations. Secondary particulates formed due to chemical conversion of gaseous pollutants such as SO_2 and NO_x also contribute significantly to $PM_{2.5}$ concentrations in different cities. A 2016 IIT-Kanpur study titled 'Comprehensive Study on Air Pollution and Green House Gases (GHGs) in Delhi'[2] indicated secondary particulates (30%) and vehicular emissions (25%) to be a major source of pollution during the summer with construction and road dust (31%) and coal and fly ash (26%) contributing majorly during the winter (Table 1). TERI and Automotive Research Association of India (ARAI) in their recent study conducted for the Department of Heavy Industry on 'Source Apportionment of $PM_{2.5}$ & PM_{10} of Delhi NCR for Identification of Major Sources'[3], published during August 2018, states that seasonal variation of PM_{10} shows higher contribution of dusty sources in summer (38%–42%) as compared to the winters in Delhi as well as in the NCR region. This can be attributed to dry conditions and higher wind velocities resulting in entrainment of dust. However, contribution of dusty sources (e.g., road, construction and soil dust) was also significant in the winter season (23%–31%). Contribution of vehicles to PM_{10} was slightly higher in winters (17%–

TABLE 1: SOURCE APPORTIONMENT OF DELHI

CPCB Study (2010)				
Source	**% contribution (PM_{10}): Range for 10 monitoring locations**			
Vehicles	8.7–20.5			
Road dust	14.5–29.0			
Construction	22–23.1			
Industries	6.3–9.3			
Garbage burning	10.5–24.4			
Domestic	2.7–9.4			
DG sets	6.8–12.3			
IIT Kanpur Study (2015)				
Source	**Average for six monitoring locations**			
	% contribution (PM_{10})		**% contribution ($PM_{2.5}$)**	
	Winter	**Summer**	**Winter**	**Summer**
Vehicles	19.7	6.4	25.1	8.5
Secondary particulates	24.6	10.15	29.9	14.9
Biomass burning	16.7	6.8	25.8	12.2
Industries	0.65	1.05	0.8	1.2
Coal and fly ash	12.1	37.2	4.8	25.95
Construction material	3.1	4.1	1.5	3.0
Soil and road dust	14.4	26.5	4.3	27.1
Soil waste burning	8.75	7.75	7.75	7.2



2 DPCC, 2016. Comprehensive study on air pollution and greenhouse gases (GHGs) in Delhi. Delhi Pollution Control Committee, New Delhi.

3 DOHI, 2018. Source Apportionment of $PM_{2.5}$ & PM_{10} of Delhi NCR for Identification of Major Sources. Department of Heavy Industry Ministry of Heavy Industries and Public Enterprises, New Delhi.

18%) in Delhi and NCR regions than in summers (15%–16%). Biomass burning contribution was slightly higher in winters in Delhi (14%) than in summers (12%), whereas in the NCR regions the contribution was similar in both the seasons (15%–16%). Contribution from industrial sources was similar in both the summer and winter seasons in Delhi (10%–12%) and NCR regions (14%–15%). Contribution in the NCR regions was higher as compared to Delhi due to the close proximity of industries. Other sources, which include DG sets showed similar contribution of about 4%–5%. Contribution of secondary ions to PM_{10} is significantly higher in winters (23%–25%) than in summers (11%–15%) in both Delhi and the NCR regions.

Seasonal variation of $PM_{2.5}$ shows significantly higher contribution of dusty sources in summers (31%–34%), as compared to winters (15%) in Delhi as well as

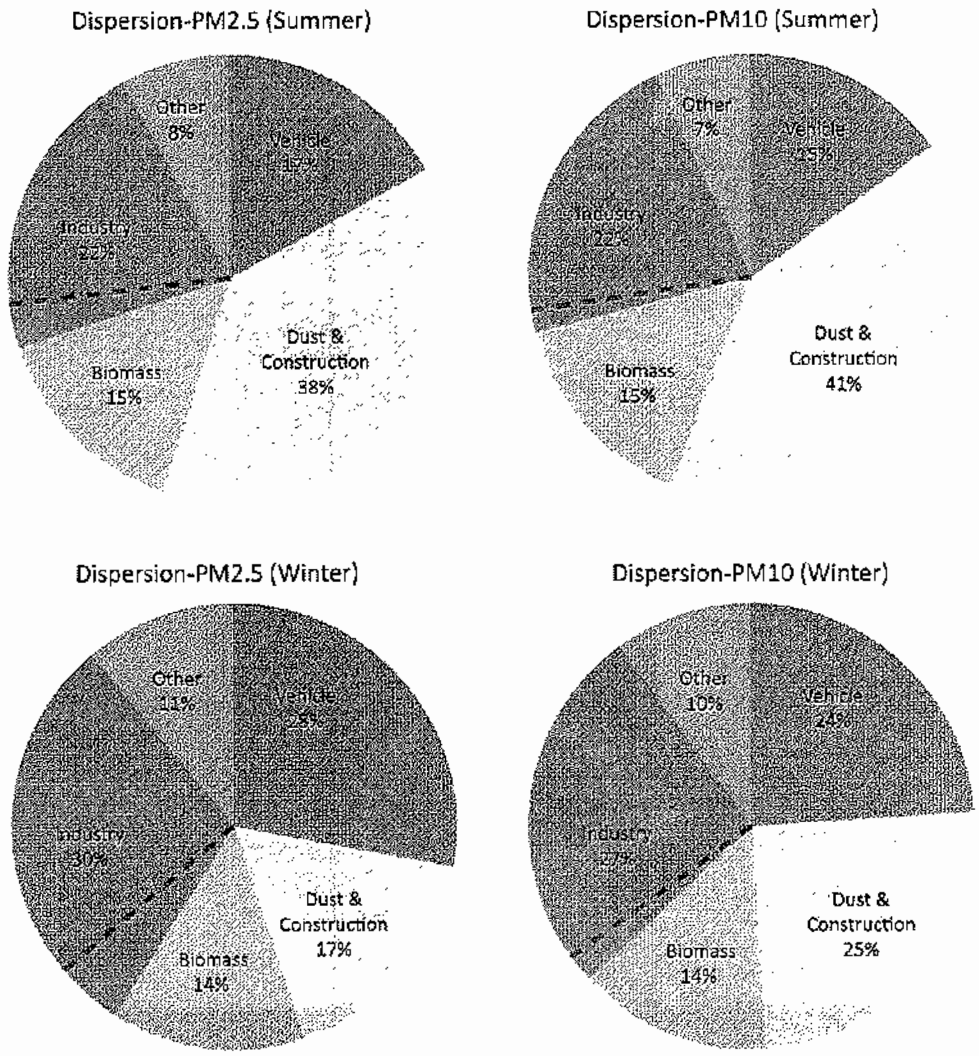


FIGURE 1. SOURCE CONTRIBUTIONS IN $PM_{2.5}$ AND PM_{10} CONCENTRATIONS IN DELHI (TERI-ARAI SOURCE APPORTIONMENT STUDY)

* Dotted line represents the contribution of biomass burning in industrial sector

the NCR regions. Higher contribution of the dusty sources, even in $PM_{2.5}$, can be attributed to dry weather conditions and higher wind velocities in summers, thus resulting in contribution from far-off sources. Primary contribution of vehicles to $PM_{2.5}$ was higher in winters (20%–23%) in Delhi and the NCR regions than in summers (18%–20%). Biomass burning contribution was significantly higher in winters in Delhi and the NCR regions (22%) than in summers (15%). Contribution from industrial sources was similar in both the summer and winter seasons in Delhi (10%–11%) and NCR regions (13%). Contribution in the NCR regions was higher as compared to Delhi due to the presence of industries in the proximity. Other sources, which include DG sets showed contribution of less than 5%. Contribution of secondary ions to $PM_{2.5}$ was higher in winters (26%) than in summer (17%–18%) in both Delhi and the NCR regions.

The study concluded that significantly higher contribution of dust in PM_{10} and also in $PM_{2.5}$ particularly in the summer season may be attributed to the transboundary contribution. Variation in the contribution of sources, such as vehicles (15%–23%), biomass burning (12%–22%), and dust (15%–42%) may be attributed to the variation in activities at local the level and meteorology. Contribution from sources outside Delhi, such as residential cooking, agricultural waste burning, industries (tall stacks), and dust particles are likely due to winds carrying pollution with the incoming air towards Delhi and the NCR regions indicating the regional aspect of air pollution. Current knowledge on the urban sources provide a basis to initiate action in the different sectors, though city-specific source apportionment studies is needed to refine air quality management plans for the city.

Accordingly, the air quality management framework should include strategies at different levels i.e. local, city, state, regional and trans-boundary level, for effective control of pollution.

4 ONGOING GOVERNMENT INITIATIVES

4.1 NATIONAL AIR QUALITY MONITORING PROGRAMME

The government is executing a nation-wide programme of ambient air quality monitoring known as NAMP. The network consists of 703 manual operating stations covering 307 cities/towns in 29 states and 6 Union Territories of the country. Under NAMP, four air pollutants viz. SO_2, NO_2, suspended particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$) have been identified for regular monitoring at all the locations. In addition, there are 134 real-time Continuous Ambient Air Quality Monitoring stations (CAAQMS) in 71 cities across 17 states, monitoring 08 pollutants viz. PM_{10}, $PM_{2.5}$, SO_2, NO_x, ammonia (NH_3), CO, ozone (O_3), and benzene. PM_{10} are inhalable coarse particles, which are particles with a diameter between 2.5 and 10 micrometers (μm) and $PM_{2.5}$ are fine particles with a diameter of 2.5 μm or less. Particulates are the deadliest form of air pollutants due to their ability to penetrate deep into the lungs and blood streams unfiltered. The smaller $PM_{2.5}$ are particularly deadly as it can penetrate deep into the lungs.

The objectives of NAMP are: (i) to determine the status and trends of ambient air quality; (ii) to ascertain whether the prescribed ambient air quality standards are violated; (iii) to identify non-attainment cities; (iv) to obtain the knowledge and understanding necessary for developing preventive and corrective measures; and (v) to understand the natural cleansing process undergoing in the environment through pollution dilution, dispersion, wind-based movement, dry deposition, precipitation, and chemical transformation of the pollutants generated.

The monitoring of meteorological parameters, such as wind speed and wind direction, relative humidity (RH), and temperature were also integrated with the monitoring of the air quality. The monitoring of pollutants is carried out for 24 hours (a 4-hourly sampling for gaseous pollutants and an 8-hourly sampling for particulate matter) twice a week, to have 104 observations in a year. The monitoring is being carried out with the help of the Central Pollution Control Board (CPCB), State Pollution Control Boards (SPCB), Pollution Control Committees (PCC), National Environmental Engineering Research Institute (NEERI). The CPCB co-ordinates with these agencies to ensure uniformity and consistency of air quality data and provides technical and financial support for operating the monitoring stations. NAMP is being operated through various monitoring agencies. A large number of personnel and equipments are involved in the sampling, chemical analysis, data reporting, etc. It increases the probability of variation and personnel biases reflecting in the data, hence it is pertinent to mention that these data be treated as indicative rather than absolute. A state and city-wise distribution of the operating stations under NAMP along with their location has been given in Appendix I.

4.2 NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

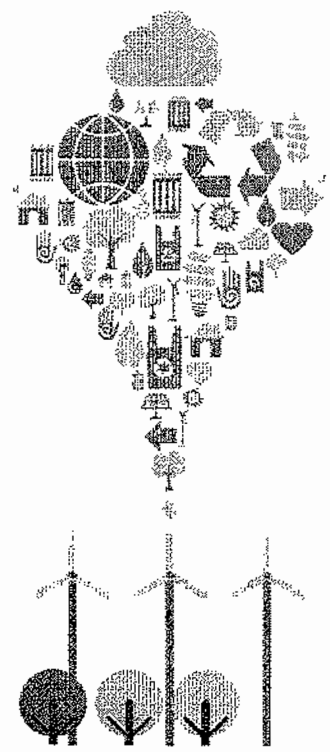
Ambient air quality refers to the condition or quality of the outdoor air. NAAQs are the standards for ambient air quality with reference to various identified pollutant notified by the CPCB under the Air (Prevention and Control of Pollution) Act, 1981. Major objectives of NAAQS are: (i) to indicate necessary air quality levels and appropriate margins required to ensure the protection of vegetation, health, and property, (ii) to provide a uniform yardstick for the assessment of air quality at the national level and (iii) to indicate the extent and need of the monitoring programme. Annual standards are basically the annual arithmetic mean of a minimum 104 measurements in a year, at a particular site taken twice a week, at a uniform 24-hourly interval and at either a 24 hourly, 8 hourly, or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. However, there is a 2% chance of exceeding the limits but not on two consecutive days of monitoring. The NAAQS notified as on November 2009 has been given in Table 2.

TABLE 2: NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)

Sr. No	Pollutants	Time Weighted Average	Concentration in Ambient Air	
			Industrial, Residential, Rural, and Other Areas	Ecologically Sensitive Area
1	Sulphur dioxide (SO_2), µg/m³	Annual*	50	20
		24 hours**	80	80
2	Nitrogen dioxide (NO_2), µg/m³	Annual*	40	30
		24 hours**	80	80
3	Particulate matter (Size <10 µm) or PM_{10} µg/m³	Annual*	60	60
		24 hours**	100	100
4	Particulate matter (Size<2.5 µm) or $PM_{2.5}$ µg/m³	Annual*	40	40
		24 hours**	60	60
5	Ozone (O_3), µg/m³	8 hours**	100	100
		1 hours **	180	180
6	Lead (Pb), µg/m³	Annual*	0.50	0.50
		24 hours**	1.0	1.0
7	Carbon monoxide (CO), mg/m³	8 hours**	02	02
		1 hours **	04	04
8	Ammonia (NH_3), µg/m³	Annual*	100	100
		24 hours**	400	400
9	Benzene (C6 H6) , µg/m³	Annual*	05	05
10	Benzo(a) pyrene (BaP)-particulate phase only, ng/m³	Annual*	01	01
11	Arsenic (As), ng/m³	Annual*	06	06
12	Nickel (Ni), ng/m³	Annual*	20	20

* Annual arithematic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals

** 24 hourly or 08 hourly or 01 hourly monitored values,as applicable shall be complied with 98% of the time in a year. 2 % of the time may exceed the limits but not on two consecutive days of monitoring.



Additionally, the MoEF&CC has notified environmental standards for 84 sectors, out of which, the effluent standards have been notified for 45 industrial sectors and the emission standards have been notified for 63 industrial sectors. Beside, ambient air quality standards and general standards for emission and effluent have also been developed. The installation of an online continuous (24x7) monitoring system has been made mandatory in 17 categories of highly polluting industries.

4.3 NATIONAL AIR QUALITY INDEX (AQI)

The AQI was launched by the Prime Minister in April, 2015 starting with 14 cities and now extended to 71 cities in 17 states. The AQI is a tool for the effective communication of air quality status to people in terms, which are easy to understand. It transforms complex air quality data of various pollutants into a single number (index value), nomenclature and colour. There are six AQI categories, namely, good, satisfactory, moderately polluted, poor, very poor, and severe. Each of these categories is decided based on the ambient concentration values of air pollutants and their likely health impacts (known as health breakpoints). The AQ sub-index and health breakpoints are evolved for eight pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Lead (Pb)) for which short-term (upto 24-hours) National Ambient Air Quality Standards are prescribed. Based on the measured ambient concentrations of a pollutant, a sub-index is calculated, which is a linear function of concentration (e.g., the sub-index for $PM_{2.5}$ will be 51 at concentration 31 µg/m^3, 100 at concentration 60 µg/m^3, and 75 at concentration of 45 µg/m^3). The worst sub-index determines the overall AQI. The AQI categories and health breakpoints for the eight pollutants are given in Table 3.

TABLE 3: AQI CATEGORIES AND HEALTH BREAKPOINTS

AQI	Associated Health Impacts
Good (0-50)	Minimal Impact
Satisfactory (51-100)	May cause minor breathing discomfort to sensitive people
Moderate (101-200)	May cause breathing discomfort to the people with lung disease such as asthma and discomfort to people with heart disease, children and older adults
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease with short exposure
Very Poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
Severe (401-500)	May cause respiratory effects even on healthy people and serious health impacts on people with lung/heart diseases. The health impacts may be experienced even during light physical activity

4.4 FORTY-TWO ACTION POINTS

The CPCB has issued a comprehensive set of directions under Section 18 (1) (b) of Air (Prevention and Control of Pollution) Act, 1986, for the implementation of 42 measures to mitigate air pollution in the major cities, including Delhi and NCR comprising action points to counter air pollution, which include control and mitigation measures related to vehicular emissions, re-suspension of road dust and other fugitive emissions, bio-mass/municipal solid waste (MSW) burning, industrial pollution, construction and demolition (C&D) activities, and other general steps. Directions containing 42 action points, which was issued initially for implementation in NCR was subsequently extended to state boards for the implementation in other non-attainment cities. The copy of the direction is given in Appendix II.

In addition, few regular, specific directions are being issued to various authorities in all 22 districts in the NCR, that is, to the municipal commissioners for road dust and garbage burning; to the Superintendent of Police for the effective movement of traffic at busy intersections; to the Director (Agriculture) in the NCR regions and Punjab for stubble burning.

4.5 ENVIRONMENT POLLUTION (PREVENTION AND CONTROL) AUTHORITY (EPCA)

Environment Pollution (Prevention and Control) Authority (EPCA) was constituted under Section 3(3) of Environment (Protection) Act, 1986, in 1998 in pursuance of the Hon'ble Supreme Court Order dated 7.1.1998 in Writ Petition (C) no. 13029/1985 in the matter of M.C. Mehta vs UoI & Ors to look into the matter pertaining to environmental pollution in the NCR region. As per the order, the authority was proposed to be comprised of Shri Bhure Lal, Secretary, CVC as Chairman; and Shri D K Biswas, Shri Anil Aggarwal, Shri Jagdish Khattar, and Smt Kiran Dhingra as members. Accordingly, this ministry notified the constitution of the EPCA vide notification no. SO 93(E) dated 29.2.1998 for two years comprising the above-stated members and TOR. In the notification, jurisdiction of the EPCA has been stated as the NCR region as defined in clause (f) of section 2 of National Capital Region Planning Board Act, 1985 (2 of 1985). The EPCA has been subsequently re-constituted from time to time, extending the tenure of the authority and/or substituting or including new members.

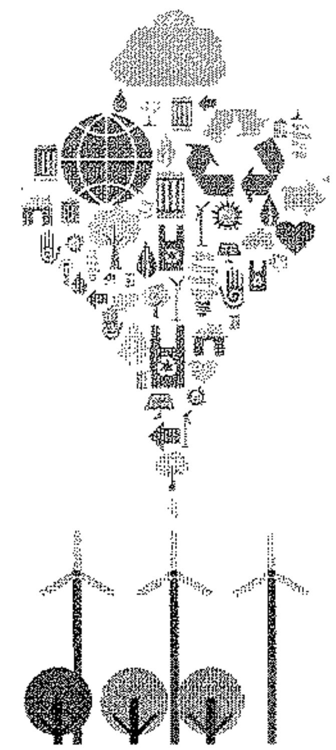
4.6 GRADED RESPONSE ACTION PLAN (GRAP)

The government has notified a graded response action plan for Delhi and the NCR region, which comprises the graded measures for each source framed according to the AQI categories. It also takes note of the broad health advisory for each level of the AQI that was adopted by the Government of India along with the AQI. The proposal has been framed keeping in view the key pollution sources in Delhi and the NCR region. While the major sources of pollution, including vehicles, road dust, biomass burning, construction, power plants, and industries remain continuous throughout all seasons, the episodic pollution from stubble burning, increase in biomass burning, etc., varies across seasons.

During winters, the relative share of vehicles, biomass burning, MSW burning, firecracker, stubble burning, construction, and secondary particles increase. During summers, the influence of road dust, fly ash, vehicles, biomass burning, etc., is high. The proposed graded measure approach has considered all these aspects and includes appropriate measures for each level of pollution according to the AQI. The graded measures according to the AQI are listed, starting from the public health emergency level and then progressing downwards. The measures are cumulative. The emergency and severe levels include cumulatively all other measures listed in the lower levels of the AQI, including very poor, poor, and moderate. It is also clear that the actions listed in the poor category need to be implemented throughout the year. However, during months when the weather conditions turn adverse, there is a need for greater scrutiny on enforcements. The responsibility of implementing GRAP lies with the EPCA. GRAP has been given as Appendix III.

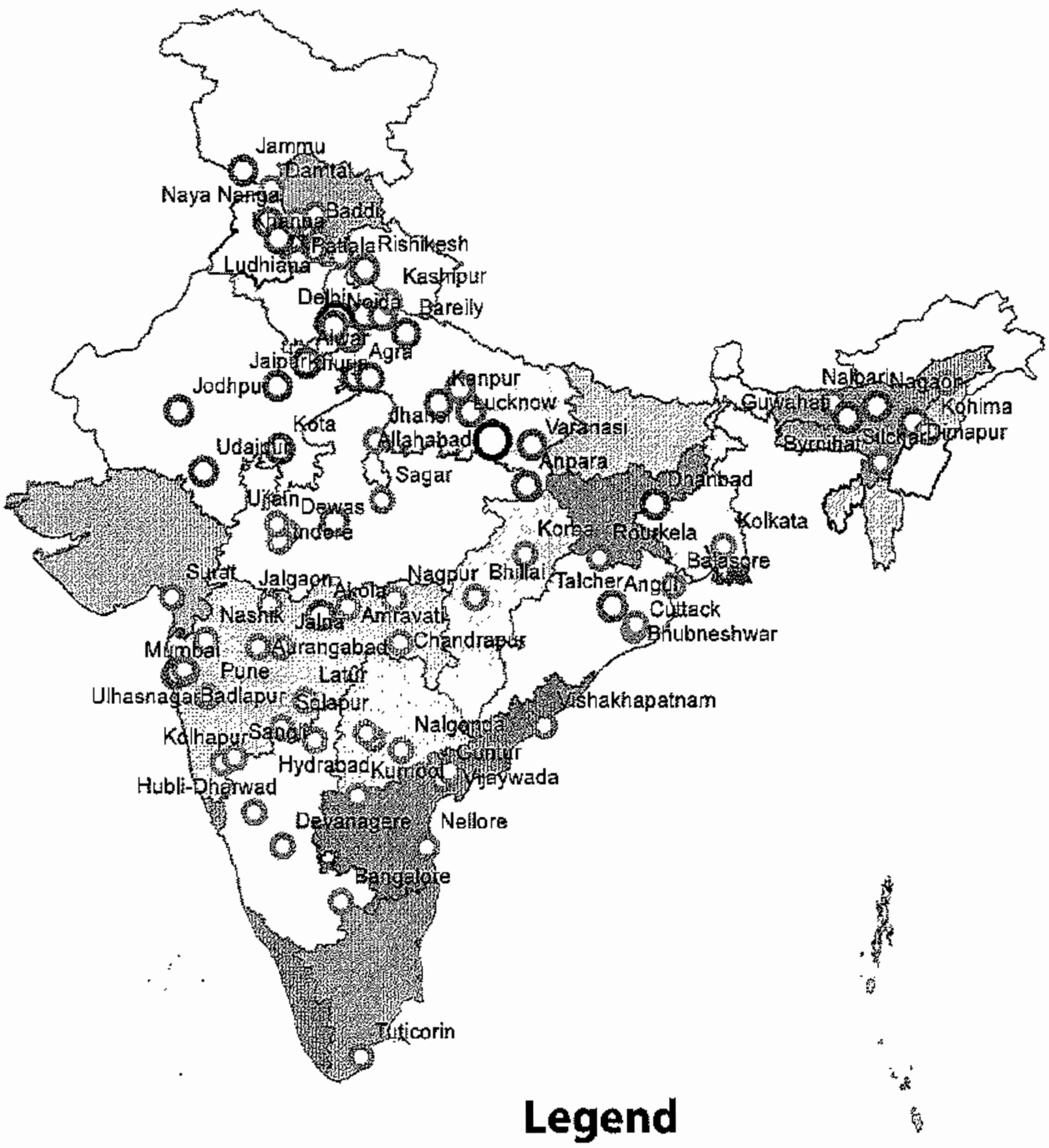
4.7 OTHER MEASURES

Focussing on pollution from waste, five waste management rules on solid waste, hazardous waste, plastic waste, biomedical waste, and e-waste have been revised and the rules pertaining to construction and demolition waste as a major source of dust pollution was newly notified during 2016. Further, a ban was imposed on the burning of leaves, biomass, and MSW. There are other measures which were taken by the government for improvements in energy efficiency and air pollution control in India. Some of which are cited below:



1. Advanced vehicle emission and fuel quality standards– BSIV from 2017 and BS-VI from 2020.
2. Plan to introduce a voluntary fleet modernization and an old-vehicle scrappage programme in India.
3. Introducing a National Electric Mobility Mission Plan 2020.
4. Introducing gas as an automotive fuel in many cities.
5. Introduction and enhancement of the metro-rail and bus-based public transport systems in selected cities.
6. Ujjawala scheme to accelerate the LPG penetration programme for cooking in households.
7. Electrification to reduce kerosene consumption for lighting.
8. Introducing an energy-efficiency labelling programme for energy-intensive home appliances such as air conditioners.
9. Notifying new stringent standards for diesel generator sets for standby power generation.

NON-ATTAINMENT CITIES



Legend

Non-attainment cities

PM_{10} ($\mu g/m^3$)

- 61 - 120
- 121 - 180
- 181 - 240
- 241 - 260

5 NON-ATTAINMENT CITIES

The CPCB has identified a list of polluted cities in which the prescribed NAAQS are violated. These cities have been identified based on the ambient air quality data obtained (2011–2015) under NAMP. PM_{10} has been found to be exceeding in 94 cities consecutively for five years and NO_2 is exceeding the limits in five cities. $PM_{2.5}$ data since 2015 indicates 16 cities as non-attainment cities. In addition, recently in April 2018, the WHO has updated the fourth Ambient Air Quality Database on its website on the basis of $PM_{2.5}$ data. The aim of its database was to reflect the monitoring efforts undertaken in countries reflected in the list. This was further to raise awareness and facilitate adequate response to protect public health from the adverse impacts of outdoor air pollution. Integrating the top 10 cities from the WHO list, there are 102 non-attainment cities. The list of the 102 non-attainment cities has been given in Table 4.

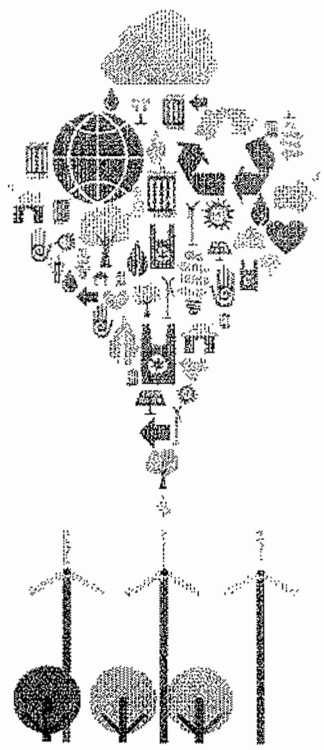
TABLE 4: NON-ATTAINMENT CITIES WITH RESPECT TO AMBIENT AIR QUALITY INDIA (2011–2015) AND THE WHO REPORT 2014–2018

Sl. No	State	Cities Sl. No	Cities
1	Andhra Pradesh	1.	Guntur
		2.	Kurnool
		3.	Nellore
		4.	Vijaywada
		5.	Vishakhapatnam
2	Assam	6.	Guwahati
		7.	Nagaon
		8.	Nalbari
		9.	Sibsagar
		10.	Silchar
3	Chandigarh	11.	Chandigarh
4	Chattisgarh	12.	Bhillai
		13.	Korba
		14.	Raipur
5	Delhi	15.	Delhi
6	Gujarat	16.	Surat
		17.	Ahmedabad

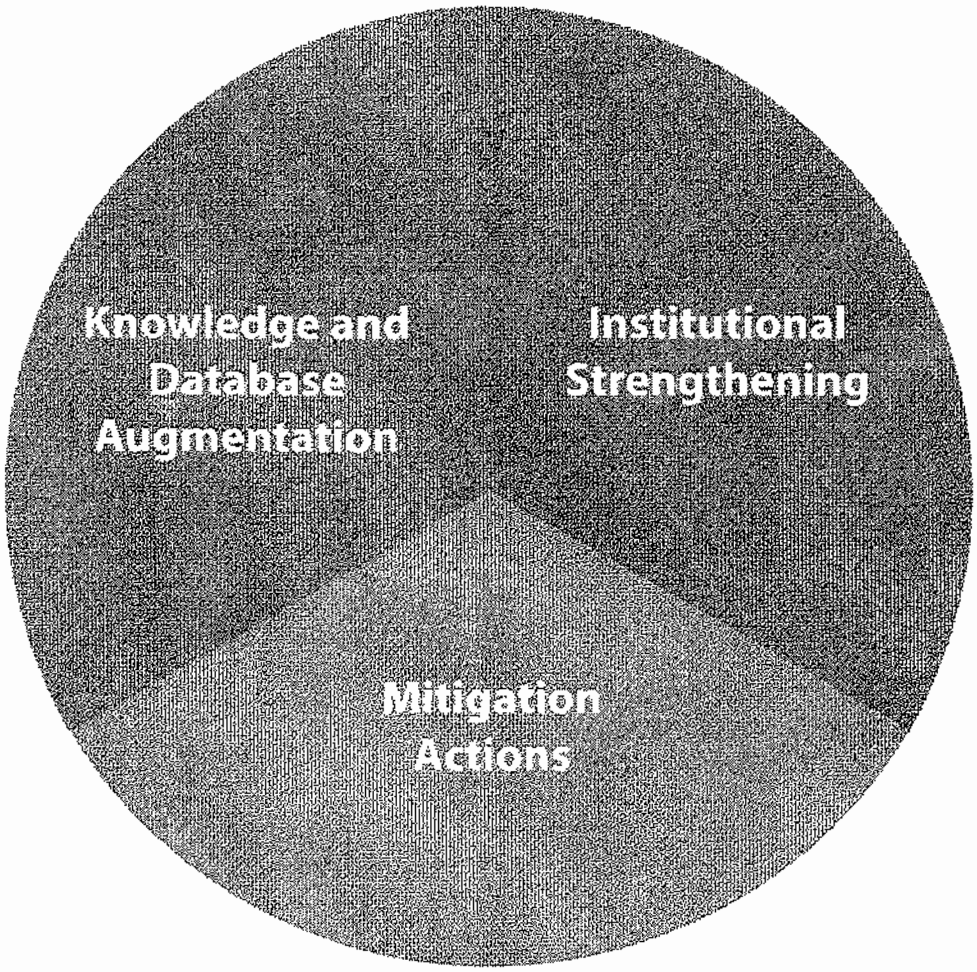
Sl. No	State	Cities Sl. No.	Cities
7	Himachal Pradesh	18.	Baddi
		19.	Damtal
		20.	Kala Amb
		21.	Nalagarh
		22.	Paonta Sahib
		23.	Parwanoo
		24.	Sunder Nagar
8	Jammu & Kashmir	25.	Jammu
		26.	Srinagar
9	Jharkhand	27.	Dhanbad
10	Karnataka	28.	Bangalore
		29.	Devanagere
		30.	Gulburga
		31.	Hubli-Dharwad
11	Madhya Pradesh	32.	Bhopal
		33.	Dewas
		34.	Indore
		35.	Sagar
		36.	Ujjain
		37.	Gwalior
12	Maharashtra	38.	Akola
		39.	Amravati
		40.	Aurangabad
		41.	Badlapur
		42.	Chandrapur
		43.	Jalgaon
		44.	Jalna
		45.	Kolhapur
		46.	Latur
		47.	Mumbai
		48.	Nagpur
		49.	Nashik
		50.	Navi Mumbai
		51.	Pune
		52.	Sangli
		53.	Solapur
		54.	Ulhasnagar

Sl. No	State	Cities Sl. No.	Cities
13	Meghalaya	55.	Byrnihat
14	Nagaland	56.	Dimapur
		57.	Kohima
15	Odisha	58.	Angul
		59.	Balasore
		60.	Bhubneshwar
		61.	Cuttack
		62.	Rourkela
		63.	Talcher
16	Punjab	64.	Dera Bassi
		65.	Gobindgarh
		66.	Jalandhar
		67.	Khanna
		68.	Ludhiana
		69.	Naya Nangal
		70.	Pathankot/Dera Baba
		71.	Patiala
		72.	Amritsar
17	Rajasthan	73.	Alwar
		74.	Jaipur
		75.	Jodhpur
		76.	Kota
		77.	Udaipur
18	Tamil Nadu	78.	Tuticorin
19	Telangana	79.	Hydrabad
		80.	Nalgonda
		81.	Patencheru

Sl. No	State	Cities Sl. No.	Cities
20	Uttar Pradesh	82.	Agra
		83.	Allahabad
		84.	Anpara
		85.	Bareily
		86.	Firozabad
		87.	Gajraula
		88.	Ghaziabad
		89.	Jhansi
		90.	Kanpur
		91.	Khurja
		92.	Lucknow
		93.	Muradabad
		94.	Noida
		95.	Raebareli
		96.	Varanasi
21	Uttarakhand	97.	Kashipur
		98.	Rishikesh
22	West Bengal	99.	Kolkata
23	Bihar	100.	Patna
		101.	Gaya
		102.	Muzaffarpur



NATIONAL CLEAN AIR ACTION PLAN



6 NATIONAL CLEAN AIR ACTION PLAN

With these recent policy interventions, the air quality has purportedly shown some minor improvement in some major cities in recent times, which, as of now, cannot be called a trend. This is not sufficient and a higher level of focused, time-bound initiatives, at both the city and rural level, appear obligatory to address the issue in a comprehensive manner at the national level. It is in this context that the need for a National Clean Air Programme (NCAP) as a national-level strategy for reducing the levels of air pollution at both the regional and urban scales is felt. Overview of NCAP is shown in Figure 2.

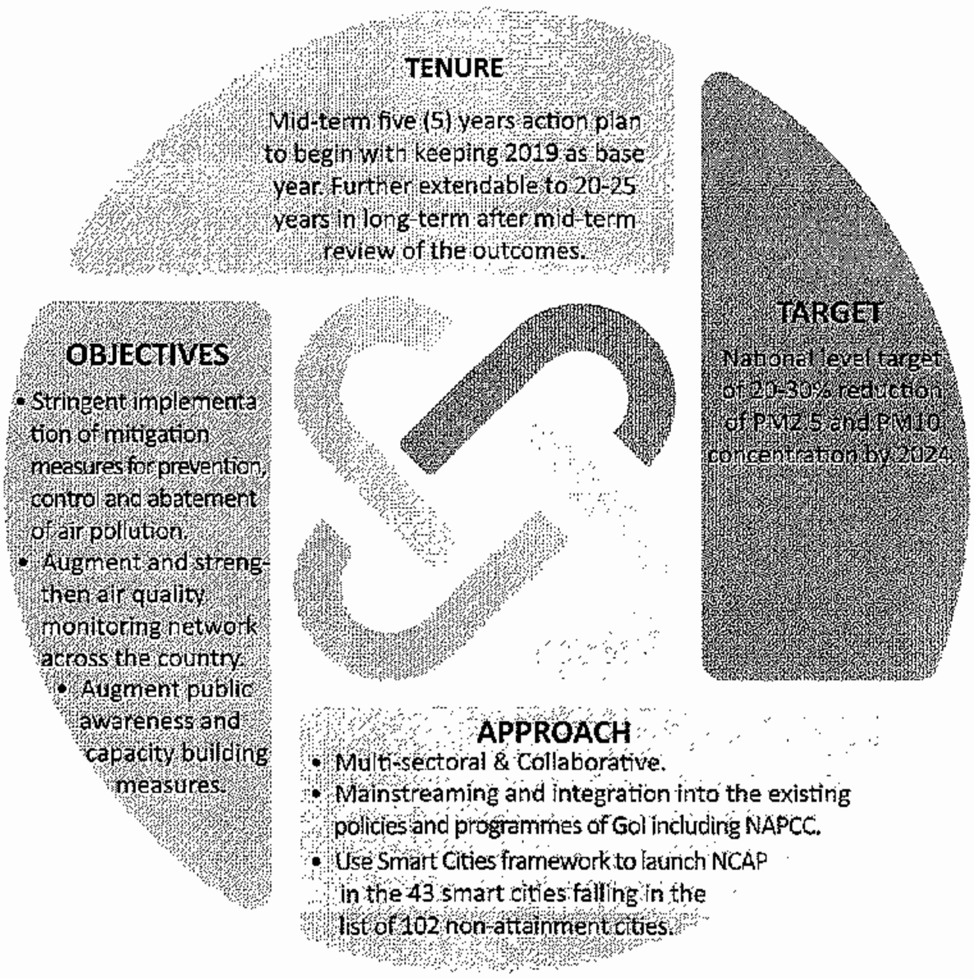


FIGURE 2. OVERVIEW OF NATIONAL CLEAN AIR PROGRAM

6.1 GOAL

The goal of the NCAP is to meet the prescribed annual average ambient air quality standards at all locations in the country in a stipulated timeframe (long-term).

6.2 TARGET

The global experiences clearly highlight the fact that internationally, the actions had been city specific rather than country oriented and, accordingly, the statistics indicates 35%–40% $PM_{2.5}$ reduction in five years for cities, such as Beijing and Seoul, whereas cities, such as Santiago and Mexico City have shown 73% and 61% reduction in 22 to 25 years with regard to $PM_{2.5}$ and PM_{10} concentrations, respectively (this has been given in Appendix IV).

Recently, a new Lancet study by Peking University School of Public Health on the impact of China's 'Air Pollution Prevention and Control Action Plan'(2013–2017) has found that an annual average concentration of $PM_{2.5}$ decreased by 33.3% and PM_{10} levels reduced by 27.8% in the 74 key cities in China where the plan was implemented in the last five years. Sulphur dioxide reduced by 54.1% and CO by 28.2% in five years, but no significant improvements were seen in NO_2 or O_3 concentrations.

TERI and ARAI report dated August, 2018, analysed various interventions and estimated their possible impacts over $PM_{2.5}$ and PM_{10} concentrations in Delhi and NCR. An alternative scenario has been developed considering the interventions which can provide maximum air quality benefits. The alternative scenario results in a reduction of 58% and 61% in $PM_{2.5}$ and PM_{10} concentrations in 2030, in Delhi and NCR with respect to the business-as-usual scenario, and achieves the daily ambient air quality standards for PM_{10} and $PM_{2.5}$. It is to be noted that in Delhi and NCR, the initiatives started in 1992 with the creation of the EPCA, and thus has a definite edge over other non-attainment cities.

Taking into account the available international experiences and national studies, the tentative national level target of 20%–30% reduction of $PM_{2.5}$ and PM_{10} concentration by 2024 is proposed under the NCAP. This is keeping 2017 as the base year for the comparison of concentration.

6.3 OBJECTIVES

1. To ensure stringent implementation of mitigation measures for prevention, control and abatement of air pollution.
2. To augment and evolve effective and proficient ambient air quality monitoring network across the country for ensuring a comprehensive and reliable database.
3. To augment public awareness and capacity-building measures encompassing data dissemination and public outreach programmes for inclusive public participation and for ensuring trained manpower and infrastructure on air pollution.

6.4 TENURE

This will be a mid-term, five-year action plan to begin with keeping 2019 as the base year. However, the international experiences and national studies indicate that significant outcome in terms of air pollution initiatives are visible only in the long-term, and hence the programme may be further extended to 20–25 years in the long-term after a mid-term review of the outcomes.

6.5 APPROACH

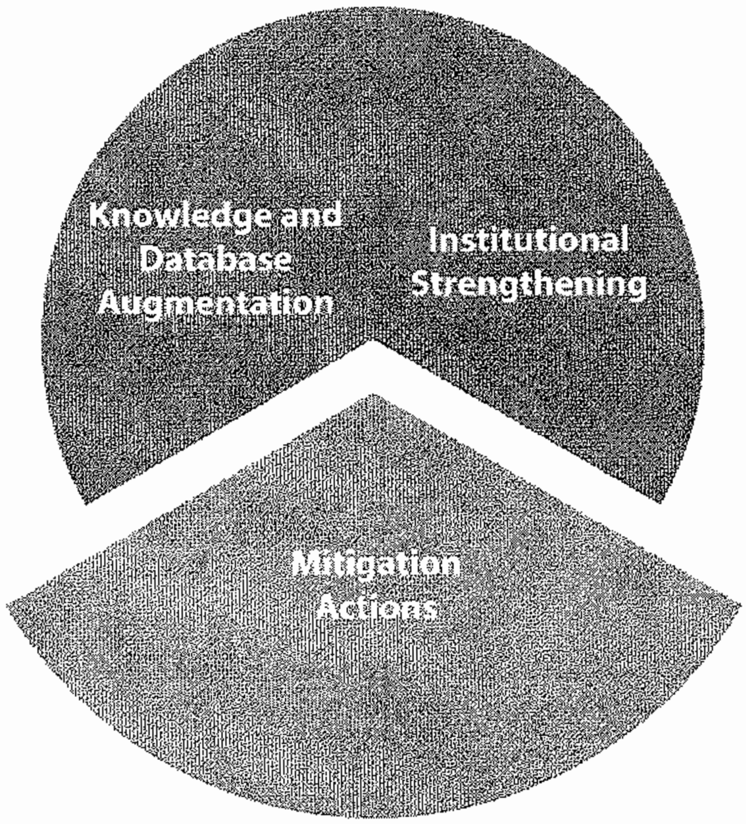
1. Collaborative, multi-scale and cross-sectoral coordination between the relevant central ministries, state governments and local bodies.
2. Mainstreaming and integrating the existing policies and programmes of the including the National Action Plan on Climate Change (NAPCC) and other initiatives of Government of India in reference to climate changes.
3. With reference to NAPCC the main focus will be on mainstreaming the initiatives under five national missions of NAPCC viz. National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Mission for a Green India and National Mission for Sustainable Agriculture.
4. While many of these policies and programmes are already part of our current actions, they may need a change in direction, enhancement of scope, and effectiveness and an accelerated implementation of time-bound plans.
5. Use the smart cities framework to launch the NCAP in the 43 smart cities falling in the list of the 102 non-attainment cities.
6. The NCAP will be dynamic and will continue to evolve based on the additional available scientific and technical information as they emerge and in response to international best practices and experiences that are available.

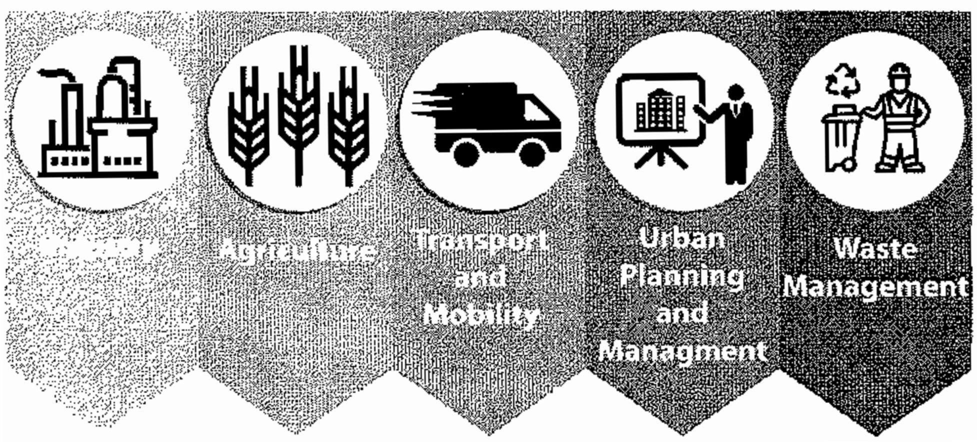
6.6 IMPLEMENTATION OF NCAP

1. The CPCB shall, in consonance with the Air (Prevention and control of Pollution) Act, 1981, and in particular with the provision of Section 16(2)(b) of the Act, execute the nation-wide programme for the prevention, control, and abetment of air pollution within the framework of the NCAP.
2. The NCAP will be institutionalized by respective ministries and will be organized through inter-sectoral groups, which include, in addition to the related ministries, the Ministry of Finance, Ministry of Health, NITI Aayog, CPCB, experts from the industry, academia, and civil society.
3. The Ministry of Road Transport and Highways (MoRTH) acts as a nodal agency for the implementation of various provisions on control of air pollution from vehicles through Motor Vehicle Act, 1988, and Central Motor Vehicle Rules 1989.
4. In addition, various other ministries viz. MoEF&CC, M/o Power, M/o Petroleum Petroleum and Natural Gas, M/o New and Renewable Energy, M/o Heavy Industry, M/o Housing and Urban Affairs, M/o Agriculture through incorporating pollution in their sectoral policies contribute to air pollution mitigation.

5. Ministry of Environment, Forest and Climate Change (MoEF&CC) is implementing NAPCC with eight missions spreading across various sectors. Five of the missions viz. National Mission for a Green India, National Mission for Enhanced Energy Efficiency, National Solar Mission, National Mission on Sustainable Habitat, National Mission for Sustainable Agriculture have direct link with mitigation of air pollution, which can be one of the co-benefit of these ongoing missions.
6. Each sector specific Working Group will be tasked to evolve specific objectives spanning the remaining years of this Plan Period and subsequently.
7. Comprehensive component-wise documents detailing objectives, strategies, plan of action, timelines and monitoring, and evaluation criteria would be developed.
8. The Apex Committee in the Ministry will periodically review the progress of these Components. Annual performance will be periodically reported upon. Appropriate indicators will be evolved for assessing the emission reduction benefits of the actions.

MITIGATION ACTIONS





7 MITIGATION ACTIONS

7.1. STRINGENT ENFORCEMENT THROUGH THREE TIER MECHANISM FOR REVIEW OF MONITORING, ASSESSMENT AND INSPECTION

The experience indicates lack of regular monitoring and inspection as the major reason for non-compliance. Trained manpower and regular inspection drive will be ensured for stringent implementation purpose. A credible, transparent, and accountable data collection, and monitoring system that is available for timely swift action is required. A three-tier system that include real-time physical data collection, data archiving and data analytics infrastructure, and action trigger system to be created. This three-tier system will work independently under the supervision of a single authority, which will ensure accreditation of three independently operating entities. These entities will interface only through IT software and communication system.

For data collection, a phone application that could be adapted to any smart phone will be developed. The application allows a user to quickly and easily generate simple reports about individual industry that include: the current position (provided by the phones built-in GPS), type of industry, and parameters such as monitored data on site, and a picture of the industry (taken with the phone's camera). This facility at each state will be operated by a third party verifiers in close coordination with SPCBs. The data collected will be archived at a central location and will be used by high-quality IT companies specialized in data analytics to corroborate the data, establish its authenticity (with industry standards, previously collected information, data from other utilities like electricity bill and water bill), and feed into the system with GPS information. The action trigger system, will decide on appropriate action once the data authenticity is established. The action trigger system will have predefined action based on the status of the data. There will be minimal human interface in action trigger system.

Action Points

1. Web-based system on the above-mentioned lines to be evolved in association with the NIC and other relevant national and international agencies.
2. Adequate manpower will be made available for strengthening, monitoring, and inspection.
3. Intensive training of all the stakeholders involved in implementation of this web based system.
4. Mandating use of this three tier mechanism in 102 cities.

7.2 EXTENSIVE PLANTATION DRIVE

Trees mitigate air pollution primarily by absorbing pollutants via leaf stomata (pores on the outer "skin" layers of the leaf). Some gaseous pollutants are also removed via the plant surface. As has been reported, one of the efficient and effective options for preventing air pollution hazards and as well as for enhancing the environmental quality, including enrichment of human microbiome that reduces health risks and public health burden is the development of native vegetation filter strips and biodiversity Parks. The Vegetation filter strips along roads and highways and at intersecting road junctions clean the air originating from the point source pollution, while biodiversity parks serve as filters for nonpoint source air pollution. As research shows the efficacy of the vegetation filter strips depends upon the stratification of the plant community, type of species, architecture of the canopy, leaf size and morphology and surface area. A vegetation filter strips of a 100-m long stretch and 5–12 m wide with three-storied community with a 8–12 m high canopy is effective in dust trapping and also in assimilating air pollutants, including polycyclic Aromatic Hydrocarbons (PAHs), prevent flooding of roads and recharging groundwater. Such filter strips also make cities climate resilient.

Thus extensive planation drive in urban areas more specific in reference to pollution hotspots as traffic junctions, industrial zones, footpaths, dust prone areas, etc., by identification and use of specialized plant species having high pollutants absorbing capacity is expected not only to purify air but also will help in improvement of health.

The National Mission for Green India (GIM) is one of the eight missions outlined under the National Action Plan on Climate Change (NAPCC). It aims at protecting; restoring and enhancing India's diminishing forest cover and responding to climate change by a combination of adaptation and mitigation measures. This mission has adopted an integrated cross-sectoral approach as it will be implemented on both public as well as private lands with a key role of the local communities in planning, decision making, implementation and monitoring. An initial corpus of over Rs 6,000 crore has been earmarked for the programme through the Compensatory Afforestation Management and Planning Authority (CAMPA) to commence work. The programme may be scaled up to cover pollution hot spots in the cities/towns along with degraded forest land. The institutional arrangement provides for using the corpus to leverage more funds to scale up activity.

Action Points

1. Plantation initiatives under NCAP at pollution hot spots in the cities/towns to be undertaken under GIMs with Compensatory Afforestation Fund (CAF) being managed by National Compensatory Afforestation Management and Planning Authority (CAMPA).
2. Development of plantation plans for the non-attainment cities/towns.
3. Execution of city-specific plantation plans.
4. Institutes as Indian Institute of Forest Management (IIFM), Universities

as Delhi University and other Research Organizations and institutions with expertise in plantation to be involved for evolving these plans and for implementation of these plans in these 102 cities.

5. Planation target to be indicated in city-specific plantation plans.
6. Scheme on agroforestry to be prioritized and strengthened.

7.3 TECHNOLOGY SUPPORT

Science, technology, engineering, and innovation have played a game changing role in India's journey towards sustainable development. It has been integral not just in contributing to the economic boom that the country is seeing today but also has been crucial for social development and environmental protection. The government with a steadfast approach has been aiming to establish India as one of the global leaders in science and technology. New technologies, particularly the ones that are indigenously developed hold tremendous potential in resolving air pollution challenges and improving human lives. While developing and implementing technologies, it is of paramount importance that the technology suits the Indian scenario with respect to short- and long-term ecological and environment impacts, social infrastructure, cultural ethos, and characteristics of the Indian economy.

Action Points

1. Clean Technologies with potential for air pollution prevention and mitigation will be supported for R&D, pilot scale demonstration and field scale implementation.
2. The mechanism for such support will be formulated as an action plan.

7.4 REGIONAL AND TRANSBOUNDARY PLAN

As stated above, with reference to Delhi and NCR, it has been reported that a significantly higher contribution of dust in PM_{10} and $PM_{2.5}$ particularly in the summer season may be attributed to the transboundary contribution. Contribution from sources outside Delhi, such as residential cooking, agricultural waste burning, industries and dust particles are likely due to winds from regions outs Delhi indicating towards regional aspect of air pollution.

Accordingly, regional and transboundary plan have major role for effective control of pollution more specifically with reference to the Indo-Gangetic plain.

Action Points

Regional

1. Various measures specially implementation of pollution abatement policies as Transport- Auto fuel policy for stringent norms for fuel and vehicles, road to rail/waterways, fleet modernization, electric vehicle policies, clean fuels, bye-passes, taxation policies, etc.; Industries—stringent industrial standards, clean fuels, clean technology, enforcement (continuous monitoring); and biomass– enhanced LPG penetration, agricultural burning control and management need to emphasized through regional level inter-state coordination specifically for the Indo-Gangetic plain.

2. A comprehensive regional Plan to be formulated incorporating the inputs from the regional source apportionment studies.

Transboundary

1. Linking NDC's target of additional forest and tree cover of 2.5 to 3 billion tonnes of CO_2 equivalent by 2030 to NCAP. There needs to be more focus on the western regions of India (Rajasthan and Gujarat) for enhanced tree cover, which will reduce wind-blown dust within the country and will also act as barriers for trans-boundary dust.
2. The initiatives under United Nations Convention to Combat Desertification (UNCCD) to be integrated for addressing the issue of transboundary dust.
3. Air quality management at South-Asia regional level by activating the initiatives under 'Male Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia' and South Asia Co-operative Environment Programme (SACEP) to be explored.
4. A comprehensive Transboundary Plan to be formulated.

7.5 SECTORAL INTERVENTIONS

7.5.1 POLLUTION FROM ROAD DUST AND C&D

Road dust and dust arising from construction and demolition (C&D) are the major contributors to the pollution in Indian cities. IIT Kanpur report for Delhi, indicates dust as the major contributor of air pollution specifically in the summer season, going upto 50% for PM_{10}. The potential control options are sweeping and watering of roads, better construction and maintenance, growing plants, grass, etc., to prevent re-suspension of dust. City-specific plans need to evaluate the options of mechanical sweeping, greening, and landscaping of the major arterial roads, identification of major-impact roads, including national highways, etc. Spraying of water twice per day (before peak hours of traffic) is very effective in reducing air-borne dust load. Grassing of open spaces with native grasses also prevent dust pollution and clean air.

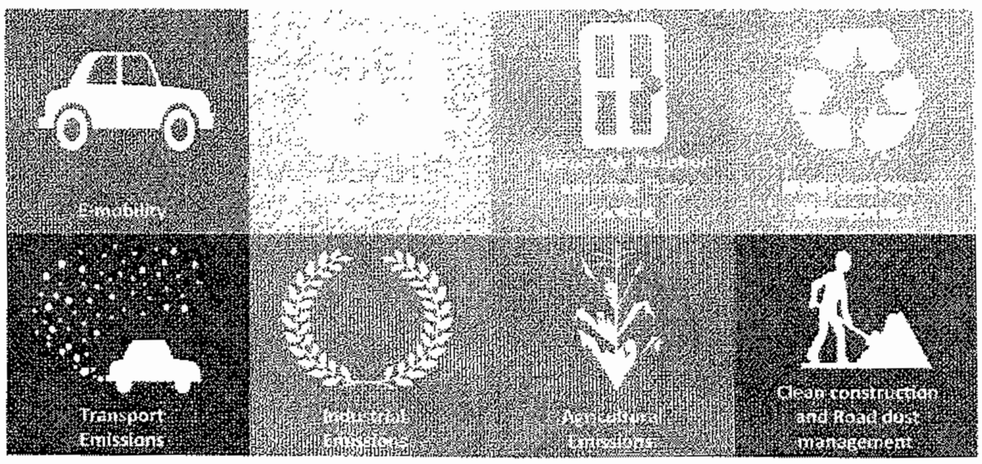


FIGURE 3. KEY SECTORAL INTERVENTIONS UNDER NCAP

The mechanical sweepers were introduced in Delhi as manual sweeping by brooms blow more dust particles in air than it cleans off the ground. Delhi has now more than a dozen mechanical sweepers, which keeps the road free of dust. At present, the dust collected is mostly taken to the landfill sites and dumped. When the wind blows, these particles return to the city rendering the entire sweeping process ineffective. Even a light wind is able to raise a dust storm if the dumped dust is not dampened with water or have a green cover over it. There is no proper mechanism or standard operating procedure (SOP) on how to dump the dust collected so that they do not return to the city after disposal.

The government has notified Construction & Demolition (C&D) Waste Management Rules, 2016, which had been an initiative towards effectively tackling the issues of pollution and waste management. The basis of these rules is to recover, recycle, and reuse the waste generated through C&D. Segregating C&D and depositing it to the collection centres for processing is now be the responsibility of every waste generator. Local bodies are to utilize 10%–20% material from C&D waste in municipal and government contracts.

It was noted that there was no regulation prescribing preventive measures to be taken for the management of dust, including road dust and C&D dust that arises during construction. Taking note of the increasing air pollution and to keep dust material under control in towns and cities, the MoEF&CC has issued a Dust Mitigation notification in January 2018 under EPA, 1986; making mandatory dust mitigation measures in infrastructural projects and demolition activities in the country. This would help to keep the dust under control to reduce air pollution in metros and cities. The notified rules inserted 11-point measures in the existing act, thereby empowering the ministry to issue notices against local authorities and state agencies for non-implementation of those actions.

Action Points

1. Introducing mechanical sweepers on the basis of feasibility study in cities.
2. Evolve SOP for addressing the specific issue of disposal of collected dust from mechanical sweeping, taking into consideration all the above cited factors.
3. Stringent implementation of C&D Rules, 2016, and Dust Mitigation notification, 2018, of Government of India.
4. Wall-to-wall paving of roads to be mandated.
5. Stringent control of dust from construction activities using enclosures, fogging machines, and barriers.
6. Greening and landscaping of all the major arterial roads and national highways after identification of major polluting stretches.
7. Maintenance and repair of roads on priority.
8. Sewage treatment plant-treated water sprinkling system along the roads and at intersecting road junctions and spraying of water twice a day before peak traffic hours.

7.5.2 POWER SECTOR EMISSIONS

MoEF&CC notified 'Environment (Protection) Amendment Rules, 2015" for Thermal Power Plants (TPPs) on 07.12.2015 regarding standards for particulate matter (PM), SO_x, NO_x, mercury emissions, and water consumption. As per the notification, all the existing stations were required to comply with the new standards within two years, that is, by December, 2017, and the new stations, including all stations presently under construction were required to meet the new norms w.e.f. 01.01.2017. Subsequently, reviewing the representation from Ministry of Power and Central Electricity Authority highlighting practical difficulties with respect to compliance of the prescribed TPP emission norms by December 2017 an earliest practical feasible plan extending up-to December 2022 was prepared for installation of FGDs and other pollution control equipment at the identified coal-based TPP units in consultation with Regional Power Committees and the utilities and notified by the Ministry in December 2017.

The TPPs shall be steadily replaced with power plants using natural gas and other cleaner fuels. As far as availability of natural gas for power plants and industries in the country is concerned, on the basis of submission of Petroleum and Natural Gas Regulatory Board (PNGRB), it is noted that there are 22 districts in the NCR region in three states, namely, Haryana, Uttar Pradesh, and Rajasthan and a whole of NCT Delhi in National Capital Region (NCR). CNG and PNG form part of the city or local distribution (CGD) networks. Out of 23 districts, the city or local gas distribution network (CGD) exists in 13 districts. With regard to states, such as UP, Haryana, Rajasthan, and Delhi; CGD covers whole Delhi. Out of the total 119 districts in the three NCR states, CGD exists only in 24 geographical areas (GAs), and baring 7 GAs, each GA comprises the entire district. The availability of network of pipelines across the country is an issue. Presently, 78 GAs have been authorized by the PNGRB for the development of a CGD network in the country and the necessary procedures have been initiated.

India has started the world's largest renewable energy expansion programme. India aims to generate 175 GW electricity from renewable sources of energy by 2022, of which, 100 GW will be from solar power. India has already achieved 20 GW installed solar power.

The National Solar Mission, is an initiative of the Government of India and the state governments to promote solar power. The mission is one of the several initiatives that are part of the National Action Plan on Climate Change (NAPCC). The programme was started in January 2010 with a target of 20GW by 2022 which was later increased to 100 GW by the 2015 Union budget of India. To meet the scaled up target of 100,000 MW, MNRE has proposed to achieve it through 60 GW of large and medium scale solar projects, and 40 GW through rooftop solar projects.

National Mission for Enhanced Energy Efficiency, one of the eight missions under NAPCC is supported by the Energy Conservation Act of 2001 which provides a legal mandate for the implementation of the energy efficiency measures through the institutional mechanism of the Bureau of Energy Efficiency (BEE) in the Central Government and designated agencies in each state. A number of schemes and programmes have been initiated and it was anticipated that these would result in a saving of 10,000 MW by the end of 11th Five Year Plan in 2012, reducing burden on TPP.

Action Points

1. Stringent compliance by all TPPs with respect to the emission norms according to the timelines upto December 2022 and as per the action plan prescribed in the direction dated December 2017 issued under EPA 1986.
2. CGD network distribution shall be taken up on priority within the country, emphasizing on 102 non-attainment cities.
3. There is need for optimizing the use of the existing power plants by prioritizing capacity utilization of natural gas/ clean fuel-based thermal power plants.
4. Phasing out older coal-based power plants and converting specific coal based power plants to natural gas.
5. Emphasis on improved power reliability in urban areas to eliminate the operation of DG sets.
6. Emphasizing the expansion of renewable power initiatives prioritizing the use of existing framework of NAPCC in non-attainment cities.
7. Need to explore the possibility of Flyash utilization in extensive way in 102 non-attainment cities.

7.5.3 INDUSTRIAL EMISSION

Industrial pollution is another area of concern that contributes majorly to the air pollution in India. Industries are growing at common centres/estates/parks as the resources, manpower, transportation and marketing are feasible. Generally, medium- and small-scale industries are developed in such areas and form industrial clusters. These industrial clusters are a major hub of pollution, thus indicating the lack of awareness and enforcement issues. To address the issue of enforcement and awareness in the industrial clusters, the CPCB has developed Comprehensive Environmental Pollution Index (CEPI) to characterize quality of the environment. In 2009, 88 prominent industrial clusters were identified for a CEPI analysis. Out of identified 88 prominent industrial clusters, 43 industrial clusters in 17 States with a CEPI score of 70 and above are identified as Critically Polluted Areas (CPAs). Further, 32 industrial clusters with CEPI scores between 60 and below 70 are categorized as severely polluted areas (SPAs). The CPCB has revised the CEPI concept and, subsequently, issued directions during April 2016 to all SPCBs/PCCs for taking stringent measures with reference to the revised CEPI concept, which inter alia includes environmental quality monitoring in all the CPAs, installation of continuous ambient air quality monitoring stations, etc. It was also directed to undertake environmental quality monitoring in the critically polluted areas falling under their jurisdiction through a third-party agency (laboratory) recognized under the Environment (Protection) Act, 1986. The environmental quality data, including CEPI score of the industrial area, as per the revised concept, shall be placed in public domain by the concerned SPCBs/PCCs through the Internet and also to be published by the State Government periodically. Control of Industrial Pollution has become a governance problem within India and is marred by law enforcement issues. Lack of accurate, independent and easily accessible data on emissions creates hurdles in ensuring compliance to standards and law enforcement.

In one of the experiments conducted in Gujarat through randomized evaluation it was observed that random assignment of auditors to industrial plants, payment from a common pool, their monitoring for accuracy and providing them with financial incentives for better reports for compliance auditing, led to 80% less likeliness of submission of false pollution readings. In addition to this, according to a study, industrial plants too reduced their air and water polluting emissions by 28%.

The ministry has developed a total of 63 industry-specific emission standards. Ten emission standards (diesel and LPG/CNG gensets; petrol and LPG/CNG gensets; dedicated LPG/CNG gensets; industrial boiler; SO_2 and NO_x standards for glass, lime kiln, reheating furnaces, foundry, ceramic industry, and airport noise) have been evolved and six emission standards (thermal power plant, sugar, man-made fibres, fertilizer, cement, and brick kiln) have been revised during 2014–till date. Criteria for categorizing industries in red/orange/green/white categories, which have been adopted by SPCBs/PCCs for strengthening the enforcement mechanism of environmental norms, have been revised.

For strengthening the monitoring mechanism and ensure the compliance of environmental standards, the CPCB has directed 17 categories of highly polluting industries to install and provide connectivity to the CPCB server for Online Continuous Emission/Effluent Monitoring System (OCEMS). So far, out of 3,531 industries, 2,743 industries have installed OCEMS and closure-directions are in force for 740 non-complying units. The CPCB under Section 18(1)(b) of the Air Act ,1981, directed SPCBs/PCCs of the NCR for the installation of online continuous emission monitoring systems in the red category-air polluting industries located in 23 districts of the NCR and Delhi in December, 2017.

Various directions have been issued by the CPCB for closure of brick kilns and stone crushers in Delhi and the NCR during air pollution exigencies. All brick kilns operating without permission and valid consent from SPCBs, not meeting prescribed norms and siting guidelines and not converted from natural draft to induced draft brick kilns (with rectangular kiln shape and zig-zag brick setting), were closed down till March 31, 2017 vide the CPCB direction dated November 2016. Regulations have been put in place regarding the use of pet coke and furnace oil in Delhi and the NCR.

It has been noted that though the CPCB has notified various emission norms for manufacturers of diesel generators, there is no regulation for generators in-use after commissioning (except the 800 KW and above category). This is in spite of the fact that PM is the major source of air pollution in our country. Accordingly, 91% of DG Sets have no regulations beyond the point of manufacture. Studies show that as DG Sets get older, they might emit 11 times the standards set for the manufacturers. Overall, DG Sets contribute to 7-18% to the ambient air pollution in non-attainment cities. As the current norms only address new generators and a limited population of old generators, it becomes crucial to address emissions from older in-use generators. Accordingly, it is proposed to formulate a notification on control of pollution from diesel generators in-use to include control and mitigation measures related to these generators. In addition to the formulation of standards by the CPCB, this may include following:

Users would be required to a. Shift to gas-based generators either by retrofitting existing generators for partial usage of gas (a mixture of diesel and gas) or buying new gas-based generators b. Use retro-fitted emission control equipment with diesel generators having a minimum specified particulate matter capturing efficiency of at least 70%. This would be the lower cost solution to consumers with a cost less than 10% of the generator set.

The retrofit emission control devices/ gas retrofits can be certified by one of the following institutions (CPCB approved institutions which also provide emissions approval for diesel generators at manufacturers' stage): (a) Automotive Research Association of India, Pune (Maharashtra); (b) International Centre for Automotive Technology, Manesar (Haryana); (c) Indian Oil Corporation, Research and Development Centre, Faridabad (Haryana); (d) Indian Institute of Petroleum, Dehradun (Uttarakhand); and (e) Vehicle Research Development Establishment, Ahmednagar (Maharashtra). These institutions can be authorized to carry out such tests, for giving certificates of Type Approval and Conformity of Production to emission control equipment manufacturers or products. The Compliance and Testing Procedure, as published by the CPCB for diesel engines, can be followed."

Action Points

1. Introduction of gaseous fuels and enforcement of new and stringent SO_2/ NO_x/$PM_{2.5}$ standards for industries using solid fuels.
2. Stricter enforcement of standards in large industries through continuous monitoring.
3. Full enforcement of zig-zag brick technology in brick kilns.
4. Elimination of DG set usage by provision of 24x7 electricity.
5. Control by innovative end of pipe control technologies.
6. Evolve standards and norms for in-use DG sets below 800 KW category.
7. For DG Sets already operational, ensure usage of either of the two options: (a) use of retrofitted emission control equipment having a minimum specified PM capturing efficiency of at least 70%, type approved by one of the 5 CPCB-recognized labs; or (b) shifting to gas-based generators by employing new gas-based generators or retrofitting the existing DG sets for partial gas usage.
8. Utilize the Gujarat case study for a compelling case for other states to adopt third-party audits for polluting industries for enhancing implementation(States)

7.5.4 TRANSPORT SECTOR EMISSION

Vehicles being identified as a major source of pollution, there had been greater emphasis on regulation of vehicular pollution. In this regard Bharat Stage IV (BS-IV) norms have been launched for mandatory implementation since April 1, 2017, and leap-frogging to BS- VI by April 1, 2020, has been proposed. Bharat stage emission standards are emission standards instituted by the Government of India to regulate the output of air pollutants from internal combustion engines and spark-ignition engines equipment, including motor vehicles. The standards and the timeline for implementation are set by the CPCB under the MoEF&CC. The standards, based on European regulations were first introduced in 2000. Progressively stringent norms have been rolled out since then. All new vehicles manufactured after the implementation of the norms have to be compliant with the regulations. Since October 2010, Bharat Stage (BS) III norms have been enforced across the country. In the 13 major cities, Bharat Stage IV emission norms have been in place since April 2010 and it is enforced for whole country from April 2017. In 2016, the Indian government announced that the country would skip the BS-V norms altogether and adopt BS-VI norms by 2020. Fuel quality standard are prescribed by M/o Petroleum and Natural Gas from time to time in advance in corroboration with the prescribed norms. Sulphur content in petrol and diesel is expected to reduce from existing 50 ppm in BSIV vehicles to 10 ppm in BSVI vehicles.

In addition to the BS norms, various other measures have been taken up by the government for control and management of vehicular emission. These measures include emphasis on cleaner / alternate gaseous fuel like CNG, LPG, etc., ethanol blending in petrol in order to reduce vehicle exhaust emissions, promotion of public transport, Pollution under Control (PUC) certificate, lane discipline, vehicle maintenance, etc.

National Mission on Sustainable Habitat under NAPCC is to make habitat sustainable through among others better urban planning and model shift to public transport. Making long term transport plans will facilitate the growth of medium and small cities in ways that ensure efficient and convenient public transport.

Pollution from In-Use vehicle

As per the Central Motor Vehicles Rules, 1989, every motor vehicle (including those conforming to BS-I/ BS-II/ BS-III/BS-IV as well as vehicles plying on CNG/ LPG) is required to carry a valid PUC certificate after the expiry of period of one year from the date of its first registration. However, the validity of 4 wheeled BS-IV compliant vehicles is one year and for other vehicles it is three months. MoRTH has proposed to develop model inspection and certification (I&C) centers in all the states.

The MoRTH, in May 2016, released the first draft of the proposed Voluntary Vehicle Fleet Modernization Programme (V-VMP). The programme proposes to offer tax benefits and discounts to people who junk old vehicles and replace them with new ones. Its primary intention is to reduce emissions and the priority is to get old fuel-guzzling and polluting trucks off the roads. Analysis of segment and age of vehicles causing air pollution has shown that MHCVs (Medium & Heavy Commercial Vehicles) constitute just 2.5% of the total fleet but contribute to 60% of pollution. Besides, the older vehicles, typically more than 10 years of age and pre-BS I compliant, constitute 15% of the total fleet but pollute 10–12 times more than a new vehicle because of drastic change in pollution norms. The scheme has the potential to reduce the vehicular emission by 25%–30%. The MoRTH is likely to announce this policy on the end of life commercial vehicles. Union Ministry of Steel will set up 20 scrapping centres in various parts of the country to produce steel from the scrap.

Green Mobility

India has for years trailed the official target of blending 5%ethanol and biodiesel in petrol and diesel, respectively to cut pricey oil import and save foreign exchange. The current blending ratio is about 2% for petrol and less than 0.5% for diesel against the target of 5%. Recently approved National Biofuel Policy, 2018, set for achieving blending target of 20% of ethanol in Petrol and 5% of biodiesel in diesel by 2030. Under the new National Policy on Biofuels, the central government has expanded the scope of raw material for ethanol production by allowing use of various agro-waste products

Further, GAIL Gas is also implementing Green Corridor Project to facilitate the availability of CNG beyond city limits so that the clean fuel can be used for long distance journeys. It also enhances the CNG usage.

Ministry of Petroleum & Natural Gas (MoPNG) launched a pilot project aimed at introducing compressed natural gas (CNG) as fuel for two-wheelers. The pilot, uses CNG-retrofitted two wheelers and aims at cutting down the rising pollution levels in cities.

The Ministry of Petroleum & Natural Gas has set up a Hydrogen Corpus Fund with a corpus of Rs.100 crores with contribution from five major Oil Companies and Oil Industry Development Board (OIDB) for supporting Research and Development in various aspects of hydrogen, which could substitute part of natural gas as transport fuel in future.

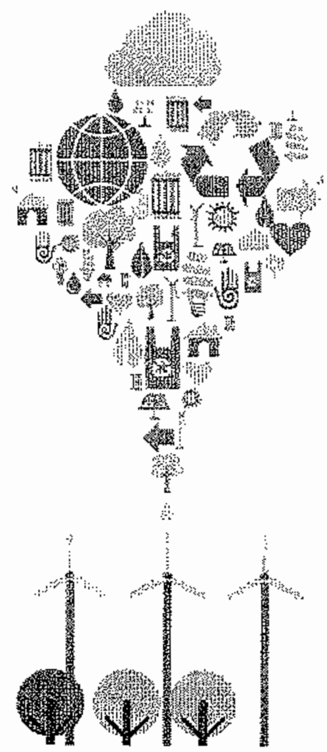
E-Mobility

The studies have demonstrated that the overall emissions are lower for Electric Vehicles than for gasoline and diesel vehicles: GHGs are reported to be reduced by approximately 82% over the lifetime of an EV, compared to a gasoline vehicle. Local air pollutants were reduced by 36% for PM, 45% for SO_x, 96% for VOCs, 81% for NO_x and 99% for CO.

The government has launched the scheme, namely, Faster Adoption and Manufacturing of Hybrid & Electric Vehicles (FAME India) under National Mission for Electric Mobility (NEMMP), 2020, in the Union Budget for 2015–16. The scheme is to provide a major push for early adoption and market creation of both hybrid and electric technologies vehicles in the country. The Ministry of Power launched the National E-Mobility Programme in 2018 announcing the Government of India's vision to provide an impetus to the entire e-mobility ecosystem, including vehicle manufacturers, charging infrastructure companies, fleet operators, service providers, etc. The programme will be implemented by Energy Efficiency Services Limited (EESL), which will aggregate demand by procuring electric vehicles in bulk to get the economies of scale. The government is focusing on creating charging infrastructure and policy frameworks so that by 2030, more than 30% vehicles are electricity-run vehicles.

However, there are some key challenges which need to be addressed while evolving any future plan on e-mobility and these include:

1. Technology: As a large component of the overall EV costs, high battery prices impact manufacturing and sales. Improved technology and indigenization of battery manufacturing can reduce battery costs, increase efficiency, and improve driving range, making EVs more accessible and attractive to potential customers. Further, lithium ion resources non-availability in India expose us to increased import dependency which can be addressed through exploring the possibility of alternate batteries which can be developed in India using the indigenous resources.
2. Infrastructure: Easy and affordable access to charging infrastructure—both standard AC charging as well as rapid DC charging—is a key to meeting customer needs.
3. Increase in Resource Demand: Globally it is predicted to increasing lithium demand fourfold and more than doubling demand for cobalt — two of the essential elements of lithium batteries. The price of cobalt has already risen by more than 80% this year.
4. Disposal of end-of life batteries: Rechargeable batteries used in electric vehicles majorly include lithium ion batteries, millions of which are already used in various electronic gadgets from smartphones to electronic toothbrushes and consume a lot of resources
   Due to lack of recycling facilities in India for these batteries, almost all of them end up in waste dumps or remain in unused gadgets in people's homes. The batteries used in electric cars are much bigger, last eight to 10 years, and will reportedly will account for 90% of the lithium-ion battery market by 2025 globally. Recycling of lithium-ion batteries is major challenge not only in India but globally.



Action Points

1. Stringent implementation of BS VI norms all over India by April 2020.

Green Mobility

1. Stringent implementation of National Biofuel Policy with respect to ethanol and biodiesel blending target of 20% and 5%, respectively by 2030.
2. City action plans to review the extension of MRT in cities/towns.
3. Improvement and strengthening of inspection and maintenance system for vehicles through extension of I&C centres.
4. Stringent implementation of PUC certificate through regular inspection and monitoring.

5. Fleet modernization and retro-fitment programmes with control devices.
6. Reducing real-world emissions by congestion management.
7. Review the Green Corridor Project and feasibility of its extension with reference to 102 cities.
8. To review the scaling up of Pilot project of MoPNG for introducing CNG in 2-wheelers and ensure timely implementation.
9. Scaling up of R&D on use of Hydrogen as transport fuel.

E-mobility

1. Formulation of a national-, state-, and city-specific action plan for e-mobility.
2. Rapid augmentation of charging infrastructure in the country focusing on 102 cities.
3. Central government offices fleets older than 15 years to be shifted to electric vehicles.
4. Government-run buses for public transport, private buses, and 3-wheelers to be converted to EVs.
5. Gradual transition to e-mobility in the 2-wheeler sector.
6. Specific allocations for creating a venture capital fund.
7. Investment in R&D and pilots focusing on the indigenization of battery manufacturing, cheap alternate resource to lithium and cobalt, resource efficiency associated with a circular economy, re-use and recycling for lithium batteries, etc.

7.5.5 AGRICULTURAL EMISSION

Various studies, including satellite data observations on aerosol properties suggests transport of particles from agriculture crop residue burning in the Indo-Gangetic Plains over large regions. Studies suggest that although outdoor fires are not the dominant air pollution source in India throughout the year, post-monsoon fires contribute substantially to regional air pollution and high levels of population exposure around Delhi. These results suggest that providing viable alternatives to agricultural residue burning could help improve post-monsoon air quality for a growing population within Delhi's air shed.

Paddy straw burning is currently practiced on a, large scale in Punjab and Haryana to clear the fields for the sowing of rabi crops, that is, rainy wheat and potato, because the time window available between the harvesting of paddy crop (September 20–November 15, depending upon the varieties of paddy) and the sowing of the next crop is very short (two–three weeks). Burning of paddy straw is most common in combine harvested fields because it leaves harvested paddy straw and standing stubbles (25–30 cm height) in the field. Paddy straw is seldom used as fodder due to its high silica content.

Environmentally sustainable paddy crop residue management practices entail incremental costs for the farmers (additional tractor operations and use of required machinery, etc.). Farmers, therefore, prefer burning as they can avoid incurring such costs by resorting to burning. They also believe that burning destroys the soil-born insects/pests and diseases to a large extent. An estimated 23 million tonnes of paddy straw is burnt in Punjab, Haryana, and Uttar Pradesh.

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The stubble burning shoots up the carbon dioxide levels GHG in the air by 70%. The concentration of carbon monoxide and nitrogen dioxide also rises by 7% and 2.1%, respectively. It has been estimated that, burning of one tonne of paddy straw releases 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash, and 2 kg SO_2. These gases affect human health due to general degradation in air quality, thus resulting in the aggravation of eye and skin diseases. Fine particles also aggravate chronic heart and lung diseases. On the other hand, one tonne of paddy straw contains approximately 5.5 kg N, 2.3 kg P_2O_5, 25 kg K_2O, 1.2 kg S, 50%-70% of micro nutrient absorbed by rice and 400 kg of carbon, which are lost due to burning. Some of the soil properties' like soil temperature, pH, moisture, available phosphorus and soil organic matter are greatly affected due to burning.

Amongst all available options for management of paddy straw (viz., Bio-Char, pellets/ briquettes making for thermal power plants, ethanol production, etc.), in situ use of paddy straw as mulch for sowing of wheat and its incorporation in soil for planting of potato and other vegetable crops has been observed to be most feasible and economical option for handling the paddy straw to begin with. Accordingly, a new Central Sector Scheme (100% Central Share) on 'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Punjab, Haryana, Uttar Pradesh and NCT of Delhi' for the period from 2018-19 to 2019-20 has been approved with the total outgo from the Central funds of Rs. 1,151.80 crore. Out of this total allocation as amount of Rs 575.18 has been released for the FY 2018/19.

The scheme has the components on (i) establishment of farm machinery banks for custom hiring of in-situ crop residue management machinery; (ii) financial assistance to farmers for the procurement of agriculture machinery and equipment for in-situ crop residue management; and (iii) information, education, and communication for awareness on in situ crop residue management. The State Department of Agriculture of the State Governments of Punjab, Haryana, Uttar Pradesh, and the Delhi NCT are the nodal departments for implementing the scheme in the states.

Ministry of Agriculture, Government of India, had finalized National Policy for Management of Crop Residues (NPMCR) – 2014. The policy envisages adoption of technical measures and extending central financial assistance for various interventions. Various ex-situ options for management of crop residue burning such as production of Prali-Char, biochar, pellets, briquettes, bioCNG, bioethanol are alternate fuel for brick kilns, industrial boilers, paper and packaging, coal-fired TPPs, transport sector, etc.

The government has recently announced National Policy on Biofuels (NPB), 2018, which aims to achieve 20% blending of ethanol in Petrol & 5% blending of biodiesel in diesel by 2030. The policy not only widens the feedstock base which now also includes crop residues for the production of biofuels but also indicates the roadmap for achieving the blending targets.

Air pollution from farms directly affects the environment, chiefly through the production of gaseous nitrogen and some of the greenhouse gases responsible for global warming. Agricultural air pollution comes mainly in the form of ammonia, which enters the air as a gas from heavily fertilized fields and livestock waste. It then combines with pollutants from combustion—mainly nitrogen oxides and sulfates from vehicles, power plants and industrial processes—to create tiny solid particles, or aerosols. Nitrous oxide is the major GHG that is contributed by fertilizers. Many studies indicate it as single biggest source of air pollution.

Action Points

1. Evaluate the status of implementation of the above scheme in the states and impact on reduction of air pollution in Delhi and the NCR.
2. Evaluate the socio-economic feasibility for implementation of ex-situ options like production of Prali-Char, biochar, pellets, briquettes, bioCNG, bioethanol, etc., as ex-situ solutions for management of crop residue burning especially with NPB in place.
3. Extending the initiatives for addressing the issue of crop residue burning from the NCR to other part of the country and from paddy to sugarcane and other crops.
4. Coordination with ISRO for regular availability of Remote Sensing Monitoring data for crop burning by the farmers.
5. Evolve plan for management of agricultural emissions from fertilizers and livestock waste on the basis of strong R&D. The R&D for the purpose to be supported.
6. Implement plan for management of agricultural emissions
7. The capacity-building initiatives for Krishi Vigyan Kendra (KVK) shall be strengthened.

7.5.6 EMISSIONS FROM UNSUSTAINABLE WASTE MANAGEMENT PRACTICES

It is estimated that, annually, 62 MMT of municipal solid waste gets generated in India. The generation of MSW in Indian cities has resulted in severe environmental and health problems due to improper management. Air pollution is one of the major environmental concerns in India due open disposal and burning of MSW. Waste products, such as plastic and rubber when burnt pollute the atmosphere with noxious fumes, such as dioxins and furans. E-waste burning releases toxic ashes, cadmium, dioxin, and furans. Organic solid wastes emit an obnoxious odour on their decomposition and make the environment polluted. Centralized waste disposal systems involving the use of landfills is the most commonly adopted practice for disposal of waste all over the world.

The waste sector is uniquely situated to substantially mitigate the second most-abundant greenhouse gas, methane. Focusing on waste with improvements in solid waste management can also bring various co-benefits such as an improvement in air quality, a reduction in contamination-related illnesses, economic growth, and a boost to energy resources.

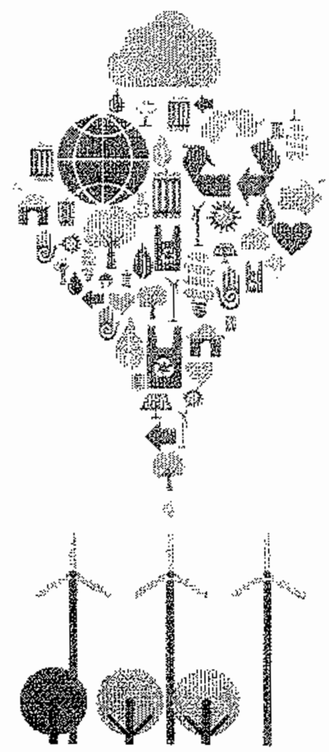
An integrated solid waste management strategy, including targeting waste prevention, recycling, composting, energy recovery, treatment, and disposal, can have a significant impact on reducing greenhouse gas emissions. For instance, landfill gas, which is composed of about 50% methane and 50% carbon dioxide, can be captured and used as a source of clean energy and a substitute for fossil fuel. Methane not only contributes to warming the atmosphere, it has also been linked to the concentration of surface ozone, which is known to cause air quality and public health issues.

An study investigating global emissions of trace gases, particulate matter, and hazardous air pollutants from open burning of domestic waste revealed that the fires (open trash burning) produce emissions equivalent to as much as 29% of officially reported human-related global emissions of small particulates ($PM_{2.5}$), as well as 10% of mercury and 64% of a group of gases known as polycyclic aromatic hydrocarbons (PAHs).

The dumpsites are riddled with instances of dangerous methane discharge, incessant fire outbreaks, landfill slides, and human rights violations of wastepickers as well as residents in the area. As per one of the estimation, emissions from biomass and open burning of waste contribute to almost 20%–30% of the total air pollution in cities like Delhi. Yet, unsustainable solid waste management practices, including open burning, landfill fires, and incineration are a common sight not only in the capital city but across the country.

Shortage of landfill capacity has consistently been touted as the reason to push for waste to energy incinerators in India. However, burning waste in inefficient incinerators only worsens the already-polluted air. Inefficient waste-to-energy incinerators, have proven to be notorious sources of air pollution and highly toxic ash residues. The most lethal incineration emissions are dioxins and furans, which are highly carcinogenic and persist in the environment.

National Mission on Sustainable Habitat under NAPCC is to make habitat sustainable through improvements in energy efficiency in buildings, management of solid waste and modal shift to public transport. Recycling of material and Urban Waste Management will be a major component of ecologically sustainable economic development. India already has a significantly higher rate of recycling of waste compared to developed countries. A special area of focus is development of technology for producing power from waste.



The smart city mission, is an urban renewal and retrofitting programme administered by the Union Ministry of Housing and Urban Affairs with the mission to develop 100 cities across the country, making them citizen friendly and sustainable. The mission is being implemented in collaboration with the state governments of the respective cities. Features of Smart cities inter-alia include reduce congestion, air pollution and resource depletion, boost local economy, promote interactions and ensure security. The road network is to be created or refurbished not only for vehicles and public transport, but also for pedestrians and cyclists, Promoting a variety of transport options - Transit Oriented Development (TOD), public transport and last mile para-transport connectivity. 43 of these smart cities fall in the list of 102 non-attainment cities.

Similarly, the Swachh Bharat Mission is a campaign that aims to clean up the streets, roads and infrastructure of India's cities, smaller towns, and rural areas. Swachh Hawa is an integral component of Swachh Bharat. Integrated Solid Waste Management including C&D, E-waste, hazardous waste will be useful in meeting the outcome under the NCAP.

Action Points

1. Use the smart cities framework to launch the NCAP in the 43 smart cities falling in the list of 102 non-attainment cities.
2. Transform our centralised waste disposal infrastructure to a sustainable decentralized system in 102 cities.
3. Source segregation into dry and wet waste to be made mandatory through involvement of municipalities and the RWA.
4. Mandatory Training and capacity building of municipalities and the RWA.
5. Transitioning towards a zero-waste pathway through an integrated solid waste management strategy, including targeting waste prevention, recycling, composting, energy recovery, treatment, and disposal.
6. Waste reduction schemes such as 'polluters pay' principle, recycling projects, composting, biomethanation, RDF plants and co-processing to be supported under an integrated solid waste management strategy.
7. Construction of decentralized compositing plant, biomethanation plant and C&D waste plants.
8. Deployment of fixed compactor and doing away with dhalaos.
9. Focus on training municipalities and SPCBs to be on national and international technologies for integrated waste management options.
10. In line with the National Biofuel Policy, promote technologies which can convert waste/plastic, MSW to energy resulting in reduction of traditional fuel use.
11. Stringent implementation and monitoring for extended producer responsibility for e-waste and plastic waste.
12. Strict implementation of existing six waste management's rules on solid, Hazardous, Electronic, Bio-medical, Plastics and C&D waste.
13. The Swachh Bharat Mission and National Mission on Sustainable Habitat to be used as a platform to push the objectives under this sector.

7.5.7 INDOOR AIR POLLUTION MANAGEMENT

It refers to the physical, chemical, and biological characteristics of air in the indoor environment within a home, building, or an institution or commercial facility. Health risks related to indoor air pollution have become an issue of concern because people generally spend most of their time indoors at home and at work. The problem has been exacerbated by well-meaning efforts to lower air-exchange rates in buildings in order to conserve energy; these efforts unfortunately allow contaminants to accumulate indoors.

Indoor air pollutants include various combustion products from stoves, kerosene space heaters, and fireplaces as well as volatile organic compounds (VOCs) from household products (e.g., paints, cleaning agents, and pesticides). Formaldehyde off-gassing from building products (especially particleboard and plywood), and from dry-cleaned textiles can accumulate in indoor air. Bacteria, viruses, moulds, animal dander, dust mites, and pollen are biological contaminants that can cause diseases and other health problems, especially if they build up in and are spread by central heating or cooling systems. Environmental tobacco smoke, also called second-hand smoke, is an indoor air pollutant in many homes, despite widespread knowledge about the harmful effects of smoking. Second-hand smoke contains many carcinogenic compounds as well as strong irritants. In some geographic regions, naturally occurring radon, radioactive gas, can seep from the ground into buildings and accumulate to harmful levels. Indoor air pollution can begin within the building or be drawn in from outdoors. Other than nitrogen dioxide, carbon monoxide, and lead, there are a number of other pollutants that affect the air quality in an enclosed space. Exposure to all indoor air pollutants can be reduced by appropriate building construction and maintenance methods, limitations on pollutant sources, and provision of adequate ventilation.

In the developing countries, it is the rural areas that face the greatest threat from indoor pollution, where some 3.5 billion people continue to rely on traditional fuels such as firewood, charcoal, and cowdung for cooking and heating. India is home to more than 24 crore households out of which about 10 crore households are still deprived of LPG as cooking fuel and have to rely on firewood, coal, dung cakes, etc., as a primary source of cooking. The smoke from burning, such fuels cause alarming household pollution and adversely affect the health of women and children causing several respiratory diseases/ disorders. The Pradhan Mantri Ujjwala Yojana (PMUY) aims to safeguard the health of women & children by providing them with a clean cooking fuel – LPG, so that they don't have to compromise their health in smoky kitchens or wander in unsafe areas collecting firewood.
The Pradhan Mantri Ujjwala Yojana was launched by the Hon'ble Prime Minister Shri Narendra Modi on May 1, 2016, in Ballia, Uttar Pradesh. Under this scheme, 5 crore LPG connections have been provided to BPL families with a support of Rs 1,600 per connection over the next three years.

Action Points

1. Building specific guidelines and protocols on monitoring and management of indoor air pollution.
2. Extend PMUY in 102 cities/towns and the associated village areas.
3. Guidelines and provisions for building designs that define proper ventilation, clean cooking, and living areas to maintain healthy air quality inside the house to be integrated with the Pradhan Mantri Awas Yojana (PMAY).

7.6 CITY SPECIFIC AIR QUALITY MANAGEMENT PLAN FOR 102 NON-ATTAINMENT CITIES

The city action plans need to be guided by a comprehensive science-based approach, involving source apportionment studies. Source apportionment study is resource intensive and a highly specialized technical work, considering that such studies are required in about 102 non-attainment cities/towns; capacity building and networking of domestic institutes will be extremely important.

These studies are taken up in a few cities and towns, to begin with. It has been observed that towns in northern India, particularly in the Indo-gangetic plains, have higher ambient particulate concentrations in comparison to the southern parts. Similarly, source activities (industries, typical urban, etc.) and meteorological settings (e.g., coastal) are the other important factors that may influence the air pollution levels. It is, therefore, proposed to select candidate cities and towns considering the above-mentioned factors. Further, the state capitals and cities with a population more than a million (due to a higher number of people being exposed to higher PM concentrations) may be taken up on priority. All the non-attainment cities and towns may be covered in a phased manner. In the first phase, 10 cities may be taken up with support of leading institutes like the IITs, NEERI, TERI, ARAI, etc. Each of these Institutes may associate two or three Institutes during the study for their capacity building and involvement in subsequent phases.

Action Points

1. Preliminary city-specific action plans to be formulated for 102 non-attainment cities.
2. City-specific action plans to be taken up for implementation by State Government and city administration.
3. City-based clean air action plans are to be dynamic and evolve based on the available scientific evidence, including the information available through source apportionment studies.
4. A separate emergency action plan in line with GRAP for Delhi to be formulated for each city for addressing the severe and emergency AQIs.

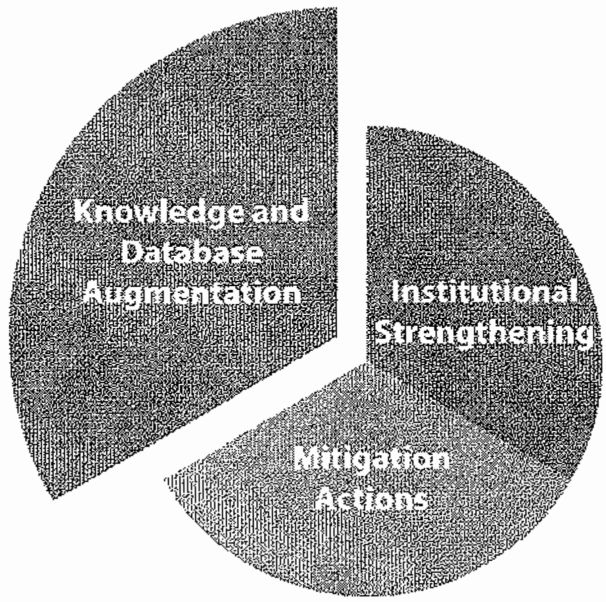
7.7 STATE ACTION PLAN FOR AIR POLLUTION

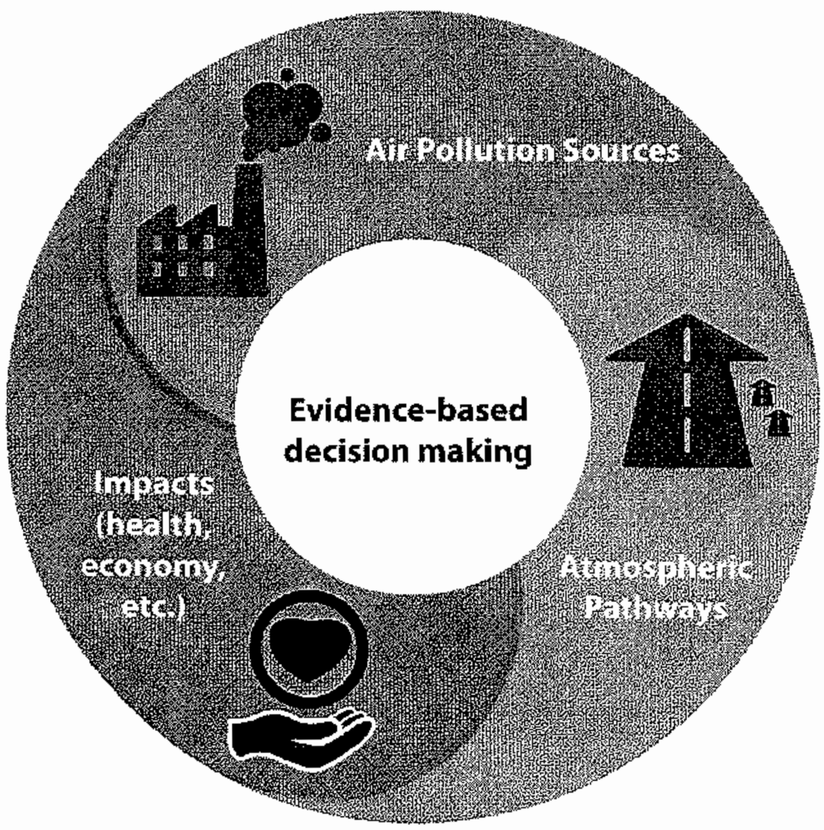
Since collaborative and participatory approach involving State Governments, Local bodies, relevant Central Ministries, and other Stakeholder with focus on all sources of pollution form crux of the Programme, success of NCAP is depending upon active involvement of State Governments. State Government's participation is not limited for evolving an effective implementation strategy but as has been indicated by Department of Expenditure since the outcome of the NCAP would be contingent upon the investments to be made by the States, more involvement of the States in the area of funding is to be explored.

Action Points

1. Preliminary State Action Plan for Air Pollution to be formulated for all 23 states which harbour 102 non-attainment cities;
2. State Action Plan for Air Pollution to be taken up for implementation by State Government and city administration;
3. The State Action Plan to have detailed funding mechanism.

KNOWLEDGE & DATABASE AUGMENTATION





8 ACTIONS FOR KNOWLEDGE AND DATABASE AUGMENTATION

8.1 AIR QUALITY MONITORING NETWORK

Air quality monitoring network is one of the key components under NCAP (Figure 4). National air quality monitoring network to be revisited, past data to be analyzed for rationalization of monitored parameters, and monitoring needs be reassessed for augmenting the monitoring network adopting optimum blending of techniques such as manual, continuous, sensor & satellite based techniques.

Action Points

1. Manual monitoring stations

With reference to existing 4000 cities in the country, 703 manual monitoring stations in 307 cities reflects limited number and need augmentation. It is proposed to augment it to 1500 stations from existing 703 stations.

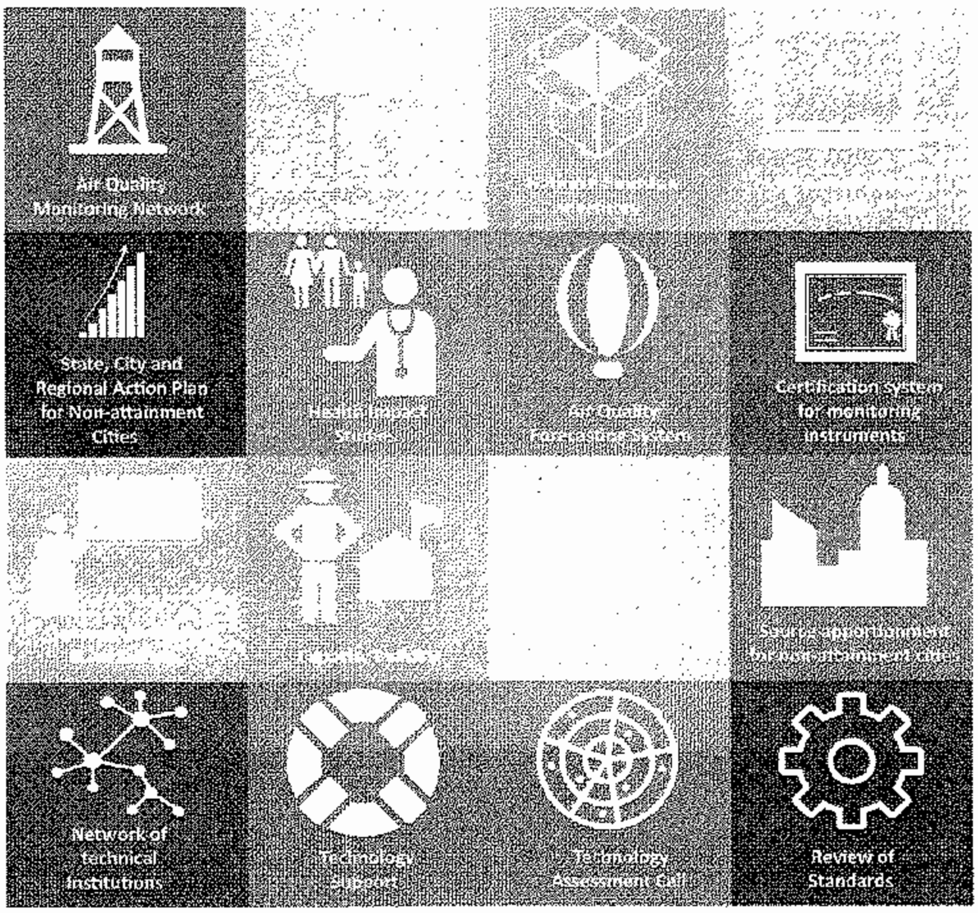


FIGURE 4. KEY COMPONENTS OF NCAP

2. CAAQMS

Recognizing the need to monitor real time and peak concentration levels of critical pollutants avoiding the time lag, more specifically with reference to the AQI, it is proposed under the NCAP to augment the existing number of Continuous Ambient Air Quality Monitoring Stations (CAAQMS). Presently, there are 134 CAAQMS stations in 71 cities and 17 States. Acknowledging the fact that air pollution in India has regional ramifications and the Indo-Gangetic plain, spanning approximately 45–50 cities spreads across the states of Assam, Bihar, Haryana, Jharkhand, Madhya Pradesh, Punjab, Rajasthan, Uttarakhand, Uttar Pradesh, and West Bengal, is the main region impacted by air pollution; the expansion of real-time monitoring stations would mainly focus on this region, and approximately 150 CAAQMS with an average of 2–3 stations in each city is to be decided on the basis of population, industrial activities, etc., will be targeted. Further, impetus will be on low-cost indigenous real-time monitoring stations. Real-time monitoring in other cities will be taken up with identification of these low-cost sensors.

3. Satellite based monitoring

Application of Aerosol Optical Depth (AOD) from satellite-based observations is being widely accepted for the assessment of ambient particulate matter levels. This is significant considering the extensive monitoring needs and required resources. The NCAP proposes to use this technique to supplement its monitoring network. Under the programme, capacities will be strengthened to develop indigenous satellite-based products and techniques to derive useful air quality information. The required algorithm to correlate AOD values with ground-level PM concentrations over the Indian regions will be derived from an indigenous database. Other satellite-based products also need to be explored to assess gaseous pollutant concentrations.

4. Identification of alternative technology for real time monitoring

CPCB is to steer the process of identifying and for developing/validating alternative cost-effective technology for source and ambient air quality monitoring in consultation with the IIT, CSIR, and other such institutes as NEERI. Mobile air quality monitoring network are to be made part of these alternative technologies.

5. Rural Monitoring Network

Air quality in rural areas remains a neglected issue so far. The common belief is that rural areas are free from air pollution. On the contrary, air quality in the rural areas all over the world and particularly in the developing countries may be more polluted than some of the urban areas. Rural areas suffer from outdoor air pollution as well as indoor air pollution. Major sources of outdoor air pollution are indiscriminate use of insecticides/pesticides sprays and burning of wheat and paddy straw. Atmospheric concentration of ozone has been observed higher in rural areas as compared to urban areas. Since rural areas have not been covered under NAMP it is proposed to set up 75 such stations in rural areas.

6. Protocol for setting up of monitoring stations and monitoring

Guidelines for Ambient Air Quality Monitoring has been issued by the CPCB in 2003 for assisting and taking decision with respect to the setting up of monitoring stations. However, it is noted that the guideline needs revision in reference to sound decision making in selection of pollutants, selection of locations, frequency, duration of sampling, sampling techniques, infrastructural facilities, man power, and operation and maintenance costs. The network design also depends upon the type of pollutants in the atmosphere through various common sources. Accordingly, it is planned to review the existing guideline and issue protocol for setting up of monitoring stations and monitoring.

7. Monitoring of $PM_{2.5}$

Particulates are the deadliest form of air pollutants due to their ability to penetrate deep into the lungs and blood streams unfiltered, causing various health issues. The smaller $PM_{2.5}$ are particularly deadly, as it can penetrate deeper into the lungs and blood stream. The monitoring data also indicates higher concentration of $PM_{2.5}$ in major cities. Accordingly, in order to evolve a comprehensive mechanism for the management of $PM_{2.5}$, it is proposed to augment the number of monitoring stations for $PM_{2.5}$ from the existing 167 in 80 cities to all stations under NAMP.

8. Setting up of 10 city Super Network

This network may capture the overall air quality dynamics of the nation, impact of interventions, trends, investigative measurements, etc. The cities may be identified for capturing possible variations (e.g., metro city, village, mid-level town, coastal town, controlled background location, industrial town, etc.). Each city may have one well-equipped monitoring station representing the city background. In addition to the notified 12 pollutants, constituents of PM1, particle number, etc., may be monitored. It should generate highly-quality controlled data and will represent national air quality dynamics. The plan for this network to be formulated and implemented in consultation with the CPCB.

9. Super sites as representative sites in cities and rural areas

These representative monitoring sites are to be selected to assess the background level and major sources so as to draw a scientific statistically sound assessment of pollution and its impact on health.

8.2 EXTENDING SOURCE APPORTIONMENT STUDIES TO ALL NON-ATTAINMENT CITIES

The air pollution problem becomes complex due to the multiplicity and complexity of air-polluting sources (e.g., industries, automobiles, generator sets, domestic fuel burning, road side dusts, construction activities, etc.). A cost-effective approach for improving air quality in the polluted areas involves (i) identification of emission sources; (ii) assessment of extent of contribution of these sources on ambient environment; (iii) prioritizing the sources that need to be tackled; (iv) evaluating various options for controlling the sources with regard to feasibility and economic viability; and (v) formulation and implementation of most appropriate action plans. Source apportionment study, which is primarily based on measurements and tracking down the sources through receptor modelling, helps in identifying the sources and extent of their contribution. The auto fuel policy document of the Government of India also recommended carrying out source apportionment studies. Accordingly, source apportionment studies have been initiated in six major cities, viz. (i) Delhi; (ii) Mumbai; (iii) Chennai; (iv) Bangalore; (v) Pune; and (vi) Kanpur. The study would focus on the apportionment of particulate matters (PM_{10} and $PM_{2.5}$), being the most critical. Statistics generated from source apportionment studies of Delhi by the CPCB and IIT Kanpur, showing percentage contribution of PM_{10} from various sources, is given in Table 1.

Source apportionment study, which is primarily based on measurements and tracking down the sources through receptor and dispersion modelling, helps in identifying the sources and extent of their contribution.

Action Points

1. Unified guideline for source apportionment study will be formulated and updated (centre).
2. Source apportionment studies to be extended to all 102 non-attainments (centre).

8.3 AIR POLLUTION HEALTH AND ECONOMIC IMPACT STUDIES

Many international studies often report data on mortality due to air pollution exposures. These studies use extrapolation techniques for air quality- and health/disease-related data, which probably may not be realistic. While there is no denial on serious health implications, attributing one to one correlation and number of deaths due to air pollution needs to be further investigated and supported by indigenous studies. More authentic Indian data and studies may further strengthen our efforts and public participation in improving the air quality. With a focus on environmental health issues, the MoEF&CC has constituted an Apex Committee and a Working Group under the joint chairmanship of the Indian Council of Medical Research (ICMR) and the Ministry to identify thrust areas in environment health and to evaluate the related projects. In line with recommendation of the Working Group, the ministry has initiated action towards a study on the National Environmental Health Profile for 20 cities with an emphasis on the impact of air pollution on health.

There are numerous effects of air pollution on the ecosystem, which in turn have various economic implications. In simple terminology, we can say that air pollution effects can be both direct and indirect. For instance, air pollution primarily causes respiratory and other health hazards in people who are being directly exposed to various harmful gases. The secondary, and long-run impact, would be that following the health problems, the productivity of workers might be adversely affected, which in turn hamper output levels. This is how air pollution exerts an indirect effect on the overall economy. The recognition of anthropogenic sources of pollutants and their biological and economic effects on managed ecosystems, such as agricultural crops and forests provided impetus for air pollution control programmes.

The link between economics and natural science economic analysis can be an effective tool for comparing the costs and benefits of alternative resource or environmental management policy actions. When correctly formulated, such economic analyses can be useful in estimating the monetary values of vegetation and other receptor losses from air pollution or the welfare consequences of air pollution reductions.

Action Points

1. Study on the National Environmental Health Profile to be completed in time.
2. Response study and cohort study programme to be undertaken.
3. Ministry of Health to actively take up environmental health for ensuring regular health profile or database for assisting decision making.
4. Studies on health and economic impact of air pollution to be supported.
5. Framework for monthly analysis of data w.r.t health to be created. The data from mapping of industry; tabulation of daily AQI, $PM_{2.5}$ and PM_{10} measurements (24 hours average); metrological parameters; deaths due to heart attacks, strokes, respiratory arrest, following the existing respiratory ailments, trends in lung cancer if available with respect to all cities to be fed in to a central computer and to be analysed every month by people trained in environmental health for correct interpretation.
6. Awareness and orientation workshops to be undertaken focussing on a target audience
7. Media is to be used for wide dissemination of information and the precise information to be shared has to be carefully worked out by a team of experts in air pollution and environmental health.
8. Training researchers in study design through holding workshops in epidemiology, toxicology, and biostatistics

8.4 INTERNATIONAL COOPERATION INCLUDING SHARING OF INTERNATIONAL BEST PRACTICES ON AIR POLLUTION

The issue of management of air pollution in developing countries and countries with economy in transition is impacted by lack of expertise, technology and adequate related information. With reference to developing countries and countries with economy in transition as India, technological and expertise limitations are considered as major hindrance in achieving our obligations under various international conventions and in meeting the national commitments with reference to prevention, control and abatement of pollution; and protection of environment. Accordingly, technology transfer and information sharing is the way forward for any collaboration on environment. Technology transfer does not just relate to equipment or 'hardware', but also to total systems and their component parts, including know-how, goods and services, equipment, and organizational and managerial procedures. Accordingly, multilateral and bilateral cooperation on air pollution, including in related demonstration/pilot projects, including a prototype development for the best-available technologies and best environmental practices for pollution prevention, minimization, and mitigation strategies and for the control and abatement of pollution, specifically air pollution, are being proposed.

Action Points

1. International scientific and technical cooperation in the area of air pollution will be established in accordance with national priorities and socio-economic development strategies and goals.
2. Modalities of such cooperation may include joint research and technology development, field studies, pilot scale plants and field demonstration projects with active involvement of academia, research institutions and industry on either side.

8.5 REVIEW OF AMBIENT AIR QUALITY STANDARDS AND EMISSION STANDARDS

Ambient air standards which sets limits on pollutants with reference to quality of air surrounding us in the outdoors and emission standards which set quantitative limits on the permissible amount of specific air pollutants that may be released from specific sources over specific timeframes have already been notified barring for some of the sources.

Action Points

1. The CPCB to come up with guidelines with respect to the periodicity of review of such standards.
2. The existing standards need to be strengthened periodically and new standards need to be formulated for the sources where standards are not available, based on extensive scientific evidence with reference to protection of public health and environment.

8.6 NATIONAL EMISSION INVENTORY

An emission inventory is an accounting of the amount of pollutants discharged into the atmosphere. An emission inventory usually contains the total emissions for one or more specific air pollutants, originating from all source categories in a certain geographical area and within a specified time span, usually a specific year. Emissions and releases to the environment are the starting point of every environmental pollution problem. Information on emissions therefore

is an absolute requirement in understanding environmental problems and in monitoring progress towards resolving these. Emission inventories are essential for policy formulation and implementation, and other related scientific studies. Its significance is in tracking progress towards emission reduction targets and as inputs to air quality model.

Action Points

1. Comprehensive National Emission Inventory which is still lacking in the country will be formalized under the NCAP.

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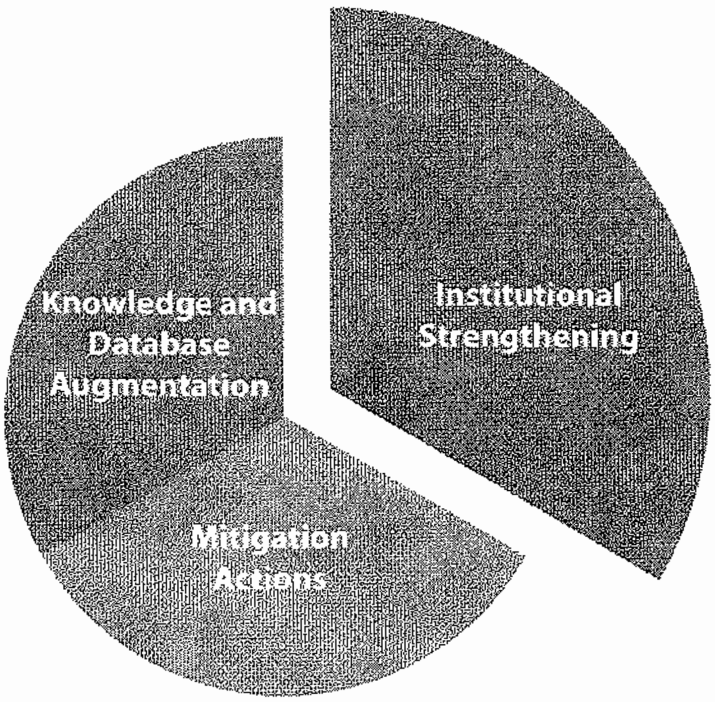
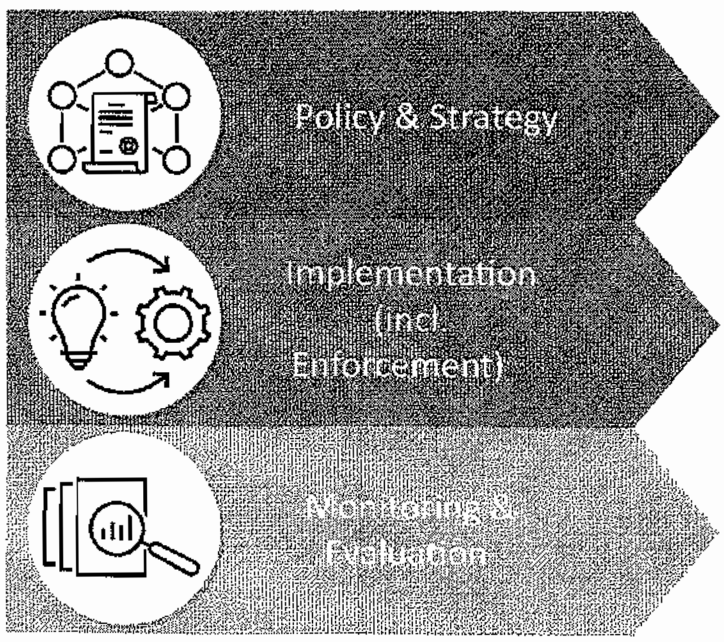
INSTITUTIONAL STRENGTHENING





9 ACTIONS FOR INSTITUTIONAL STRENGTHENING

9.1 PUBLIC AWARENESS AND EDUCATION

Awareness and education initiatives towards prevention, control, and mitigation of air pollution combined with specific information sharing on health advisories and dealing with air pollution exigency is an essential component, which provides communities with the knowledge and tools to take action and help improve their local air quality. Problem areas can easily be identified and monitored using citizen science methods, empowering communities, and reducing the risks of exposure to air pollution. Studies shows that simple measures such as walking just a few yards away from the kerbside of a busy road could reduce exposure by 30%. Idling your car engine uses more fuel and is worse for your engine than restarting. The all-important first step is awareness. Engaging children at an early age is the best way to ensure we build a foundation in order to ensure clean air for the future generations. With air quality now engrained in public health frameworks and local authority jurisdiction, an ever-increasing number of industries are required to take action and all institutions have a responsibility to reduce their air quality footprint. The public can become more involved in reducing local air pollution impacts in their communities. Extensive awareness and outreach programme for various stakeholder groups need to be taken up prioritizing the non-attainment cities. Building public awareness will be vital in supporting implementation of the NCAP. This will be achieved through national portals, media engagement, civil society involvement, curricula reform and recognition/ awards, details of which will be worked out by an empowered group. The Group will also consider methods of capacity building to support the goals of the NCAP. Advocacy and IEC to be strategy element.

Action Points

1. City-specific awareness programme targeting key stakeholders to be formulated and taken up for implementation. This could include awareness generation in general public for prevention of adverse effects of air pollution.
2. Sensitization of the media for right interpretation of international reports and data as well as for disseminating information on measures being taken by the government for the abatement of air pollution to be undertaken.

9.2 TRAINING AND CAPACITY BUILDING

One of the major issues, which is a hurdle in an effective implementation of air pollution management plans have been observed to be a lack of capacity on air quality issues due to limited manpower and infrastructure in the CPCB and SPCBs, lack of formal training for various associated stakeholders, a limited number of trained individuals in air quality management, limited publications designed to provide information on local air quality issues, limited collaboration between government, universities, and other research institutions, lack of a forum for sharing of published local research work on air quality, etc.

Action Points

1. Extensive capacity-building programmes for both the CPCB and SPCBs with reference to both manpower and infrastructure augmentation.
2. Intensive training, comprising national and international best practices and technological options, of all the associated stakeholders.

9.3 SETTING UP AIR INFORMATION CENTRE

Air information centers may be set up at the central and state level, which will be responsible for creating a dash board, data analysis, interpretation, dissemination, including through GIS platform, issuing bulletins, keeping track of international developments, and bringing out policy updates. This may be set up with the assistance of the IITs, IIMs, and other universities and research organizations involved in such studies. The Government of India is implementing the National Action Plan on Climate Change (NAPCC), wherein various institutes are engaged under National Communication (NATCOM). Relevant institutes from NATCOM list can be utilized for setting up such centres.

Action Points

1. Plan accordingly for setting up of these centres will be formulated.
2. Air information centres at the central level and regional level will be set up in some of the identified institutes.

9.4 CERTIFICATION SYSTEM FOR MONITORING INSTRUMENTS

In the field of environmental monitoring, the data quality is posing a major challenge as the reliability of such measurements needs to be ascertained. The roles of instrument and the calibration are the major issues that need to be addressed. While most of the instrument used are usually imported from abroad which comes with certifications from agencies such as the USEPA, TUV, MCERTS, etc. These certificates are issued based on the environmental conditions of the certificate issuing country which are different from the environmental conditions prevalent in India, for example, high variability in temperature and humidity during the different seasons and different geographical regions. This affects the quality of measurements by the instrument operating for a long time in the Indian conditions and warrants a revisit of the certification process at regular intervals. However, as of now, no certification system is available in India for environmental monitoring equipment. The traceability of measurement is also an integral part of generation of reliable data. A measurement is valid only if the traceability to SI units is established and the uncertainties in each measurement are estimated.

CSIR-National Physical Laboratory is the National Metrology Institute (NMI) of India. It is a member of Bureau International des Poids et Mesures (BIPM) and signatory to the International Committee for Weights and Measures - Mutual Recognition Arrangement (CIPM-MRA). The NMIs demonstrate the international equivalence of their measurements through CIPM-MRA.

In view of the above, the CSIR-NPL proposes to establish an NPL-India Certification Scheme (NPL-ICS) to cater to the country's needs in respect of Online Continuous Emission Monitoring System (OCEMS), Continuous Ambient Air Quality Monitoring System (CAAQMS), and $PM_{2.5}$/PM_{10} samplers. The scheme will provide a complete and cost effective solution for test, calibration, and certification to the Indian as well as foreign manufacturers of these equipment/ systems. Due to a signatory to the CIPM-MRA, the certificates issued by the CSIR-NPL will be acceptable world-wide. This will help manufacturers of the equipment to trade in international market as well lend a helping hand in the `Make in India' programme.

The proposed certification scheme will have three major components i.e. 1) NPL-India certification body (NICB), 2) certification committee, and 3) testing and calibration facility. In this proposed scheme, the NICB will be the highest body with five members, which includes the chairman, member secretary, and the three expert members, one each from the National Metrology Institute (CSIR-NPL), Environmental Regulatory Body (CPCB), and CSIR-National Environmental Engineering & Research Institute (CSIR-NEERI).

The certification committee will have seven members (four permanent and three co-opted). The three co-opted members must be associated with independent institutes or organizations like the IITs, NABL, or other academic institutes as per the required technical/academic expertise on case to case basis.

The third component will be the heart of this scheme and will provide the required test reports. The facility will be fully capable for testing and calibrating extractive, in-stack, or cross stack measurements to allow more than one system to be tested at a time as per the test programme generated by the certification committee. The proposed facility will allow to test the online continuous emissions monitoring systems (OCEMS), continuous ambient air quality monitoring systems (CAAQMS), and data-handling systems (DAHS), besides other air pollution monitoring equipment such as $PM_{2.5}$ and PM_{10} samplers.

Other than this, the proposed testing and calibration facility will also be capable of conducting three months of field testing as per the requirement of EN-15267-3 (or Indian equivalent) and QAL-3 of EN-14181 (or Indian equivalent). The testing and calibration facility may sub-contract field testing of the system to another organization. It is the responsibility of the main testing and calibration facility to ensure that the sub-contracted organization is accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL) and registered with regulatory body (the CPCB) for the scope of work sub-contracted.

The process execution time for certification starts from the date of submission of request application from the client. The overall time required for the proposed certification from submission of application to the issue of certificate will be about 20 months.

Action Points

1. To operationlize the NPL-India Certification Scheme (NPL-ICS) at the central and regional levels to cater to the country's needs with respect to the online monitoring of air pollution.
2. To evolve an action plan for the need of certification agencies for air pollution mitigation equipment in addition to monitoring equipment.

9.5 AIR QUALITY FORECASTING SYSTEM

The Air Quality Forecasting System (AAQFS) as a state-of-the-art modelling system which forecasts the following day's air quality is being envisaged. The meteorological and emissions information is to be entered into the model which aims to accurately forecast air pollution on daily basis and also expected air pollution exigencies.

Currently, Indian Institute of Tropical Meteorology (IITM), Pune, under the Ministry of Earth Sciences (MoES), is the apex body, which runs the System of Air Quality and Weather Forecasting and Research (SAFAR) as programme to forecast air pollution trends in Delhi, Mumbai, Pune, and Ahmedabad. For these cities, it generates the likely air quality profile for a day in advance. SAFAR monitors pollutants such as PM_1, $PM_{2.5}$, PM_{10}, NO_x (NO, NO_2), CO, ozonbvve, SO_2, BC, Methane (CH_4), non-methane hydrocarbons (NMHC), benzene, VOCs, and mercury. SAFAR was developed indigenously by the Indian Institute of Tropical Meteorology (IITM), Pune, and operationalized by the India Meteorological Department (IMD). It is an integral part of India's first air quality early warning system operational in Delhi. It monitors all weather parameters such as temperature, rainfall, humidity, wind speed, and wind direction.

The Ministry of Earth Sciences institutions are working towards the development of new air quality warning modelling framework with real-time data assimilation of air pollutants derived from satellites and ground based observations. Using such modelling frameworks, an operational air quality early warning system will be put in place by the middle of October 2018. To begin with, the early warning system will give forecasts for the next two days and the outlook for another couple of days. A special password-protected website will be created by IITM, Pune, to host all observations, satellite data, and the model forecasts related to trajectory and air quality to be hosted as link to the existing Ministry of Earth Sciences-SAFAR website. SAFAR will continue to be the backbone for pollution forecast but this new system will use different method of analysis for better resolution and more accurate forecasts. Besides health, SAFAR system will benefit cost savings to several other sectors, such as agriculture, aviation, infrastructure, disaster management skill, tourism,

and many others, which directly or indirectly get affected by air quality and weather.

Action Points

All the ongoing and future initiatives under SAFAR will be integrated with the NCAP for taking all preventive measures to draw the benefits for addressing the air pollution issue from available information.

1. The efforts will be to extend it to 102 non-attainment cities under NCAP.
2. Hotspot-based forecasting to be taken up moving ahead from city-specific forecasting in 102 cities.
3. The satellite data available through the satellite network of ISRO to be integrated for monitoring and forecasting under the NCAP.

9.6 NETWORK OF TECHNICAL INSTITUTIONS- KNOWLEDGE PARTNERS

A network of highly qualified and experienced academicians, academic administrators, and technical institutions in the field of air pollution will be created to provide holistic services for the establishment and operation of policies and programmes of the Government of India on air pollution. Further, knowledge partners will also endeavour towards making these universities and higher education institutions in India globally competitive in terms of the body of knowledge, academic resources, and academic processes on the issue of air pollution. Dedicated air pollution units will be supported in these universities, organizations, and institutions. Major universities as University of Delhi, Jawaharlal Nehru University, Banaras Hindu University, the IITs, IIMs, and other academic institutions will be an integral part of this network. International expertise will also be used for effective solutions on the basis of international experiences. The national-level network is to be fed by the regional networks since air pollution has major regional implications.

Action Points

1. A detailed action plan for the setting up of the network integrating with the existing network under the NAPCC needs to be formulated.
2. System of a regular web-based online interaction mechanism will be evolved to ensure continuity of interactions.

9.7 TECHNOLOGY ASSESSMENT CELL

Technology assessment and evaluation of new technologies is based on the conviction that new technologies are relevant for the world at large rather than just for the scientific experts themselves. Technology assessment in reference to prevention, control, and mitigation of air pollution assumes a global perspective. Technology assessments, which are a form of cost–benefit analysis needs to assume an interdisciplinary approach to solving the problem of air pollution so as to prevent potential damage caused by the commercialization of new technologies. The Technology Assessment Cell is being envisaged to evaluate significant technologies with reference to prevention, control, and abatement of pollution. The cell is expected to focus on both indigenous and international monitoring and abatement technologies. The technologies in air pollution now range from engineering and chemical technologies to various sustainable biological technologies including planation technologies. The cell is also expected to contribute towards evaluating the technology and devising the mechanism of technology transfer under various bilateral and multilateral agreements.

Technology induction/ transfer would be facilitated, where necessary, with time bound goals for indigenization and local manufacturing. Appropriate bilateral and multi-lateral cooperation programmes for sharing of technologies and funding would be developed, and participation in international partnerships, where necessary, will also be explored.

Action Points

1. A detailed action plan for this cell is to be formulated.
2. The Technology Assessment Cell will be created involving the IITs, IIMs, the major universities, industries, and using the existing mechanisms and programme of the DST, India Innovation Hub, etc.

9.8 INSTITUTIONAL FRAMEWORK

An effective institutional framework, which basically refers to formal organizational structures, is the precondition for the successful implementation of pollution, specifically air pollution-related intervention tools and, therefore, needs to be considered in particular. In the field of air pollution institutional framework involves creation of a specific organizational structure and outlining the responsibilities. Institutional structure may vary as per the requirement; however the purpose is to have mechanisms for a focused dialogue and to facilitate a smooth coordination on issues pertaining to air pollution.

Action Points

Centre level

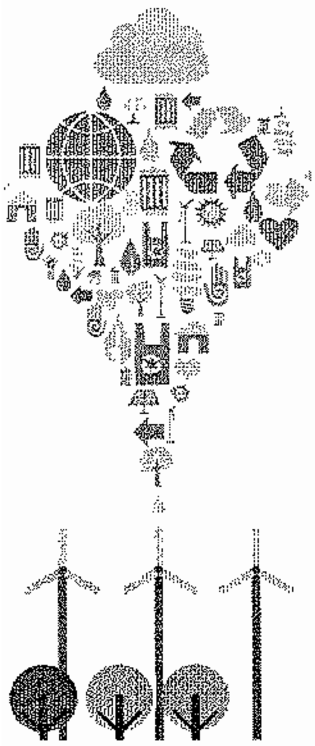
1. National Apex Committee at the MoEF&CC
2. Five sectoral working groups on a co-chairing basis
3. Technical Expert Committee at the MoEF&CC
4. National-level Project Monitoring Unit (PMU) at the MoEF&CC
5. National-level Project Implementation Unit (PIU) at the CPCB

State level

1. State-level Apex Committee under the chief secretaries in various states
2. City-level Review Committee under the municipal commissioner
3. DM-level Committee in the districts
4. State-level Project Monitoring Unit (PMU) at the SPCBs.

10 BROAD STRATEGIES AT DIFFERENT LEVELS

Level	Strategies	Implimenting Agencies
Local (city level)	▪ Control of local activities generating pollution: refuse burning, construction activities, unpaved/dusty roads ▪ Congestion management at traffic junctions: intelligent transport system (ITS), congestion pricing , low-emission zones (LEZ), etc.	▪ Municipal Corp. ▪ RO (SPCB) ▪ Traffic police
City (city/state level)	▪ Landuse planning: demand side management ▪ Transport: enhancing public transport, plying restrictions, I&M, and non-motorized transportation ▪ Waste: Solid waste management , landfill gas recovery ▪ Roads: Paving, maintenance and cleaning of roads ▪ DG set: 24x7 power supply ▪ Enforcement	▪ Dept. of Planning ▪ Dept. of Transport, ▪ Municipal Corp. ▪ PWD ▪ Dept. of Energy ▪ SPCBs
Regional (India)	▪ Transport: Auto fuel policy for stringent norms for fuel and vehicles, road to rail/ waterways, fleet modernization, electric vehicle policies, clean fuels, bye-passes, taxation policies, etc. ▪ Industries: Stringent industrial standards, clean fuels, clean technology, emission trading schemes, and enforcement (continuous monitoring) ▪ Biomass: Enhanced LPG penetration, agricultural burning control, and management	▪ MoRTH, MoPNG ▪ MoEF&CC, CPCB ▪ MoPNG, MoA
Trans-boundary	Linking INDC's target of additional forest and tree cover of 2.5 to 3 billion tonnes of CO_2 equivalent by 2030 to the NCAP. There needs to be more focus on the western regions of India (Rajasthan and Gujarat) for an enhanced tree cover, which will reduce wind-blown dust within the country and will also act as barriers for transboundary dust. Air quality management at the South-Asia regional level	MoEF&CC Intergovernmental task force.



10.1 ACTION POINT WISE AGENCIES AND TIMELINES

A Meeting was held in Department of Economic Affairs (DEA) for discussion on the funding mechanism for NCAP with reference to Memorandum for Expenditure Finance Committee (EFC) on 'Pollution Abatement' Scheme of the Ministry. NCAP is one of the sub-scheme of 'Pollution Abatement' Scheme. It concluded it to be a Central Sector Scheme, with expected contribution from State Government as the outcome of the scheme would be contingent upon the investments to be made by the States. It has also been stated by DEA in their Office Memorandum dated 14th September 2018 (Appendix V). The OM also states that other sources of funding like external sources is also to be explored. The idea is to make use of the international experiences and best practices and to expedite the implementation. Agencies and timelines are provided in the Appendix VI.

11 APPENDICES

APPENDIX I (A): STATUS OF CAAQM STATIONS INSTALLED

As on August 13, 2018

Sl. No	State	City	Station Name	No. of stations
1	Andhra Pradesh	Amaravati	Secretariat, Amaravati - APPCB	1
		Rajamahendravaram	Anand Kala Kshetram, Rajamahendravaram - APPCB	1
		Tirupati	Tirumala, Tirupati - APPCB	1
		Vijayawada	PWD Grounds, Vijayawada - APPCB	1
		Visakhapatnam	APIIC Kancharapalem, Visakhapatnam - APPCB	2
			GVM Corporation, Visakhapatnam - APPCB	
2	Bihar	Gaya	Collectorate, Gaya - BSPCB	1
		Muzaffarpur	Muzaffarpur Collectorate, Muzaffarpur - BSPCB	1
		Patna	IGSC Planetarium Complex, Patna - BSPCB	1
3	Delhi	Delhi	Alipur- DPCC	38
			Anand Vihar, Delhi - DPCC	
			Ashok Vihar, Delhi - DPCC	
			Aya Nagar, New Delhi - IMD	
			Bawana - DPCC	
			Burari Crossing, New Delhi - IMD	
			CRRI Mathura Road, New Delhi - IMD	
			Dr. Karni Singh Shooting Range, Delhi - DPCC	
			DTU, New Delhi - CPCB	
			Dwarka-Sector 8, Delhi - DPCC	
			Mundaka -DPCC	
			IGI Airport Terminal - 3, New Delhi - IMD	
			IHBAS, Dilshad Garden, New Delhi - CPCB	
			ITO, New Delhi - CPCB	
			Jahangirpuri, Delhi - DPCC	
			Jawaharlal Nehru Stadium, Delhi - DPCC	
			Lodhi Road, New Delhi - IMD	
			Major Dhyan Chand National Stadium, Delhi - DPCC	
			Mandir Marg, New Delhi - DPCC	
			Najafgarh, Delhi - DPCC	
			Narela, Delhi - DPCC	

Sl. No	State	City	Station Name	No. of stations
			Nehru Nagar, Delhi - DPCC	
			North Campus, DU, New Delhi - IMD	
			NSIT Dwarka, New Delhi - CPCB	
			Okhla Phase-2, Delhi - DPCC	
			Patparganj, Delhi - DPCC	
			Punjabi Bagh, Delhi - DPCC	
			Pitampura Delhi- IMD	
			Pusa, New Delhi - DPCC	
			Pusa, New Delhi - IMD	
			R K Puram, New Delhi - DPCC	
			Rohini, Delhi - DPCC	
			Shadipur, New Delhi - CPCB	
			Sirifort, New Delhi - CPCB	
			Sonia Vihar, Delhi - DPCC	
			Sri Aurobindo Marg- DPCC	
			Vivek Vihar, Delhi - DPCC	
			Wazirpur, Delhi - DPCC	
4	Gujarat	Ahmedabad	Maninagar, Ahmedabad - GPCB	1
5	Haryana	Faridabad	Sector- 16A, Faridabad, Haryana - HSPCB	1
		Gurugram	Vikas Sadan, Gurgaon, Haryana - HSPCB	1
		Panchkula	Sector-6, Panchkula - HSPCB	1
		Rohtak	MD University, Rohtak, Haryana - HSPCB	1
6	Jharkhand	Jorapokhar	Tata Stadium, Jorapokhar - JSPCB	1
7	Karnataka	Bengaluru	BTM Layout, Bengaluru - CPCB	10
			BWSSB Kadabesanahalli, Bengaluru - CPCB	
			Bapuji Nagar, Bengaluru - KSPCB	
			City Railway Station, Bengaluru - KSPCB	
			Hebbal, Bengaluru - KSPCB	
			Hombegowda Nagar, Bengaluru - KSPCB	
			Jayanagar 5th Block, Bengaluru - KSPCB	
			Peenya, Bengaluru - CPCB	
			Sanegurava Halli, Bengaluru - KSPCB	
			Silk Board, Bengaluru - KSPCB	
		Chikkaballapur	Chikkaballapur Rural	1
		Kalaburagi	Lal Bahadur Shastri Nagar	1
8	Kerala	Thiruvananthapuram	Plammoodu, Thiruvananthapuram - Kerala PCB	1

Sl. No	State	City	Station Name	No. of Stations
9	Madhya Pradesh	Dewas	Bhopal Chauraha, Dewas - MPPCB	1
		Mandideep	Sector-D Industrial Area, Mandideep - MPPCB	1
		Pithampur	Sector-2 Industrial Area, Pithampur - MPPCB	1
		Satna	Bandhavgar Colony, Satna - MPPCB	1
		Singrauli	Vindhyachal STPS, Singrauli - MPPCB	1
		Ujjain	Mahakaleshwar Temple, Ujjain - MPPCB	1
10	Maharashtra	Aurangabad	More Chowk Waluj, Aurangabad - MPCB	1
		Chandrapur	Chandrapur, Chandrapur - MPCB MIDC Khutala, Chandrapur - MPCB	2
		Mumbai	Bandra, Mumbai - MPCB	1
		Nagpur	Opp GPO Civil Lines, Nagpur - MPCB	1
		Nashik	Gangapur Road, Nashik - MPCB	1
		Navi Mumbai	Airoli, Navi Mumbai - MPCB	1
		Pune	Karve Road Pune, Pune - MPCB	1
		Solapur	Solapur, Solapur - MPCB	1
		Thane	Pimpleshwar Mandir, Thane - MPCB	1
11	Odisha	Brajrajnagar	GM Office, Brajrajnagar - OSPCB	1
		Talcher	Talcher Coalfields,Talcher - OSPCB	1
12	Punjab	Amritsar	Golden Temple, Amritsar - PPCB	1
		Bathinda	Hardev Nagar, Bathinda - PPCB	1
		Jalandhar	Civil Line, Jalandhar - PPCB	1
		Khanna	Kalal Majra, Khanna - PPCB	1
		Ludhiana	Punjab Agricultural University, Ludhiana - PPCB	1
		Mandi Gobindgarh	RIMT University, Mandi Gobindgarh - PPCB	1
		Patiala	Model Town, Patiala - PPCB	1
		Rupnagar	Ratanpura, Rupnagar - PPCB	1
13	Rajasthan	Alwar	Moti Doongri, Alwar, Rajasthan - RSPCB	1
		Ajmer	Civil Lines, Ajmer - RSPCB	1
		Bhiwadi	RIICO Ind. Area III, Bhiwadi, Rajasthan - RSPCB	1
		Jaipur	Adarsh Nagar, Jaipur - RSPCB Police Commissionerate, Jaipur - RSPCB Shastri Nagar, Jaipur - RSPCB	3
		Jodhpur	Collectorate, Jodhpur - RSPCB	1
		Kota	Shrinath Puram, Kota - RSPCB	1
		Pali	Indira Colony Vistar, Pali - RSPCB	1
		Udaipur	Ashok Nagar, Udaipur - RSPCB	1

Sl No	State	City	Station Name	No of stations
14	Tamil Nadu	Chennai	Alandur Bus Depot, Chennai - CPCB	3
			Manali, Chennai - CPCB	
			Velachery Res. Area, Chennai - CPCB	
15	Telangana	Hyderabad	Bollaram Industrial Area, Hyderabad - TSPCB	6
			Central University, Hyderabad - TSPCB	
			ICRISAT Patancheru, Hyderabad - TSPCB	
			IDA Pashamylaram, Hyderabad - TSPCB	
			Sanathnagar, Hyderabad - TSPCB	
			Zoo Park, Hyderabad - TSPCB	
16	Uttar Pradesh	Agra	Sanjay Palace, Agra - UPPCB	1
		Baghpat	New Collectorate- UPPCB	1
		Bulandshahr	Yamunapuram, Bulandshahr - UPPCB	1
		Ghaziabad	Vasundhara, Ghaziabad, UP - UPPCB	1
		Greater Noida	Knowledge Park - III, Greater Noida - UPPCB	1
		Kanpur	Nehru Nagar, Kanpur - UPPCB	1
		Lucknow	Central School, Lucknow - CPCB	4
			Lalbagh, Lucknow - CPCB	
			Nishant Ganj, Lucknow - UPPCB	
			Talkatora District Industries Center, Lucknow - CPCB	
		Moradabad	Lajpat Nagar, Moradabad - UPPCB	1
		Muzaffarnagar	New Mandi, Muzaffarnagar - UPPCB	1
		Noida	Sector - 125, Noida, UP - UPPCB	2
			Sector - 62, Noida, UP - IMD	
		Varanasi	Ardhali Bazar, Varanasi - UPPCB	1
17	West Bengal	Asanol	Asanol Court Area, Asanol - WBPCB	1
		Durgapur	Sidhu Kanhu Indoor Stadium, Durgapur - WBPCB	1
		Haldia	Haldia, Haldia - WBPCB	1
		Howrah	Ghusuri, Howrah - WBPCB	2
			Padmapukur, Howrah - WBPCB	
		Kolkata	Rabindra Bharati University, Kolkata - WBPCB	2
			Victoria, Kolkata - WBPCB	
		Siliguri	Ward-32 Bapupara, Siliguri - WBPCB	1

Total number of states: 17 | Total number of cities: 71 | Total number of stations installed: 134

APPENDIX I (B): STATUS OF MANUAL AMBIENT AIR QUALITY MONIROTING STATIONS OPERATING UNDER NATIONAL AIR QUALITY MONITORING PROGRAMME (NAMP)

Sl	State/Union Territory	City	Operating Monitoring Station
1	Arunachal Pradesh	Itananagar	1
		Naharlagun	1
2	Andhra Pradesh	Visakhapatnam	8
		Kakinada	1
		Rajamundry	1
		Eluru	1
		Vizianagaram	1
		Srikakulam	1
		Kurnool	1
		Tirupati	1
		Chittor	2
		Kadapa	1
		Anatapur	1
		Vijayawada	3
		Ongole	1
		Guntur	1
		Nellore	1
3.	Assam	Bongaigaon	3
		Gawahati	6
		Tezpur	1
		Sibasagar	2
		Dibrugarh	1
		Golaghat	1
		Silcher	2
		Daranga	1
		Margheita	1
		North Lakhimpur	1
		Nagaon	1
		Tinsukhia	3
		Nalbari	1
4	Bihar	Patna	2
		Barauni	1
		Mujjafarpur	1
		Gaya/Bodhgaya	1
5	Chandigarh (UT)	Chandigarh	5

SL	State/Union Territory	City	Operating Monitoring Station
6	Chattisgarh	Korba	3
		Bhilai	3
		Raipur	3
		Bilaspur	1
		Raigarh	2
7	Delhi (UT)	Delhi	10
8	Dadara & Nagar Haveli (UT)	Silvasa	2
9	Daman Diu (UT)	Daman	2
10	Goa	Panaji	1
		Vasco	1
		Marmagao	1
		Codli tisk	1
		Honda Junction	1
		Bicholim City	1
		Amona	1
		Assanora Junction	1
		Curchorem	1
		Usgao-Pale	1
		Margao Town	1
		Mapusa Town	1
		Sanguem	1
		ponda	1
		Tilamol	1
		Kundaim	1
		Tuem Industrial Estate	1
		Cuncolim	1
11	Gujarat	Ahmedabad	9
		Ankaleshwar	2
		Jamnagar	1
		Rajkot	2
		Surat	3
		Vadodara	5
		Vapi	2
12	Haryana	Faridabad	2
		Hissar	2
		Yamuna Nagar	1

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Sl	State/Union Territory	City	Operating Monitoring Station
13	Himachal Pradesh	Damtal	2
		Parwanoo	2
		Poanta Sahib	2
		Shimla	2
		Kala Amb	2
		Baddi-Barotiwala	3
		Nalagarh	1
		Una	2
		Sunder Nagar	2
		Dharamshala	2
		Marhi	1
		Gulaba	1
		Vashisht	1
		Manali	2
14	Jammu& Kashmir	Jammu	3
15	Jharkand	Dhanbad	3
		Jharia	1
		Sindri	1
		Jamshedpur	2
		Ranchi	1
		Saraikela-Kharsawan	1
		West Singhbhum	1
16	Karnataka	Bangalore	9
		Dharwar, Hubli	2
		Mangalore	1
		Hassan	1
		Mysore	2
		Gulbarga	1
		Belgaum	1
		Devanagere	3
		Mandya	1
		Raichur	1
		Bijapur	1
		Chitradurga	1
		Shimaga	1
		Karwar	1
		Bagalkote	1
		Kolar	1
		Tumkar	1
		Bidar	1

Sl.	State/Union Territory	City	Operating Monitoring Station
17	Kerala	Kozhikode	2
		Kottayam	2
		Cochin	7
		Thiruvanantapuram	4
		Palakkad	1
		Alappuzha	2
		Pathanamthitta	1
		Kollam	2
		Sulthan, Bathery, Wayanad	1
		Kakkanchery, Mallappuram	1
		Thrissur	1
18	Lakswadeep	Lakswadeep islands	1
19	Madhya Pradesh	Bhopal	8
		Indore	3
		Jabalpur	2
		Nagda	3
		Gwalior	2
		Sagar	2
		Satna	2
		Singrauli	3
		Ujjain	4
		Prithampur	2
		Chindwara	2
		Amlai	2
		Katni	2
		Dewas	3
		Aurangabad	4
		Bhiwandi	3
		Lote	2
		Tarapur	3
20	Maharashtra	Kolhapur	3
		Mumbai	3
		Ambernath	2
		Chandrapur	6
		Nagpur	7
		Nasik	4

Sl.	State/Union Territory	City	Operating Monitoring Station
		Solapur	2
		Pune	3
		Pimpri Chinchiwad	1
		Thane	3
		Navi Mumbai	6
		Mahad	3
		Roha	2
		Sangli	3
		Amravati	3
		Latur	3
		Ulhas Nagar	2
		Badlapur	1
		Nanded	3
		Jalgaon	3
		Jalna	2
		Akola	3
21	Meghalaya	Shillong	4
		Dwaki	1
		Ri-Bhoi, Brynihat	1
		Tura	1
		Nongstoin	1
		Umaim	1
		Khlihriat	1
22	Mizoram	Aizwal	5
		Lunglei	2
		Kolasib	2
		Champhai	2
23	Manipur	Imphal	1
24	Nagaland	Dimapur	2
		Kohima	2
25	Orissa	Rayagada	2
		Rourkela	6
		Talcher	2
		Angul	2
		Bhubaneshwar	6
		Cuttack	3
		Sambalpur	1
		Balasore	3
		Kalinga Nagar	3
		Berhampur	1
		Puri	2
		Konark	1
		Jarsuguda	3
		Paradeep	3

Sl.	State/Union Territory	City	Operating Monitoring Station
26	Punjab	Gobindgarh	3
		Jalandhar	4
		Ludhiana	4
		Naya Nangal	2
		Khanna	2
		Pathankot(Dera baba)	1
		Amritsar	2
		Derra Bassi	2
		Bhatinda	1
		Batala	1
		Patiala	2
		Sangrur	1
		Rasulpur	1
		Faridkot	1
		Jaito/Gurdaspur	2
		Firozpur Ludhiana District	2
		Hoshiarpur	1
27	Puducherry (UT)	Pondicherry	3
		Karaikal	3
28	Rajasthan	Alwar	3
		Jaipur	9
		Jodhpur	9
		Kota	6
		Udaipur	3
		Bharatpur	3
		Bhiwadi	3
29	Sikkim	Gangtok	2
		Namchi (South Sikkim)	1
		Jorithang / Ravangla (South Sikkim)	1
		Mangan (North Sikkim)	1
		Chungthang (North Sikkim)	1
		Singtam (East Sikkim)	1
		Rangpo (East Sikkim)	1
		Pelling (West Sikkim)	1

Sl.	State/Union Territory	City	Operating Monitoring Station
30	Tamilnadu	Chennai	11
		Tuticorin	3
		Coimbatore	3
		Madurai	3
		Salem	1
		Trichy	5
		Cuddalore	3
		Mettur	2
31	Tirupura	Agartala	2
32	Telangana	Hyderabad	10
		Ramagundum	1
		Patencheru	1
		Nalgonda	2
		Khammam	2
		Warangal	2
		Karimnagar	1
		Sangareddy	3
		Nizamabad	1
		Kothur	1
		Manchiriala, Adilabad	1
33	Uttar Pradesh	Agra	6
		Allahabad	5
		Anpara	2
		Firozabad	3
		Gajroula	2
		Ghaziabad	2
		Kanpur	9
		Lucknow	8
		Noida	2
		Varanasi	5
		Jhansi	2
		Khurja	2
		Meerut	2
		Bareily	2
		Moradabad	2
		Mathura	2
		Saharanpur	2
		Unnao	2
		Gorakhpur	3
		Rai Bareli	3

Sl	State/Union Territory	City	Operating Monitoring Station
34	Uttaranchal	Dehradun	3
		Haridwar	1
		Rishikesh	1
		Haldwani	1
		Rudrapur	1
		kashipur	1
35	West Bengal	Kolkata	20
		Durgapur	4
		Haldia	5
		Howrah	4
		Asansol	3
		South Suburban	3
		Barrckpore	3
		Sankrail	4
		Raniganj	3
		Uluberia	1
		Barasat	1
		Kalyani	1
		Ranaghat	1
		Krishnanagar	1
		Baharampur	1
		Dankuni	1
		Rishra	1
		Chinsura	1
		Tribeni	1
		Kharagpur	1
		Medinipur Town	1
		Ghatal	1
		Tamluk	1
		Bardhaman	1
		Bankura	1
		Suri	1
		Rampurhat	1
		Bolpur	1
		Purulia	1
		Malda	1
		Siliguri	1
		Jalpaiguri	1
		Darjeeling	1
		Coochbihar	2
		Balurghat	1
		Raigunj	1

Stations: 703 | Cities: 307 | States: 29 | UTs: 6

APPENDIX II:42 ACTION POINTS

Control of Vehicular Emissions

Sl. No.	Action Points	Time Frame for Implementation
i)	Launch extensive awareness drive against polluting vehicles;	Immediate
ii)	Ensure Strict action against visibly polluting vehicles;	Immediate
iii)	Install weigh i n mot ion bridges at Delhi borders to prevent overloading;	Immediate
iv)	Take steps to prevent parking of vehicles in the non-designated areas;	Immediate
v)	Introduce early alarm system for benefit of commuters related to traffic congestion on major routes for route diversion ;	Immediate
vi)	Consider introducing plan for Flexi/staggered timings to minimize peak movement of vehicles on the road;	Immediate
vii)	Take steps for retrofitting of diesel vehicles with Particulate Filters;	Immediate
viii)	De-congest pathways;	Immediate
ix)	Synchronize traffic movements / Introduce intelligent traffic systems for lane-driving;	30 days
x)	Install vapor recovery system in fueling stations;	30 days
xi)	Take steps for installation of remote sensor based PUC system etc.;	90 days
xii)	Formulate action plan for controlling decongestion of fuel stations including increasing number of dispensing machines;	90 days
xiii)	Prepare action plan to check fuel adulteration and random monitoring of fuel quality data;	90 days
xiv)	Prepare action plan for public transport on CNG mode;	90 days
xv)	Undertake road widening and improvement of infrastructure for decongestion of road ;	90 days
xvi)	Promote battery operated vehicles;	90 days
xvii)	Take steps to expedite early completion of Western and Eastern Peripheral expressway and submit completion schedule;	60 days

Control of Road Dust Re-suspension of Dust and Other Fugitive Emission

Sl. No	Action Points	Time Frame for implementation
i)	Formulate action plan for creation of green buffers along the traffic corridors;	immediate
ii)	Introduce wet/ mechanized vacuum sweeping of roads;	30 days
iii)	Maintain pot holes free roads for free-flow of traffic to reduce emissions and dust;	60 days
iv)	Introduce water fountains at major traffic intersect ion, wherever feasible;	90 days
v)	Undertake greening of open areas, gardens, community places, schools and housing societies;	90 days
vi)	Take steps for blacktopping/pavement of road shoulders to avoid road dust;	180 days

Control of Air Pollution from Bio-Mass Burning

Sl. No.	Action Points	Time Frame for implementation
i)	Take stringent action against open burning of bio-mass mass/leaves/tyres etc to control such activities and submit periodic status reports;	Immediate
ii)	Ensure proper collection of horticulture waste (bio-mass) and composting-cum-gardening approach;	Immediate
iii)	Ensure strict enforcement of ban on burning of agriculture waste and crop residues;	Immediate
iv)	Prohibit use of coal in hotels and restaurants and eliminate use of kerosene for cooking in Delhi ;	60 days

Control of Industrial Air Pollution

Sl. No.	Action Points	Time Frame for implementation
i)	Ensure strict action against unauthorized brick kilns;	30 days
ii)	Ensure strict action against industrial units not complying with standards ;	60 days
iii)	Enforce strict compliance of conversion of Natural draft brick kilns to induced-draft;	90 days
iv)	Launch action plan for switching over to natural gas by industries, wherever feasible.	120 days

Control of Air Pollution from Construction and Demolition Activities

Sl. No.	Action Points	Time frame for implementation
i)	Control dust pollution at construction sites through appropriate cover;	Immediate
ii)	Undertake control measures for fugitive emissions from material handling, conveying and screening operations through water sprinkling, curtains, barriers and dust suppression units;	30 days
iii)	Ensure carriage of construction material in closed/cove red vessels;	30 days

Other Steps to control Air Pollution

Sl. No.	Action Points	Time Frame for implementation
i)	Set-up helpline in States/UT for taking action against reported compliance;	Immediate
ii)	Evolve a system of reporting of garbage / municipal solid waste burning through mobile based applications and other social media platform linked with Central and State level Control Rooms;	30 days
iii)	Establish Standard Operating Procedure to provide quick and effective response to complaints;	30 days
v)	Ensure DG sets meeting the standards only be allowed to operate;	30 days
vi)	Promote use of LPG instead of coal in restaurants/ dhabas/ road side;	90 days
vii)	Undertake Satellite based monitoring for tracking and enforcing agriculture;	90 days
viii)	Take steps for setting up of bio-mass based power generation units;	One year

APPENDIX III: GRADED RESPONSE ACTION PLAN

The graded measures according to AQI are listed from public health emergency level to downward. The measures are cumulative. Emergency and Severe levels include cumulatively all other measures listed in the lower levels of AQI including Very Poor, Poor and Moderate. It is also clear that the actions listed in the poor category need to be implemented though out the year. But during months when weather conditions turn more adverse there is need for greater scrutiny on enforcement.

Severe + or Emergency	Agency responsible/ Implementing Agency
When $PM_{2.5}$ levels cross 300 µg/m³ or PM_{10} levels cross 500 µg/m³ (5 times above the standard) and persist for 48 hours or more	
Stop entry of truck traffic into Delhi (except essential commodities)	Municipal Corporations and Traffic Police of Delhi and NCR Towns
Stop construction activities	Delhi Pollution Control Committee/Municipal Corporations of Delhi and NCR towns
Introduce odd and even scheme for private vehicles based on license plate numbers and minimize exemptions	Secretary cum Commissioner of Transport Department, NCT of Delhi, and Transport Commissioners of NCR towns
Task Force to take decision on any additional steps including shutting of schools	
Severe	
When $PM_{2.5}$ levels are above 250 µg/m³ or PM_{10} levels are above 430 µg/m³	
Close brick kilns, Hot Mix plants, Stone Crushers	Chairpersons of Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh Superintendent of Police and Deputy Commissioner of respective districts
Shut down Badarpur power plant and maximize generation of power from existing natural gas based plants to reduce operation of coal based power plants in the NCR.	Chairpersons of Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh
Intensify public transport services. Introduce differential rates to encourage off-peak travel.	Secretary cum Commissioner of Transport Department, NCT of Delhi, and Transport Commissioners of NCR towns Chairperson, Delhi Metro Rail Corporation (DMRC)

Severe + or Emergency	Agency responsible/ Implementing Agency
When $PM_{2.5}$ levels cross 300 µg/m³ or PM_{10} levels cross 500 µg/m³ (5 times above the standard) and persist for 48 hours or more	
	Chairpersons, State Transport Corporations
Increase frequency of mechanized cleaning of road and sprinkling of water on roads. Identify road stretches with high dust generation.	All road owning agencies including Municipal Corporations of NCT of Delhi and NCR towns, Public Works Departments and National Highway Authority of India
Very Poor	
When $PM_{2.5}$ levels are between 121-250 µg/m³ or	
PM_{10} levels are between 351-430 µg/m³	
Stop use of diesel generator sets	Chairpersons of Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, Uttar Pradesh
Enhance parking fee by 3-4 times	Municipal Commissioner Municipal Corporations of NCT of Delhi and NCR towns
Increase bus and metro services by augmenting contract buses and increasing frequency of service	Principal Secretary, Department of Transport of NCT of Delhi Delhi Transport Corporation (DTC) Delhi Integrated Multi-modal Transit System Ltd (DIMTS) Delhi Metro Rail Corporation (DMRC) State Transport Corporations in NCR towns
Stop use of coal/firewood in hotels and open eateries	Municipal Corporations of NCT of Delhi and NCR towns
Residential Welfare Associations and individual house owners to provide electric heaters during winter to security staff to avoid open burning by them	Resident Welfare Associations
Alert in newspapers/TV/radio to advise people with respiratory and cardiac patients to avoid polluted areas and restrict outdoor movement.	Chairpersons, Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh
Moderate to poor	

Severe + or Emergency	Agency responsible/ Implementing Agency
When $PM_{2.5}$ levels cross 300 µg/m³ or PM_{10} levels cross 500 µg/m³ (5 times above the standard) and persist for 48 hours or more	
Poor – When $PM_{2.5}$ levels are between 91-120 µg/m³ or	
PM_{10} levels are between 251-350 µg/m³	
Moderate – When $PM_{2.5}$ is between 61-90 µg/m³ or	
PM_{10} is between 101-250 µg/m³	
Stringently enforce/stop garbage burning in landfills and other places and impose heavy fines on person responsible	Municipal Commissioner Municipal corporations of Delhi and NCR towns
Close/stringently enforce all pollution control regulations in brick kilns and industries	Chairpersons, Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh
Stringently enforce pollution control in thermal power plants through PCB monitoring	Plant in-charge of power plants in NCR, and Delhi Pollution Control Committee and State Pollution Control Boards of Haryana, Rajasthan and Uttar Pradesh
Do periodic mechanized sweeping on roads with heavy traffic and water sprinkling also on unpaved roads every two days	Municipal Commissioner, Municipal Corporations of NCT of Delhi and NCR towns Commissioners, Traffic Police of Delhi and NCR towns to identify roads with heavy traffic and provide information to respective Municipal Commissioners Chief Engineers of officers in charge of CPWD, PWD of Delhi and NCR towns to identify unpaved roads with heavy traffic and provide information to respective Municipal Commissioners
Strict vigilance and no tolerance for visible emissions – stop plying of visibly polluting vehicles by impounding or heavy fine.	Commissioner or Officer in Charge, Transport Department and Traffic Police of NCT Delhi and NCR towns
Strict norms vigilance and enforcement of PUC	
Stringently enforce rules for dust control in construction activities and close non-compliant sites	Commissioner or Officers in charge of Police Departments of Delhi and NCR towns

Severe + or Emergency	Agency responsible/ Implementing Agency
When $PM_{2.5}$ levels cross 300 µg/m³ or PM_{10} levels cross 500 µg/m³ (5 times above the standard) and persist for 48 hours or more	
Deploy traffic police for smooth traffic flow at identified vulnerable areas	Commissioners of Traffic Police of Delhi and NCR Towns
Strictly enforce Supreme Court order on diversion of non-destined truck traffic and ensure only trucks registered after 2005 are allowed entry into Delhi	Municipal Corporations of NCT of Delhi and NCR towns Traffic Police of NCT of Delhi and NCR towns
Strictly enforce Supreme Court on firecrackers ban	Chief Controller of Explosives Petroleum and Explosive Safety Organizations (PESO) Commissioner of Officer in charge of licensing in the police departments of Delhi and NCR
Ensure fly ash ponds* are watered every alternate day during summer months (March – May).	Plant in charge of Power Plants in Delhi and NCR towns
Information dissemination—Social media, mobile Apps should be used to inform people about the pollution levels, contact details of control room, enable them to report polluting activities/sources to the concerned authorities, and actions that will be taken by government based on the level of pollution.	Chairpersons, Delhi Pollution Control Committee, State Pollution Control Boards of Haryana, Rajasthan, and Uttar Pradesh

Note: * IIT Kanpur Report finds high fly ash in air during summer months. Therefore, action is necessary during this period. But long term action has to be removal of this source of pollution from Delhi and its vicinity through the reuse and removal of all fly ash dumps.

APPENDIX IV: GLOBAL EXPERIENCES

City, Country	Highest Concentration	% Reduction	Timeframe
Beijing, China	$PM_{2.5}$ > 100 $\mu g/m^3$	<40%(to <60 $\mu g/m^3$)	5 years (2013-2017)
Mexico City, Mexico	PM_{10}> 180 $\mu g/m^3$	73%(to 48 $\mu g/m^3$)	25 years (1990-2015)
Santiago, Chile	$PM_{2.5}$ > 54 $\mu g/m^3$	61%(to 21 $\mu g/m^3$)	22 years (1989/90-2011/12)
Seoul, South Korea	$PM_{2.5}$ > 40 $\mu g/m^3$	35%(to 26 $\mu g/m^3$)	5 years (2002-2008)
Ulan Batar, Mongolia	$PM_{2.5}$ > 250 $\mu g/m^3$	64%(to 90 $\mu g/m^3$)	6 years (2009-2015)
Bangkok, Thailand	PM_{10} > 85 $\mu g/m^3$	(to 40 $\mu g/m^3$)	13 years (1997-2010)

APPENDIX V: OFFICE MEMORANDUM BY DEA

F.No.54 (05)/PFC-I/2017
Government of India
Ministry of Finance
Department of Expenditure
Public Finance Central-I Division

North Block, New Delhi.
Dated: 14th September, 2018

OFFICE MEMORANDUM

Subject: Revised Draft Memorandum for Expenditure Finance Committee (EFC) for "Pollution Abatement" Scheme for the year 2018-19 and 2019-20-reg.

The undersigned is directed to refer to Minister of Environment Forests Climate Change (M/o EF&CC) CP Division's Revised Draft Memorandum for Expenditure Finance Committee (EFC) for "Pollution Abatement" Schemes for the year 2018-19 and 2019-20 submitted vide O.M. No. G-27017/02/2017-CPW dated 5th September 2018 and to state that

(i) The response of M/o EF&CC to the comments of this Department submitted vide O.M. of even number dated 24th July 2018 may be suitably incorporated in the final EFC Memo.

(ii) It may be ensured that the financial estimates are realistic and within the Medium Term Expenditure Framework (MTEF) of M/o EF&CC and also within the budgetary resources available/likely to be available.

(iii) Other sources of funding like external sources may be explored. It may be ensured that there is adequate convergence with the existing schemes within M/o EF&CC and schemes of other Ministries catering to similar objectives and duplication of efforts be avoided.

(iv) Funds may be arranged out of the savings made under available schemes of the Ministry through re-appropriation.

(v) As the outcome of the scheme would be contingent upon the investments to be made by the States, more involvement of the States in the area of funding may be explored.

2. This issues with the approval of Additional Secretary (Expenditure).

Swayamprava Pani 14/9/18

(Swayamprava Pani)
Joint Director (PFC-I)
Tel No. 23092280

Ministry of Environment, Forests & Climate Change,
[Shri R.N. Pankaj, Scientist 'D' (CP Division)],
2nd Floor, Prithvi Wing, Indira Paryavaran Bhawan,
Aliganj, Jor Bagh Road, New Delhi.

APPENDIX VI: NCAP– AGENCIES AND TIMELINES

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1	**AIR POLLUTION MITIGATION ACTIONS**				
1.1	**STRINGENT ENFORCEMENT THROUGH A THREE-TIER MECHANISM FOR REVIEW MONITORING, ASSESSMENT, AND INSPECTION**				
1.1.1	Web-based system on the above line to be evolved in association with the NIC and other relevant national and international agencies.	Centre	Centre/ State	MoEF&CC/ CPCB	2020
1.1.2	Intensive training of all the stakeholders involved in the implementation of this web-based system.	Centre	State/ City	MoEF&CC/ CPCB	Ongoing
1.1.3	Mandatory use of this three-tier mechanism in 102 cities.	State/ City	State/ City	MoEF&CC/ CPCB	ongoing
1.1.4	Review of the existing legislations to ensure an effective implementation of the NCAP	Centre	Centre/ State	MoEF&CC/ CPCB	2019
1.2	**EXTENSIVE PLANTATION DRIVE**				
1.2.1	Plantation initiatives under the NCAP at pollution hot spots in the cities/towns to be undertaken under GIMs with Compensatory Afforestation Fund (CAF) being managed by National Compensatory Afforestation Management and Planning Authority (CAMPA).	State	State/City	MoEF&CC	Ongoing

Sl. No	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.2.2	Institutes, such as the Indian Institute of Forest Management (IIFM), universities, such as the University Delhi, and other research organizations and institutions with expertise in plantation are to be involved for developing these plans along with ensuring the implementation in the identified 102 cities.	Centre	Cities/ States	MoEF&CC	2019
1.2.3	Execution of city-specific plantation plans.	State	Cities/ States	MoEF&CC	ongoing
1.3	**TECHNOLOGY SUPPORT**				
1.3.1	Clean technologies with potential for air pollution mitigation will be supported for R&D, pilot-scale demonstration, and field-scale implementation.	Centre	Cities/ States	MoEF&CC	2024
1.3.2	The mechanism for such support will be formulated as an action plan.	Centre	Centre	MoEF&CC	2019
1.4	**REGIONAL AND TRANSBOUNDARY PLAN**				
	Regional Measures				

Sl.No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.4.1	Various measures, especially the implementation of pollution-abatement policies need to be emphasized through regional-level interstate coordination for the Indo-Gangetic plain. The following policies should be taken into consideration:	Centre/ State	States	MoRTH, MoPNG	ongoing
	Transport: Auto fuel policy for stringent norms for fuel and vehicles, road to rail/ waterways, fleet modernization, electric vehicle (EV) policies, clean fuels, bypasses, taxation policies, etc.			MoEF&CC, CPCB	
	Industries: Stringent industrial standards, clean fuels, clean technology, and enforcement (continuous monitoring)			MoPNG, MoA, MoHUA	
	Biomass: Enhanced LPG penetration, agricultural burning, control, and management				
1.4.2	A comprehensive regional plan to be formulated incorporating the inputs from the regional source apportionment studies.	Centre	Centre/ State		2020
	Transboundary Measures				

Sl.No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.4.3	Linking the NDC's target of an additional forest and tree cover of 2.5 to 3 billion tonnes of CO2 equivalent by 2030 to the NCAP. There needs to be more focus on the western regions of India (Rajasthan and Gujarat) for an enhanced tree cover, which will reduce wind-blown dust within the country and will also act as a barrier for transboundary dust.	Centre	State	MoEF&CC	2019
1.4.4	The initiatives under the United Nations Convention to Combat Desertification (UNCCD) to be integrated here for addressing the issue of transboundary dust.	Centre	Centre	MoEF&CC	2019
1.4.4	Air quality management at the South-Asian regional level by activating the initiatives under 'Male Declaration on Control and Prevention of Air Pollution and Its Likely Transboundary Effects for South Asia' and SACEP to be explored.	Centre	Centre	MoEF&CC	2019
1.4.5	A comprehensive transboundary plan to be formulated	Centre	State	MoEF&CC	2019
	SECTORAL INTERVENTIONS				
1.5	**DUST MANAGEMENT (ROAD DUST and C&D)**				
1.5.1	Introducing mechanical sweepers on the basis of feasibility study in cities.	State	State	MoHUA, Municipal Corporation	ongoing
1.5.2	Evolve SOP for addressing the specific issue of disposal of the collected dust from mechanical sweeping.	Centre	Cities/State	MoEF&CC/ CPCB	2019

Sl No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.5.3	Stringent implementation of C&D Rules, 2016, and Dust Mitigation Notification, 2018, of the Government of India.	Centre/ State	Cities/State	CPCB, SPCBs, Municipal Corporation	ongoing
1.5.4	Wall-to-wall paving of roads to be mandated.	State	Cities/State	Municipal Corporation	ongoing
1.5.5	Control of dust from construction activities by using enclosures, fogging machines, and barriers along with a close adherence to the C&D rules, - stringent implementation of C&D Rules	State	Cities/State	SPCBs, Municipal Corporation	ongoing
1.5.6	Greening and landscaping of all the major arterial roads and national highways after identifying all the major polluting stretches.	State	Cities/State	SPCBs, Municipal Corporation	ongoing
1.5.7	Maintenance and repair of roads on priority.	State	Cities/State	SPCBs, Municipal Corporation	ongoing
1.5.8	Sewage treatment plant-treated water sprinkling system with PVC (Polyvinyl Chloride) pipeline along the roads and at intersecting road junctions and spraying of water twice a day before peak traffic hours.	State	Cities/State	SPCBs, Municipal Corporation	ongoing
1.6	**INDOOR AIR POLLUTION MANAGEMENT**				
1.6.1	Building specific guidelines and protocols on monitoring and management of indoor air pollution.	Centre	Centre	MoEF&CC, CPCB, MoH	2019
1.6.2	Extend PMUY in 102 cities, towns, and associated village areas.	Centre	City/ State	MoPNG	2019

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.6.3	Guidelines and provisions for building designs that define proper ventilation, clean cooking and living area to maintain healthy air quality inside the house to be integrated with Pradhan Mantri Awas Yojana (PMAY)	Centre	Centre/ State	MoHUA, MoRD	2019
1.7	**POWER SECTOR EMISSIONS**				
1.7.1	Stringent compliance by all TPPs with respect to the emission norms according to the timelines up to December 2022, and as per the action plan prescribed in the direction dated December 2017, issued under the EPA, 1986.	State	State	MoP, MoEF&CC	2022
1.7.2	The CGD network distribution shall be taken up on priority within the country, emphasizing on 102 non-attainment cities.	State	City/State	MoPNG	2019
1.7.3	There is a need for optimizing the use of the existing power plants by prioritizing the capacity utilization of natural gas/ clean fuel-based thermal power plants.	State	State	MoPNG	2021
1.7.4	Phasing out older coal-based power plants and converting the specific coal-based power plants to natural gas.	State	City/State	MoP, MoPNG	2024
1.7.5	Emphasis on improved power reliability in urban areas to eliminate the operation of the DG sets. A 30% reduction in the usage of DG sets.	State	City/State	MoP, D/o Energy, DISCOMs	2024

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.7.6	Emphasizing the expansion of renewable power initiatives prioritizing the use of the existing framework of the NAPCC in non-attainment cities.	Centre	City/State	MoP, MNRE, MoEF&CC	2024
1.8	**INDUSTRIAL EMISSION**				
1.8.1	Introduction of gaseous fuels in industries, including SMEs. The report for 102 cities has been completed.	State	State	D/o Heavy Industry, SPCBs	2022
1.8.2	Enforcement of new and stringent SO_2/NO_x/ $PM_{2.5}$ standards for industries using solid fuels.	State	State	SPCBs, CPCB	immediately
1.8.3	Stricter enforcement of standards in large industries through continuous monitoring.	State	State	SPCBs, CPCB	immediately
1.8.4	Full enforcement of zig-zag brick technology in brick kilns.	State	State	SPCBs, CPCB	immediately
1.8.5	Elimination of the usage of industrial DG sets by the provision of round-the-clock 24x7 electricity.	State	City/State	MoP, D/o Energy, DISCOMs	
1.8.6	Evaluate and evolve industry-specific innovative end-pipe control technologies.	Centre	City/State	MoEF&CC, CPCB	2024
1.8.7	Evolve standards and norms for in-use DG sets.	Centre	City/State	CPCB, MoEF&CC	2020
1.8.8	Ensure that only the DG sets that meet the standards are the ones allowed to be marketed and sold.	State	City/State	SPCB, CPCB	immediately

Sl. No	Component/Activities	Level for Funding	Level For Implemen-tation	Agencies	Timeline (Year)
1.8.9	For the DG sets already operational, ensure usage of either of the two options: (i) Use of retrofitted emission-control equipment with a minimum specified PM-capturing efficiency of at least 70%, type approved by one of the five CPCB-recognized labs. (ii) Shifting to gas-based generators by employing new gas-based generators or retrofitting the existing DG sets for partial gas usage.	State	City/State	SPCB, CPCB	2022
1.8.10	Utilize the Gujarat case study for a compelling case for the other states to adopt third-party audits for polluting industries for enhancing implementation.	State	City/State	SPCBs, CPCB	2021
1.9	**TRANSPORT SECTOR EMISSION**				
1.9.1	Stringent implementation of BS VI norms all over India by April 2020.	State	City/State	MoRTH, D/o Transport, SPCB	2020
	Green Mobility				
1.9.2	Stringent implementation of the national biofuel policy with respect to ethanol and biodiesel blending target of 20% and 5%, respectively by 2030.	Centre	State	MoP, MNRE, MoA	2030
1.9.3	City action plans to review the extension of Mass Rapid Transit (MRT) in cities/towns.	Centre	City/State	MoRTH, D/o Transport, CPCB	2024

Sl. No	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.9.4	Improvement and strengthening of inspection and maintenance systems for vehicles through the extension of inspection and certification (I&C) centres.	Centre	City/State	MoRTH, D/o Transport	2022
1.9.5	Stringent implementation of the PUC certificate through regular inspection and monitoring.	State	City/State	MoRTH, D/o Transport	immediately
1.9.6	Fleet modernization and retrofitting programmes with control devices in place.	Centre	City/State	MoRTH, D/o Transport	2020
1.9.7	Reducing real-world emissions by congestion management.	State	State	D/o Transport	immediately
1.9.8	Review the 'Green Corridor' project and the feasibility of its extension with reference to the 102 cities.	Centre	City/State	MoPNG, MNRE	2022
1.9.9	To review the scaling up of the pilot project of the MoPNG for introducing CNG in two-wheelers and ensure a timely implementation.	Centre	City/State	MoPNG	2020
1.9.10	Scaling up of R&D on the use of hydrogen as a transport fuel.	Centre	City/State	MoPNG &MNRE	2022
	E-Mobility				
1.9.11	Formulation of national-, state-, and city-specific action plans for e-mobility.	Centre	City/ State	MoP, DHI, NITI Aayog, MoEF&CC	2021
1.9.12	Rapid augmentation of the charging infrastructure in the country focusing on the identified 102 cities.	Centre	City/ State	MoP, DHI	2024

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Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.9.12	Central government offices fleets older than 15 years to be shifted to EVs.	Centre	Centre	MoP, DHI	2020
1.9.13	Government-run buses for public transport, private buses, and three-wheelers to be converted to EVs.	Centre	City/ State	MoP, DHI	2024
1.9.14	Gradual transition to e-mobility in the two-wheeler sector.	Centre	City/ State	MoP, DHI	2024
1.9.15	Specific allocations for creating a venture capital fund for e-mobility.	Centre	Centre	DoE, MoF	2020
1.9.16	Investment in R&D and pilots focusing on the indigenization of battery manufacturing, cheap alternate resource to lithium and cobalt, resource efficiency associated with a circular economy, re-use and recycling of lithium batteries, etc.	Centre	Centre	MoEF&CC	ongoing
1.10	**AGRICULTURAL EMISSION**				
1.10.1	Evaluate the status of the implementation of the MoA-funded scheme in the states and the impact on the reduction of air pollution in Delhi and the NCR.	Centre	States	MoEF&CC, CPCB	2024
1.10.2	Evaluate the socio-economic feasibility for the implementation of ex-situ options, such as production of Prali-Char, biochar, pellets, briquettes, bioCNG, bioethanol, etc., as ex-situ solutions for the management of crop residue burning, especially with the NPB in place.	Centre	State	MoA, MoEF&CC, CPCB	2020

Sl No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.10.3	Extending the initiatives for addressing the issue of crop residue burning from the NCR to other parts of the country and from paddy to sugarcane and other crops.	Centre	State	MoA, MoEF&CC, CPCB	2020
1.10.4	Coordination with ISRO for a regular availability of remote sensing monitoring data for crop burning by the farmers.	Centre	Centre	MoEF&CC, CPCB	2019
1.10.5	Evolve a plan for the management of agricultural emissions from fertilizers and livestock waste on the basis of strong R&D.	Centre	Centre	MoEF&CC MoA	2020
1.10.6	Implement plan for the management of agricultural emissions.	Centre	State	MoA	2024
1.11	**WASTE MANAGEMENT**				
1.11.1	Formulate plan for use of Smart Cities framework to launch NCAP in the 43 smart cities falling in the list of 102 non-attainment cities.	Centre	City/State	MoHUA, MoEF&CC	2019
1.11.2	Transform our centralized waste disposal infrastructure to a sustainable decentralized system in 102 cities.	State	City/State	MoHUA, MoEF&CC	2024
1.11.3	Source segregation into dry and wet waste to be made mandatory through the involvement of municipalities and the RWA.	State	City/State	MoHUA, Municipal Corporation	2020
1.11.4	Mandatory training and capacity building of municipalities and the RWA.	State	City/State	MoHUA, Municipal Corporation	ongoing

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.11.5	Formulation of a city-specific plan for transitioning towards a zero-waste pathway through an integrated solid waste management strategy, including targeting waste prevention, recycling, composting, energy recovery, treatment, and disposal.	Centre	City/State	MoHUA, Municipal Corporation	2020
1.11.6	Stringent implementation of integrated waste management plan in cities.	State	City/State	MoHUA, Municipal Corporation	ongoing
1.11.7	Waste reduction schemes, such as the 'polluters pay' principle, recycling projects, composting, biomethanation, RDF plants, and co-processing to be supported under an integrated solid waste management strategy.	State	City/State	MoHUA, Municipal Corporation	2020
1.11.8	Construction of a decentralized compositing plant, biomethanation plant, and C&D waste plants.	State	City/State	MoHUA, Municipal Corporation	2024
1.11.9	Deployment of a fixed compactor and doing away with dhalaos.	State	City/State	MoHUA, Municipal Corporation	2024
1.11.10	Focus on training the municipalities and SPCBs to be on national and international technologies for integrated waste management options.	Centre	City/State	MoHUA, MoEF&CC, Municipal Corporation	ongoing

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.11.11	In line with the National Biofuel Policy, promote technologies which can convert waste/plastic and cause the MSW to drop in fuels. A tonne of such waste has the potential to provide a 20% (approx.) of drop in fuels.	Centre	City/State	MNRE, MoHUA, Municipal Corporation	2020
1.11.12	Stringent implementation and monitoring for extended producer responsibility for e-waste and plastic waste.	State	City/State	CPCB, SPCB, Municipal Corporation	immediately
1.11.13	Strict implementation of the existing six waste management rules on solid, hazardous, electronic, bio-medical, plastics, and C&D waste.	State	City/State	CPCB, SPCB, Municipal Corporation	immediately
1.11.14	The Swachh Bharat Mission and National Mission on Sustainable Habitat to be used as platforms to push the objectives of this sector.	Centre	City/State	MoHUA, MoEF&CC	immediately
1.12	**CITY-SPECIFIC AIR QUALITY MANAGEMENT PLAN FOR 102 NON-ATTAINMENT CITIES**				
1.12.1	Preliminary city-specific action plans to be formulated for 102 non-attainment cities.	Centre	City/State	CPCB, MoEF&CC	2019
1.12.2	City-specific action plans to be taken up for implementation by the state government and city administration.	State	City/State	D/o Environment, SPCB	2020

Sl. No	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
1.12.3	City-based clean air action plans should be dynamic and evolve based on the available scientific evidence, including the information available through source apportionment studies.	Centre	City/State	CPCB, MoEF&CC	2020
1.12.4	A separate emergency action plan in line with GRAP for Delhi to be formulated for each city for addressing the severe and emergency AQI.	Centre	City/State	CPCB, MoEF&CC	2020
1.13	**STATE ACTION PLAN FOR AIR POLLUTION**				
1.13.1	A preliminary state action plan for air pollution to be formulated for all the 23 states, which harbour 102 non-attainment cities.	Centre	State	SPCB, CPCB, MoEF&CC	2020
1.13.2	State action plan for air pollution to be taken up for implementation by the state government and city administration.	State	State	State Govt	2020
1.13.3	The guidelines for the preparation of the state action plan to be formulated.	Centre	Centre	MoEF&CC, CPCB	2019
2	**KNOWLEDGE AND DATABASE AUGMENTATION**				
2.1	**AIR QUALITY MONITORING NETWORK**				
2.1.1	Augment the manual monitoring stations from the existing 703 stations to 1,500 stations.	Centre	City/State	CPCB, SPCBs	2024
2.1.2	150 CAAQMS with an average of 2–3 stations in each city to be installed, prioritizing the Indo-Gangetic plain.	Centre	City/State	CPCB, SPCBs	2024
2.1.3	Satellite-based measurements.	Centre	City/State	CPCB, SPCBs, SAC, ISRO	2024

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
2.1.3	Identification of an alternative technology for real-time monitoring with an impetus on low-cost indigenous real-time monitoring stations and promoting real-time monitoring in other cities with these low-cost sensors. With average of 10 sensors in each city, 1,000 sensors are being targeted.	Centre	City/State	CPCB, SPCBs	2024
2.1.4	Mobile air quality monitoring network to be made part of these alternative technologies. At least one mobile monitoring station for each city is to be considered. This will facilitate preliminary assessment in areas without conventional monitoring stations.	Centre	City/State	CPCB, SPCBs	2024
2.1.5	Set-up 100 monitoring stations in the rural areas.	Centre	City/State	CPCB, SPCBs	2024
2.1.6	Review the existing guidelines and issue a protocol for the setting up of monitoring stations and monitoring.	Centre	City/State	CPCB, SPCBs	2024
2.1.7	Augment the number of monitoring stations for $PM_{2.5}$ from the existing 167 in 80 cities to all stations under NAMP.	Centre	City/State	CPCB, SPCBs	2024
2.1.8	Set-up 10 city Super Network to generate highly-quality controlled data and represent national air quality dynamics.	Centre	City/State	CPCB, SPCBs, MoEF&CC	2021

Sl. No	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
2.1.9	The plan for 10 city Super Networks to be formulated.	Centre	Centre	CPCB, MoEF&CC	2019
2.1.10	Super sites as representative sites in cities and rural areas	Centre	Centre	CPCB, MoEF&CC	2019
2.2	**EXTENDING SOURCE APPORTIONMENT STUDIES TO ALL NON-ATTAINMENT CITIES**				
2.2.1	Unified guidelines for source apportionment study will be formulated and updated.	Centre	Centre	CPCB, MoEF&CC	2019
2.2.2	Source apportionment studies to be extended to all 102 non-attainment cities.	Centre	Cities/State	MoEF&CC, CPCB	2020
2.3	**AIR POLLUTION HEALTH AND ECONOMIC IMPACT STUDIES**				
2.3.1	Study on the national environmental health profile to be completed in time.	Centre	Centre	MoEF&CC	2019
2.3.2	Response study and cohort study programme to be undertaken.	Centre	Centre	MoH&FW	2019
2.3.3	Ministry of Health to actively take up environmental health for ensuring a regular health profile or database for assisting decision making.	Centre	Centre	MoH&FW	2019

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
2.3.4	Framework for a monthly analysis of data wrt health to be created. The data from mapping of the industry; tabulation of a daily AQI, $PM_{2.5}$ and PM_{10} measurements (24 hours average); metrological parameters; deaths due to heart attack, strokes, respiratory arrest following the existing respiratory ailments, trends in lung cancer if available wrt all cities to be fed in to a central computer and to be analysed every month by people trained in environmental health for correct interpretation.	Centre	Centre	MoH&FW	2024
2.3.5	Awareness and orientation workshops shall focus on a target audience and the media is to be used for a wide dissemination of information. However, the precise information to be shared has to be carefully worked out by a team of experts in air pollution and environmental health.	Centre	Centre	MoH&FW, MoEF&CC, CPCB	2024
2.3.6	Training researchers in study design through holding workshops in epidemiology, toxicology, and biostatistics.	Centre	Centre	MoH&FW, MoEF&CC, CPCB	2024
2.3.7	Studies on health and economic impact of air pollution to be supported.	Centre	Centre	MoH&FW, MoEF&CC, CPCB	2024

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Sl No	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
2.3.8	Media is to be used for wide dissemination of information and the precise information to be shared has to be carefully worked out by a team of experts in air pollution and environmental health.	Centre	Centre	MoH&FW	2024
2.4	**INTERNATIONAL COOPERATION INCLUDING SHARING OF INTERNATIONAL BEST PRACTICES ON AIR POLLUTION**				
2.4.1	International scientific and technical cooperation in the area of air pollution will be established in accordance with national priorities and socio-economic development strategies and goals.	Centre	Centre	MoEF&CC	2019
2.4.2	Modalities of such cooperation may include joint research and technology development, field studies, pilot -scale plants, and field demonstration projects with an active involvement of academia, research institutions, and industry on either side. Funding for co-financing purposes are to be indicated.	Centre	Centre	MoEF&CC	2019
2.5	**REVIEW OF AMBIENT AIR QUALITY STANDARDS AND EMISSION STANDARDS**				
2.5.1	Guidelines with respect to the periodicity of reviews of such standards to be formulated.	Centre	Centre	CPCB, MoEF&CC	2020

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
2.5.2	The existing standards need to be strengthened periodically and new standards need to be formulated for the sources where the standards are not available, based on extensive scientific evidence with reference to the protection of public health and environment.	Centre	Centre	MoEF&CC	2024
2.6	**NATIONAL EMISSION INVENTORY**				
2.6.1	A comprehensive national emissions inventory, which is still lacking in the country will be formalized under the NCAP.	Centre	Centre	MoEF&CC, CPCB	2020
3	**INSTITUTIONAL STRENGTHENING**				
3.1	**PUBLIC AWARENESS AND EDUCATION**				
3.1.1	City-specific awareness programme targeting key stakeholders to be formulated and taken up for implementation.	Centre	State	CPCB, SPCBs	ongoing
3.2	**TRAINING AND CAPACITY BUILDING**				
3.2.1	Extensive capacity-building programme for both the CPCB and SPCBs with reference to both manpower and infrastructure augmentation.	Centre	Centre, State	MoEF&CC, CPCB, SPCBs	2020
3.2.2	Intensive training, comprising national and international best practices and technological options, of all the associated stakeholders,	Centre	Centre, State	MoEF&CC, CPCB, SPCBs	ongoing

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
3.3	**SETTING UP OF AIR INFORMATION CENTRE**				
3.3.1	A plan for setting up air information centres will be formulated.	Centre	Centre, State	MoEF&CC, CPCB, SPCBs	2019
3.3.2	Air information centres at the central and regional levels will be set up in some of the identified institutes.	Centre	Centre, State	MoEF&CC, CPCB, SPCBs	2020
3.4	**CERTIFICATION SYSTEM FOR MONITORING INSTRUMENTS**				
3.4.1	To operationalize NPL-India Certification Scheme (NPL-ICS) at the central and regional level to cater to the country's needs in respect of online monitoring of air pollution.	Centre	Centre	MoEF&CC, CPCB	2019
3.4.2	To evolve an action plan for the need of certification agencies for air pollution mitigation equipment in addition to the monitoring equipment.	Centre	Centre	MoEF&CC, CPCB	2019
3.5	**AIR QUALITY FORECASTING SYSTEM**				
3.5.1	All the ongoing and future initiatives under SAFAR will be integrated with the NCAP for taking all preventive measures to draw the benefits for addressing the air pollution issue from the available information.	Centre	Centre	MoES, CPCB	2019
3.5.2	The forecasting to be extended to 102 non-attainment cities under the NCAP.	Centre	Centre	MoES, CPCB	2022
3.5.3	Hotspot-based forecasting to be taken up moving ahead from city-specific forecasting in 102 cities.	Centre	Centre	MoES, CPCB	2022

Sl.No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
3.5.4	The satellite data available through the satellite network of ISRO to be integrated for monitoring and forecasting under the NCAP.	Centre	Centre	MoES, CPCB	2022
3.6	**NETWORK OF TECHNICAL INSTITUTIONS- KNOWLEDGE PARTNERS**				
3.6.1	A detailed action plan for setting up the network to be formulated.	Centre	Centre	MoEF&CC, CPCB	2019
3.6.2	A system of a regular web-based online interaction mechanism will be evolved to ensure continuity of interactions.	Centre	Centre	MoEF&CC, CPCB	2020
3.7	**TECHNOLOGY ASSESSMENT CELL**				
3.7.1	A detailed action plan for a technology assessment cell to be formulated.	Centre	Centre	DST, MoEF&CC, CPCB	2019
3.7.2	A technology assessment cell will be created involving the IITs, IIMs, universities, industries, and using the existing DST mechanisms and programmes, India Innovation Hub, etc.	Centre	Centre	DST, MoEF&CC, CPCB	2019
3.8	**INSTITUTIONAL FRAMEWORK**				
	Centre Level				
3.8.1	Apex committee at the MoEF&CC	Centre	Centre	MoEF&CC	2019
3.8.2	National Level PMU at the MoEF&CC	Centre	Centre	MoEF&CC	2019
3.8.3	Five Sectoral Working Groups on a co-chairing basis	Centre	Centre	MoEF&CC, MoP, MoRTH, MoHUA, MoA, DIPP	2019
3.8.5	A Monitoring and Forecasting Working Group	Centre	Centre	MoEF&CC	2019
3.8.4	A Technical Expert Committee at the MoEF&CC	Centre	Centre	MoEF&CC	2019

Sl. No.	Component/Activities	Level for Funding	Level For Implementation	Agencies	Timeline (Year)
3.8.5	A national-level Project Implementation Unit (PIU) at the CPCB	Centre	Centre	CPCB	2019
	State Level				
3.8.6	A State Monitoring Committee under the chief secretary in the states	State	State	DoE	2019
3.8.7	State-level PMU at the SPCB	State	State	SPCB	2019
3.8.8	City-level Review Committee under the municipal commissioner	State	City	Municipal Corporation	2019
3.8.9	A DM-level committee in the districts	State	City/District	DM	2019

India is committed to create a clean environment and pollution free air and water. It is mandated in our constitution. India's commitments and obligations to environmental conservation and protection within the ambit of the targeted goals on environmental sustainability under the Sustainable Development Goals (SDGs) is manifested in the fact that several administrative and regulatory measures. Sustainable development, in terms of enhancement of human well-being, is an integral part of India's development philosophy.

However, a vast country and an emerging economy like India, faces enormous challenges with its burgeoning population and widespread poverty, in meeting its various other significant commitments associated with poverty, and eradication of hunger under the SDGs. India has been going through a phase of accelerated industrial activities for the past three decades. The associated growth in terms of industrialization and urbanization has led to manifold increase in pollution issues, in recent years.

Since Collaborative and participatory approach involving relevant Central Ministries, State Governments, Local bodies and other Stakeholder with focus on all sources of pollution form crux of the Programme, extensive consultation with all the relevant stakeholders forms the foundation for formulation of NCAP.

सत्यमेव जयते

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- TRUE COPY -

IN THE NATIONAL GREEN TRIBUNAL, PRINCIPAL BENCH,

AT NEW DELHI

IN

O.A. NO. 1016/2019

IN THE MATTER OF:

UTKARSH PANWAR ...APPLICANT

VERSUS

CENTRAL POLLUTION CONTROL BOARD & ORS. ...RESPONDENTS

PAPER BOOK

[REPLY TO CPCB REPORT DATED 06.07.2020 ON BEHALF OF THE SONEPAT DISTRICT BRICK KILN OWNERS' ASSOCIATION]

VOLUME- II

Pg No. (232- 510)

Rohit Sharma

PLACE: NEW DELHI

FILED ON: 11.09.2020

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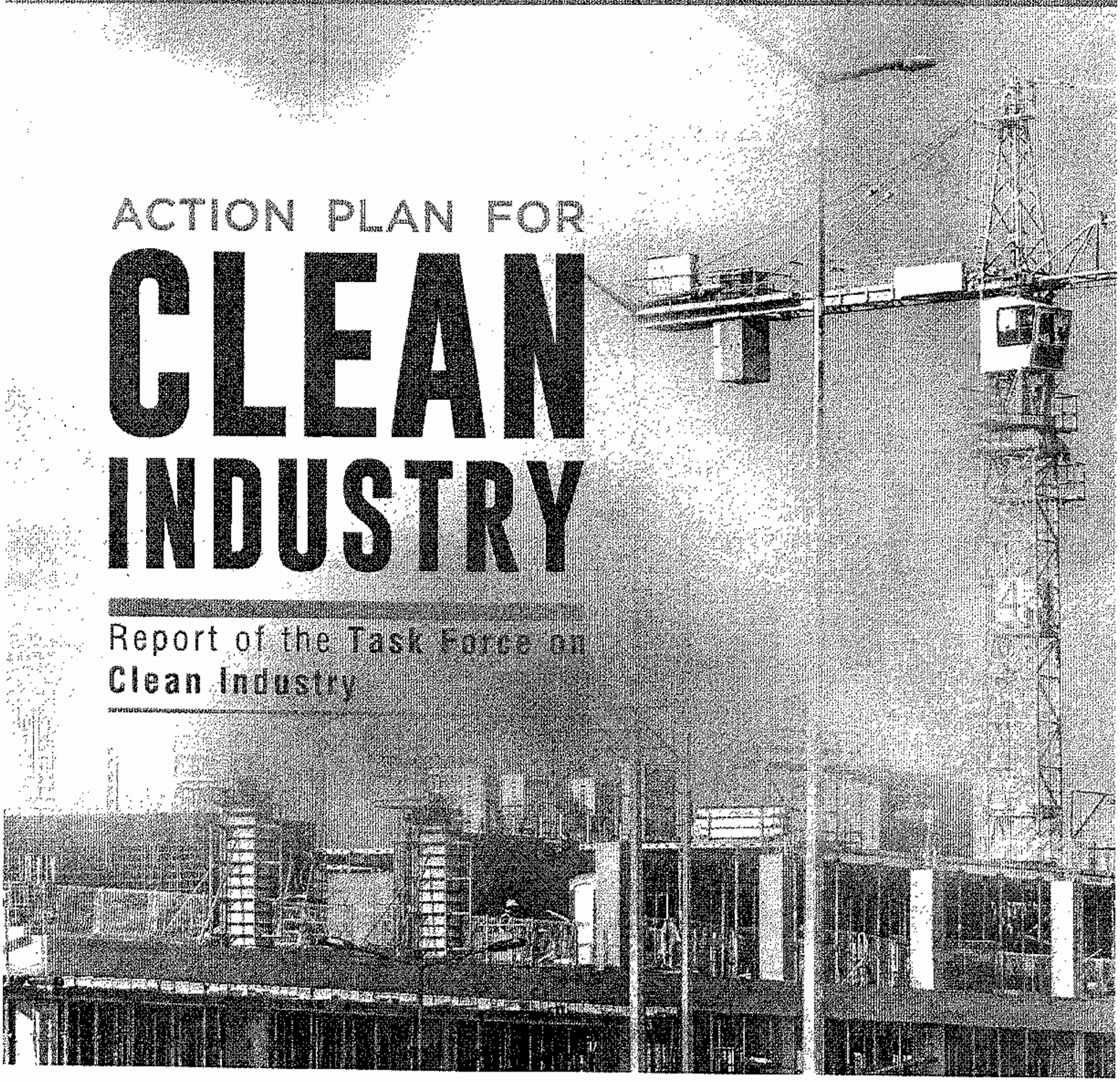
NITI Aayog

CII
Confederation of Indian Industry

'Cleaner Air-Better Life Initiative'

ACTION PLAN FOR CLEAN INDUSTRY

Report of the Task Force on Clean Industry



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FOREWORD

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सत्यमेव जयते

MESSAGE

Formulation of appropriate strategies for maintaining a clean, green and healthy environment is a priority in NITI Aayog. We are all aware that air pollution is a major threat to a healthy environment. For controlling air pollution, NITI Aayog has been working closely with Confederation of Indian Industry (CII) and other stakeholders. On the World Environment Day (5^{th} June, 2017), NITI Aayog and CII organized the first meeting of their joint initiative "Cleaner Air Better Life" with an objective to address the issue of air pollution in the country with active participation of the Government agencies, the industries and other stakeholders.

Subsequently, four Task Forces were constituted in NITI Aayog with experts as members to recommend suitable interventions for Clean Fuel, Clean Transport, Clean Industry and Biomass Management. Reports of the Task Forces on Clean Fuel, Clean Transport and Biomass Management have already been finalized and placed in the public domain (website of NITI Aayog). These reports and also the report of the Task Force on Clean Industry contain useful recommendations for controlling air pollution.

I congratulate CII team for their excellent work on the "Cleaner Air Better Life" initiative. I would also like to congratulate the Convener of the Task Force on Clean Industry for showing great leadership while undertaking extensive consultations with the stakeholders and coming up with specific recommendations. I would also like to place on record appreciation for Mr. Yaduvendra Mathur, Mr. Jitendra Kumar and other officers of the NRE Vertical, NITI Aayog for providing necessary support and relevant inputs to the Task Force.

(Amitabh Kant)

Place- New Delhi
Dated- 04/11/2019

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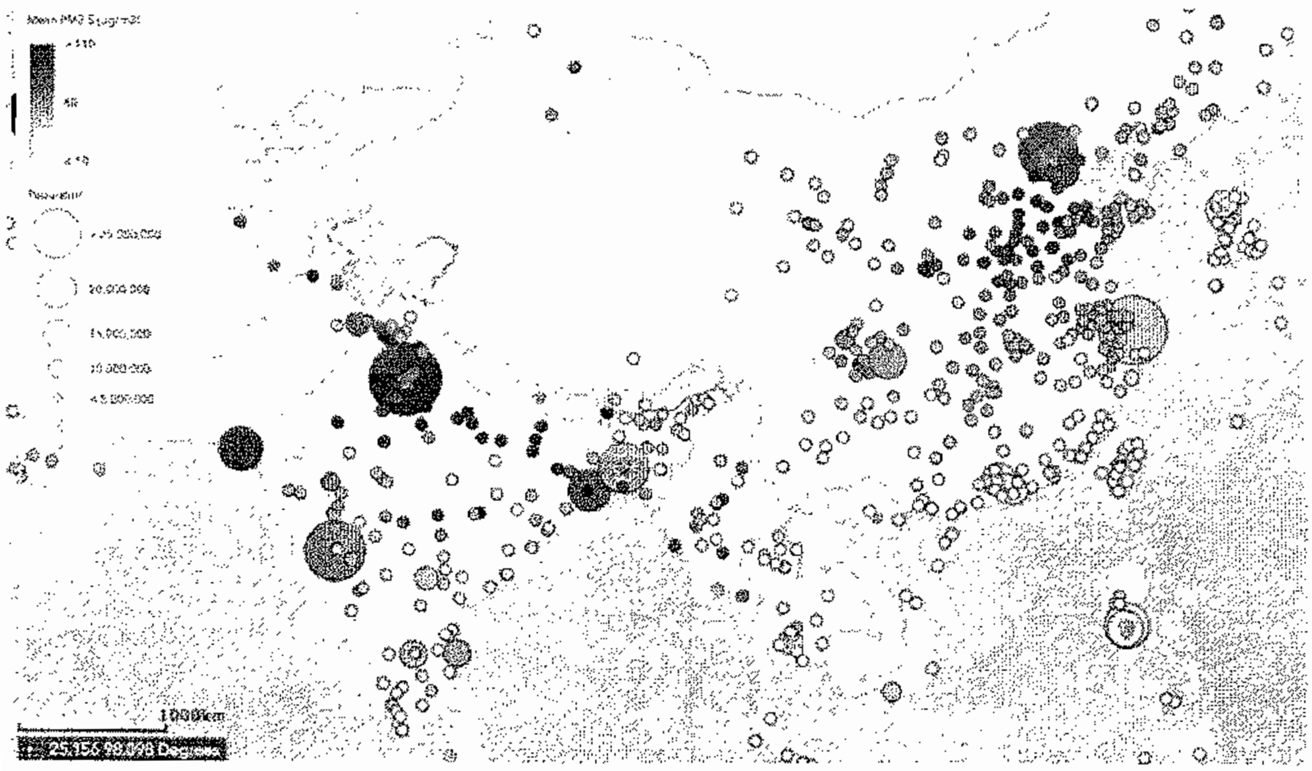
1. BACKGROUND

Air pollution in Delhi has surged to crisis level in recent years and has become a major concern for public health. As shown in Figure 1, air pollution crisis in Delhi National Capital Territory (NCT) and surrounding region has become a crisis because of the large population exposed to its health impacts. The recorded mean concentration of PM_{10} in Delhi was 292 μg/m³ in 2016 to which more than 25 million inhabitants were exposed (compared to 104 μg/m³ in Mumbai with 21 million inhabitants exposed or 92 μg/m³ in Beijing with 20 million inhabitants exposed) (WHO, 2018).

With the aim of involving diverse stakeholders to improve air quality in the airshed, the Confederation of Indian Industry (CII) partnered with the National Institution for Transforming India (NITI Aayog) under the Cleaner Air Better Life Initiative in November 2016. The first meeting of the initiative took place on 05 June

Figure 1. Exposure to Air Pollution in Regions of Asia as per Measured Data in the Year 2016

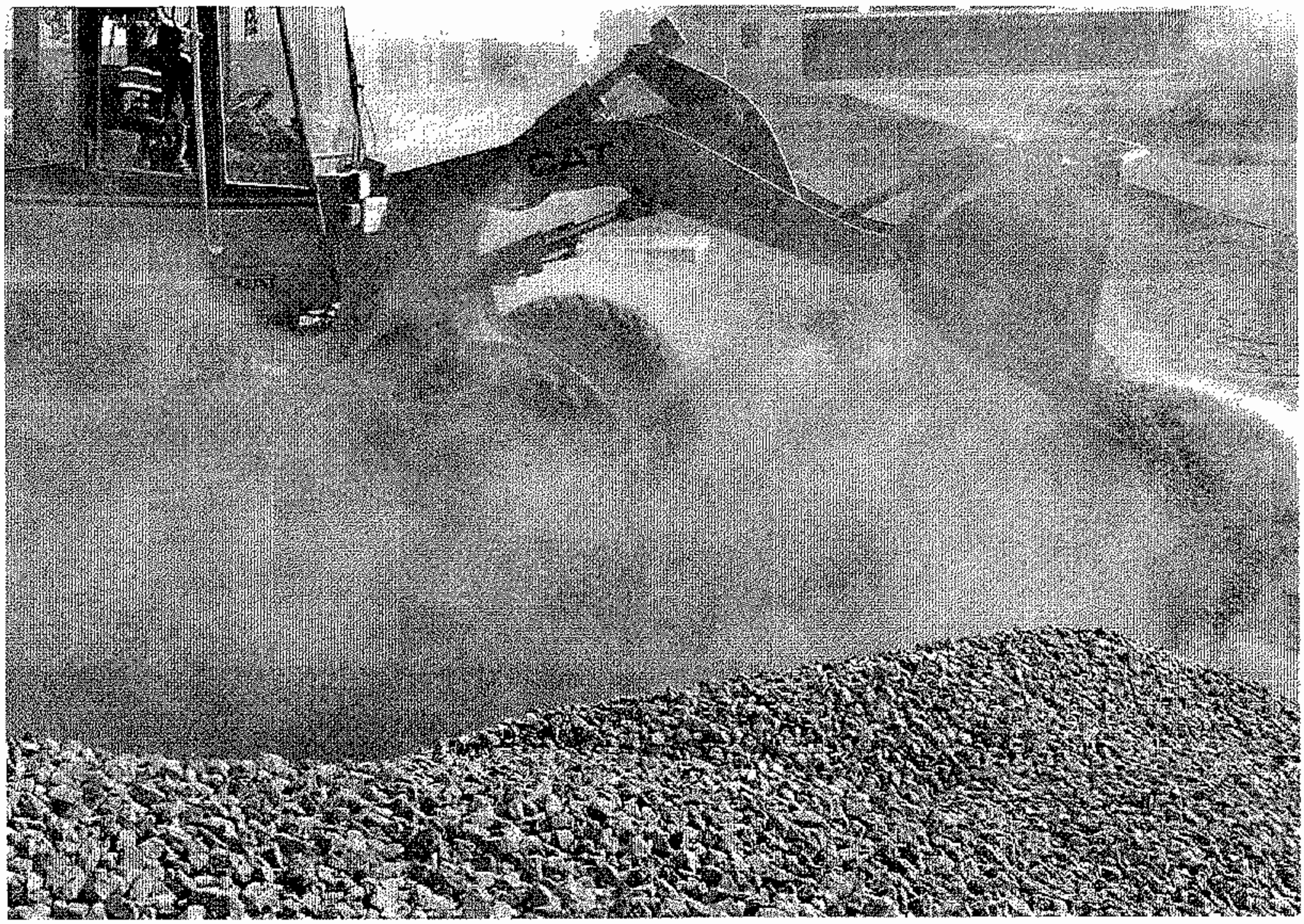


Source: WHO (2018)

2017. Subsequently, four task forces were constituted by NITI Aayog to formulate appropriate strategies for addressing the sources of air pollution. These task forces were on: Biomass Management, Clean Fuel, Clean Transportation and Clean Industry. Of these, the task forces on Biomass Management, Clean Fuel and Clean Transportation have submitted their reports which are now in the public domain[1].

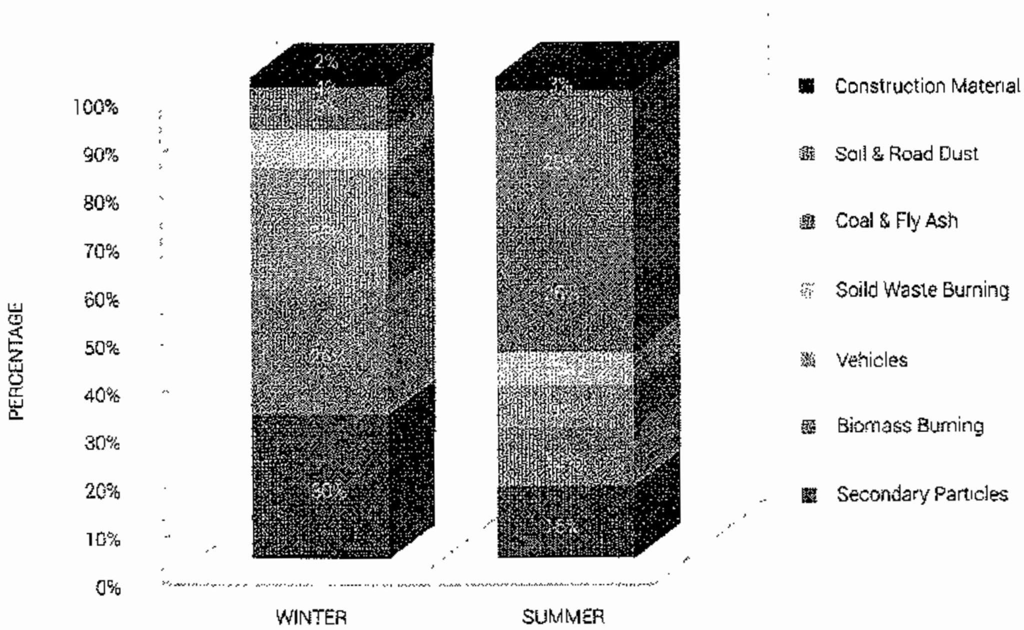
The report of this task force on clean industry addresses sources of air pollution whose contribution is significant but have received somewhat less attention such as fugitive dust from construction and roads, fly ash from coal use (both, in thermal power plants and other establishments), and stack emissions from thermal power plants.

A comprehensive source apportionment study for Delhi (Sharma and Dikshit 2016) was carried out in 2013-14 and the results in terms of contribution (percentage) of different sources to $PM_{2.5}$ (for winter and summer) and gas phase emissions (SOx and NOx) are shown in Figure 2 and Figure 3.



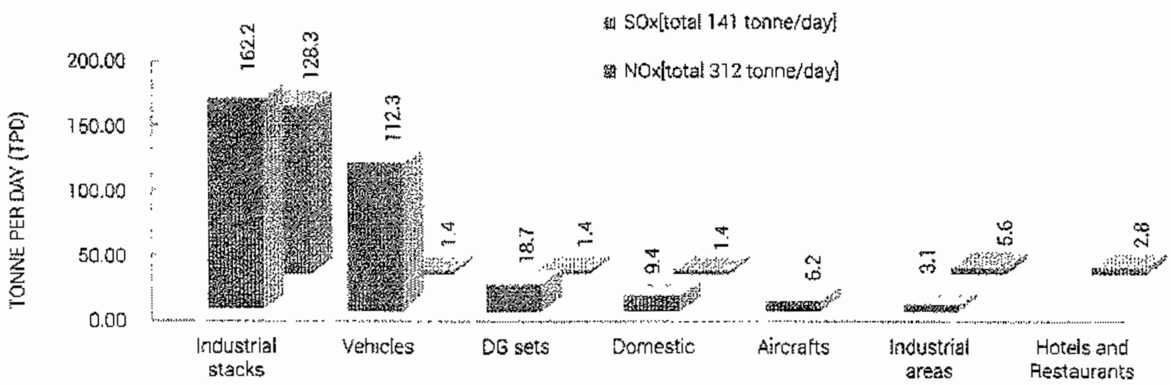
[1] Available at www.niti.gov.in/documents/reports

Figure 2. Contribution of Identified Sources to $PM_{2.5}$ in Delhi



Source: Sharma and Dikshit (2016)

Figure 3. Contribution of Identified Sources to SOx and NOx Emissions in Delhi



Source: Sharma and Dikshit (2016)

2. INCLUSIVE APPROACH OF TASK FORCE

The task force attempts to bring together: government agencies, industry, research organisations and thinks tanks to design workable solutions addressing air pollution in NCR airshed[2]. The objectives of the Cleaner Air Better Life initiative are shown in Box 1.

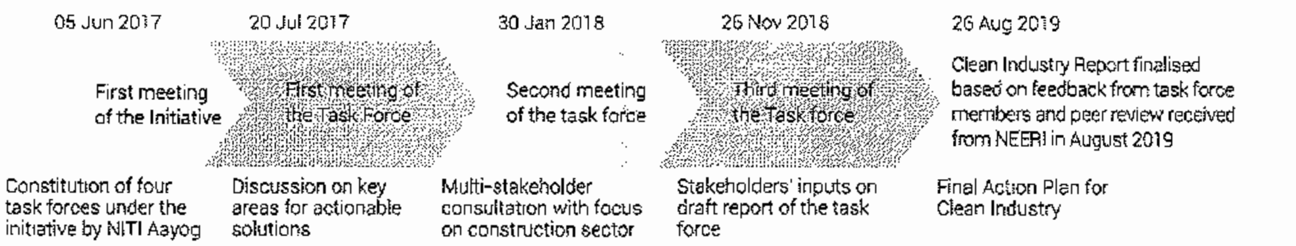
Box 1. Objectives of Cleaner Air Better Life Initiative

Developing an integrated approach that brings together policy makers, industry and academia	Building consensus amongst stakeholders on the options for improving air quality in NCR	Catalysing voluntary commitments from stakeholders towards reducing air pollution	Promoting adherence to existing polices and advocating better policies

Addressing air pollution in an airshed needs a comprehensive strategy and coordinated action in the entire region, involving multiple sectors and agencies.

Evolution of the task force's activities since its constitution and stakeholders involved are shown in Figure 4.

Figure 4. Inclusive Approach Followed by the Task Force on Clean Industry



Stakeholders Consulted:[3]

Government: Ministry of Environment Forest and Climate Change; Central Pollution Control Board; State Pollution Control Boards in NCR; Urban Local bodies in NCR.

Industry: ACC; Ambuja; Cummins; CLP India; Federation of Hotels and Restaurant Association of India; Indian Green Business Council; IL&FS; Nabha Power Limited (L&T); Tata Power; Supertech; Syntron Industries

Research institutes: Central Buildings Research Institute; Central Road Research Institute; The Energy and Resources Institute

[2]Air-shed is a common area where prevalent meteorological and geographical conditions limit dispersion of pollutants, therefore requiring a comprehensive strategy for the entire area.
[3]Refer to Annex. 11 for detailed list of stakeholders consulted

3. SOURCES OF INDUSTRIAL POLLUTION IN DELHI NCR

The Task Force considers three key air pollutants, (1) road/soil dust (2) fly ash (3) secondary particles. An analysis of source apportionment study (Sharma and Dikshit, 2016) indicates that dust and fly ash, together, contribute 19% (in winter) to 53% (in summer) of the total $PM_{2.5}$ load in Delhi while the secondary pollutants contribute 15% (in summer) to 30% (in winter) throughout the year (See Table 1). The relatively large contribution from road/soil dust and fly ash in summer is because of dry weather conditions and high wind speeds including occasional dust storms which make dust and fly ash particles airborne.

Coal or lignite based thermal power plants are significant point sources (industries in the vicinity of Delhi and with a stack height of more than 20 metres) for both, fly ash and SO_2/NO_x gas emissions. SO_2/NO_x gas emissions contribute to secondary particulate matter, formed in the atmosphere by the chemical transformation of their precursors, i.e. SO_2 and NOx. These secondary particles contribute to particulate matter in Delhi consistently throughout the year (25% PM_{10}, 30% $PM_{2.5}$ in winter, and 10% PM_{10}, 15% $PM_{2.5}$ in summer).

The updated source apportionment for Delhi NCR, ARAI-TERI (2018), is available at the time of finalising this report. The broad findings of new source apportionment are found to be consistent with the earlier study, Sharma & Dikshit (2016), which is the scientific basis for designing this action plan. As expected, the contribution of Industrial sources of air pollution is found to be higher in NCR towns compared to Delhi due to presence of Industry in proximity (ARAI-TERI 2018). Further, the Task Force on Clean Industry only focuses on the major contributors and highly distributed sources such as crematoriums and bakeries are not covered in this study.

Table 1. Contribution of Sources to Particulate Matter in Different Seasons

Percentage contribution to Particulate matter	Summer		Winter	
	$PM_{2.5}$ [%]	PM_{10} [%]	$PM_{2.5}$ [%]	PM_{10} [%]
Fly ash/coal dust	26	37	05	12
Road/soil dust	27	26	14	04
Secondary particles	15	10	30	25

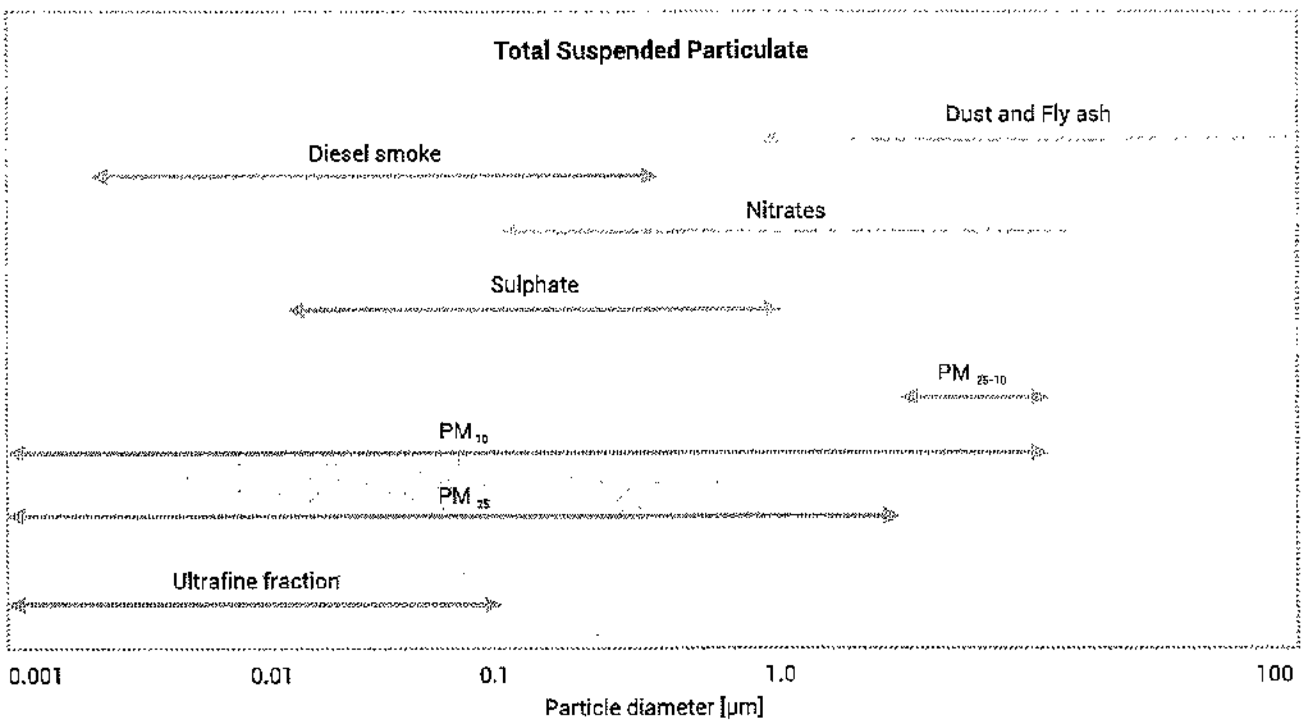
Source: Sharma and Dikshit (2016)

Thermal power plants are the single largest contributor of SOx: **90%** of SOx emission load in Delhi. They also contribute to **52%** of the total NOx emissions in Delhi, followed by vehicular emissions at **36%**.

The most significant contribution to SO_2 emissions is from industrial point sources (coal/lignite based thermal power plants) located in NCR region. These sources contribute about 90% of the total SO_2 emissions load in the city (~141 t/d) and are the single largest contributor of SOx (Sharma and Dikshit, 2016). Nearly 52% of the total NOx emissions in Delhi (~312 t/d) are attributed to the same source, followed by vehicular emissions (occurring at ground level) contributing to 36% NOx loading. Two other significant contributors to NOx emissions are DG sets (6%) and aircrafts (2%) (Sharma and Dikshit, 2016).

Secondary particles (from conversion of SO_2 and NO_x gases to particulate) and direct emissions from diesel engines (soot) are most critical in terms of health impact due to their ultrafine size (< 0.1 μm particle size). Figure 5 shows the typical size range of particles (WHO 2006; Ghosal et al 1995; and Chatterjee 2010) associated with different sources. It is evident from the Figure 5 that SOx emissions and PM emissions from diesel engines or generators contribute significantly to $PM_{2.5}$ as well as PM_{10} while NOx, fly ash and dust emissions may contribute to PM_{10} more compared to $PM_{2.5}$.

Figure 5. Typical Size Range of Airborne Particles Including Health-Related Ultrafine Fractions, $PM_{2.5}$, PM_{10} and Major Constituents Considered by this Task Force



Source: WHO (2006); Ghosal et al (1995); and Chatterjee (2010)

In order to prepare a source-specific plan of action, different industrial activities contributing to these (dust, ash, and secondary particles) emissions are broadly classified as-

1. **Fugitive Particulate Matter (PM) Emissions:** Emissions originating from spatially distributed sources and wide array of activities as opposed to specific discharge point such as exhausts and stacks. Dust emissions from construction (buildings and infrastructure), utilities operations in NCR towns (waste management, roads and highways, water, telecom), material transportation, fly ash emissions from concrete batching etc.

2. **Energy-related Emissions:** Emissions originating from energy conversion and consumption in industry subsectors. In Delhi NCR, these include: SOx, NOx and PM emissions from thermal power plants within 300 km of Delhi, PM emissions from brick kilns in NCR, PM and NOx emissions from diesel generators' use in buildings and industry subsectors such as telecom, IT, real estate, hospitality and healthcare in NCR.

3.1 Fugitive Particulate Matter (PM) Emissions

Air pollutants originating from spatially distributed sources and wide array of activities as opposed to specific discharge point such as exhausts and stacks are called fugitive emissions. Fugitive emissions have the potential for much greater ground-level impact since they are discharged and dispersed close to the ground (IFC, 2007). The two main types of fugitive emissions are Particulate Matter (PM) and Volatile Organic Compounds (VOCs)[4]. As control strategies (See Annex. 5) for addressing various fugitive emissions are the same, the more comprehensive and umbrella term: "fugitive emissions" is used in many places in the following text while addressing the fugitive dust or particulate matter emissions.

Road/soil dust, coal dust and fly ash emissions or so-called fugitive particulate matter emission originate from various economic activities in NCR towns and peri-urban areas. These particles travel up to several kilometres before settling down and at the same time, they get re-suspended in the air due to vehicular movement and resulting winds. An exhaustive list of various sources of these emissions in the city is presented in Table A5-2 (See Annex. 5). Sources include various anthropogenic activities: building constructions ranging from small building renovations to area development projects, urban infrastructure projects, operations of city-wide utilities (solid waste, electricity, roads, and water) and resuspension due to vehicular movement. Although dust storms occur frequently during pre-monsoon season in Ganga Basin in North India (Dey et al., 2004), these sources are outside the purview of this report. Only local phenomena contributing to generation and suspension of dust or particulate matter in Delhi's air are considered here.

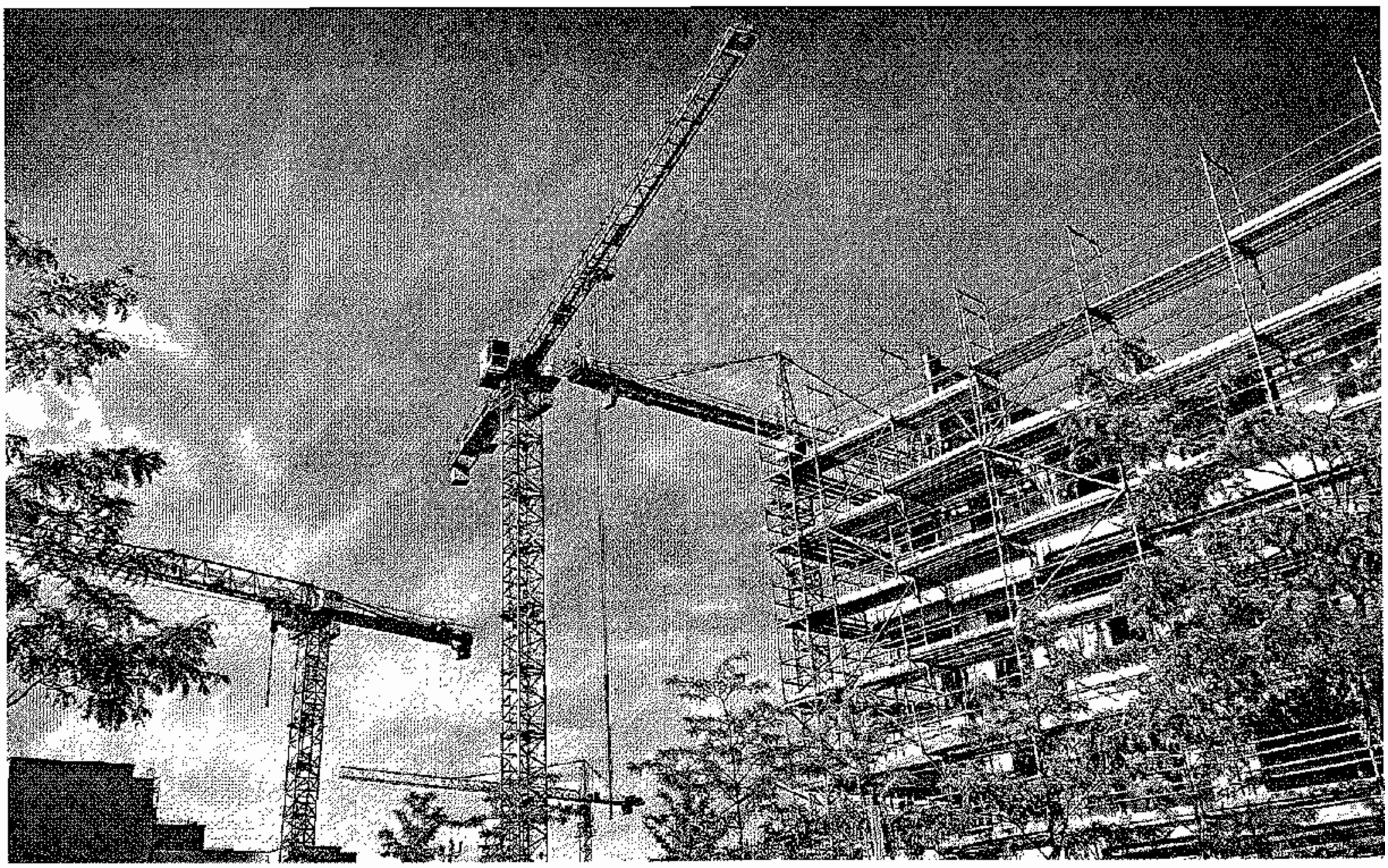
3.1.1 Building Construction

Rampant construction activities across NCR towns and rapidly expanding urban sprawl contribute to fugitive dust emissions. These activities are either greenfield or brownfield, accompanying huge amounts of construction and demolition (C&D) waste produced every day. It is estimated that 5000 tonnes of construction and demolition debris[5] is generated in Delhi NCT every day (IL&FS, 2018). This is projected to grow rapidly in future with the high growth in residential and commercial floorspace projected for the next decade[6]. Demolition activities contribute to the dust emissions not only during the demolition of structures but also during the improper transportation and disposal of construction debris. As per the Construction and Demolition (C&D) Waste Management Rules (MoEFCC, 2016a), no government authority, contractor, builder or person can store the construction and

[4]VOCs are secondary aerosols which are important component of fugitive PM emissions and associated control strategies. VOCs have not been covered under the latest source apportionment study available for Delhi (Sharma & Dikshit, 2016) and it is speculated that significant amount of VOCs are added to Delhi's air every day due to unregulated activities which are prevalent in industrial clusters and small enterprises throughout the city
[5]90% of this is estimated to be generated from demolitions activities whereas 10% from new constructions activities
[6]70% of the total floorspace by 2030 is yet to be constructed

[Demolition activities contribute to the dust emissions not only during the demolition of structures but also during the improper transportation and disposal of construction debris.]

demolitions waste outside the areas demarcated by officers of concerned authority or corporation (NGT, 2014). Those generating C&D waste beyond this threshold will pay a waste management fee to local authorities for processing or disposal of their waste whereas the generators who salvage, process and recycle (preferably in-situ) their waste will be incentivised. Local authorities are supposed to track the C&D waste generated in their jurisdiction and maintain an active database which is used for establishing and reporting the yearly generation trends. The 2016 rules also emphasise the need for maintaining a sustained system of information, education and communication by the local authority in collaboration with expert institutions and civil society. As per the rules, procurement of materials made from C&D waste should be mandatory for a certain percentage (10-20%) in municipal and government contracts. In addition, the use of recycled products from C&D Waste needs to be incentivised in construction activities as well as in non-structural concrete, paving blocks, lower layers for road pavements including the colony and village roads (MoEFCC, 2016a).



Construction activities in the city including infrastructure projects rely on allied construction industry such as brick kilns, RMC batching plants and stone crushers for supply of raw and processed materials.

3.1.2 Urban Infrastructure and Utilities

Besides building construction, large infrastructure projects (e.g. metro, roads, bridges, flyovers) contributes to dust and fly ash emissions. Handling of materials, i.e. transportation and storage (both onsite and offsite) during construction, renovation and demolition phases of different projects is a major focus area of the interventions required for dust control and management in construction/infrastructure industry. Other control options for infrastructure projects are similar to building construction, such as, paving the access roads, providing vehicle wash down facilities at site, and installing wind breakers.

Re-entrainment of dust from vehicular movement on roads (paved or unpaved) is the largest source of dust emissions in Delhi (See Annex 1 on emission inventory for Delhi). Key factors which aggravate dust generation and re-suspension include: poorly maintained road stretches, frequent digging of roads/pavements by public utilities, illegal dumping of construction debris beside roads, dust emanating from exposed surfaces in the proximity and improper (not conforming to guidelines for load conditions and containing dust) transportation of materials, and improper road/street designs. Day-to-day maintenance activities of urban utilities such as waste management, energy supply, water, sewage and roads contribute to dust generation due to frequent digging of roads and nearby surfaces. These emissions can be avoided though properly designed infrastructure, organisational behaviour change (among civic agencies and public utilities) and strict management practices. Identification of poorly maintained road stretches can be undertaken immediately by the concerned agencies in order to implement the mitigation measures on priority basis.

3.1.3 Allied Construction Industry

All construction activities in the city including infrastructure projects rely on allied industrial activities for supply of raw and processed materials. Allied construction industry is concentrated in the periphery of Delhi NCT or so-called peri-urban areas. These include mainly three allied sectors-

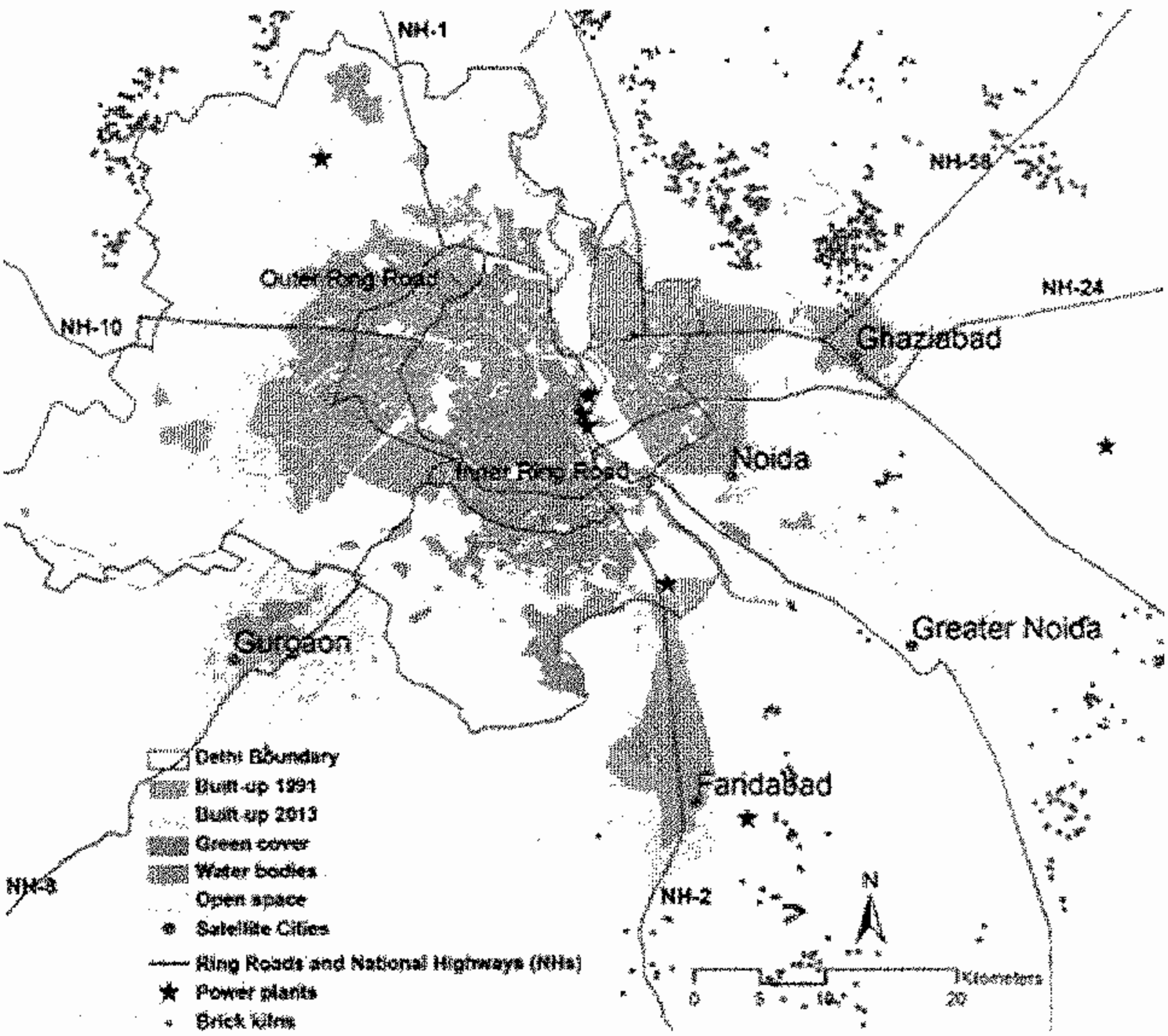
1. Ready-Mix Concrete (RMC) batching plants
2. Stone crushers
3. Brick kilns

Ready-Mix Concrete (RMC) Batching Plants

Rampant construction activities in the city require huge amounts of concrete: a mix of sand, coarse aggregates, cement and water. For small construction projects, mixing is undertaken at site (in-situ) whereas large construction projects are dependent on RMC sourced from concrete batching plants. Concrete batching plants can be located either onsite or offsite. The concrete supplied from on-site batching would involve trucks carrying different raw materials such sand, aggregates, cement etc. to the site while sourcing concrete from an off-site RMC plant avoids transportation of material and associated emissions within the control area. Concrete from RMC plant is transported to site in wet form in enclosed containers.

Besides air quality benefit, RMC also provides opportunity for use of pozzolans like fly ash and ground slag in concrete while maintaining strict quality control (BIS 2016). As per National Building Code of India, preference may be given to use of RMC, if the RMC manufacturing plant is nearby. However, due to lack of monitoring and good practices, a large amount of fly ash generation is expected from the RMC batching activities (Sharma and Dikshit, 2016). It is estimated that there are a few hundred concrete batching plants operating in NCR region (Sharma and Dikshit, 2016). The pozzolan cement used in the preparation of RMC contains 35% of fly ash (Sharma and Dikshit, 2016), main cause of fugitive emissions in the process. Although it is advisable that RMC is utilised for construction projects in order to curb dust emissions at site and promote utilisation of fly ash, it is crucial that stringent control measures are followed at RMC batching plants. These control measures are detailed in the Annex 5.

Figure 6. Brick Kiln Units Located in the NCR, Represented by Black Dots on the Map



Source: Goel and Guttikunda (2015)

Due to more efficient burning in zigzag kilns, SPM and unburnt carbon emissions are reduced drastically by **60-75%**.

Stone Crushers

Aggregates for concrete are sourced from stone crushers located in NCR or outside the region. These plants crush stones to coarse aggregates to be used as part of concrete in the construction projects. It is also possible to use Recycled Concrete Aggregates (RCAs) sourced from C&D waste processing plants and there is a huge potential to replace the virgin materials used in construction projects and avoid the transportation of materials into the city. As noted by members during the second meeting of the task force, illegal mining of virgin materials for building and construction is the key factor affecting uptake of sustainable building materials despite their clear economic and environmental advantages.

Brick Kilns

Emissions from brick kiln industry is another major area requiring attention. Fly ash from brick kilns operating in NCR contributes to the air pollution in Delhi (Sharma and Dikshit, 2016). As per 2014-15 data, there were about 2,080 brick kilns in Delhi-NCR, predominantly located in North Western and South Eastern peripherals of the city as depicted in Figure 6 (Goel and Guttikunda 2015). Majority of these brick kilns are based on old technology: Fixed Chimney Bull Trench Kiln (FCBTK), having chimneys emitting pollutants continuously during the manufacturing season (January to June) every year. Many of them do not have gravity settling chambers which purify the effluent gas from the stacks.

Latest environmental standards propose a shift from FCBTK type to zigzag type. Zigzag brick settings allow sufficient time for heating of fuel to reach ignition temperatures and result into near-complete combustion of fuel (Kamyotra 2017). Due to more efficient burning in zigzag kilns, SPM and unburnt carbon emissions are reduced drastically[7] by 60-75% (EPCA 2017; CCAC 2018). Zigzag design also reduces the specific energy consumption in kilns by almost 20% due to proper hot air circulation. As a co-benefit, the number of good quality bricks in the process are increased by up to 25% (EPCA 2017; Kamyotra 2017). High draft Zig-Zag technology was first developed by the Central Building Research Institute (CSIR-CBRI), Roorkee in 1987-88 to overcome the pollution from brick kilns. The license of the technology has been transferred by CBRI to three agencies for implementation in brick kiln all over India. But the technology has received renewed focus due to concerns about air pollution from existing brick kilns. Also, in recent years, some of the brick makers have modified the brick setting and practices and have successfully operated the kiln with natural draught (Greentech-Enzen 2012).

Despite the significant advantages and very high return on investment, zigzag kilns have not been an attractive proposition for small scale brick kiln industry. The capital expenditure for both types of kilns: FCBTK and zigzag is found to be same, i.e. INR 40-50 lakh for a brick kiln with a production capacity of 30,000-40,000 bricks per day (Kamyotra 2017) but shift to new brick kiln setting requires dismantling the existing kiln structure and laying the bricks again in the zigzag setting. International experience in moving towards zigzag technology shows that imparting awareness and training to brick makers is extremely important. Specific training programmes are required to educate brick makers on shortcomings of existing technologies/practices and their impact on revenue, climate, agriculture and health (CCAC 2018) vis-à-vis various benefits of cleaner technology/practices such as fuel saving, improved occupational health, better product quality, increased revenues, and compliance to environmental regulation. Also, the role of cleaner brick firing practices, including practical training for fire master on zig-zag kiln firing practices (CCAC 2018) is very important for ensuring lower emissions in the long

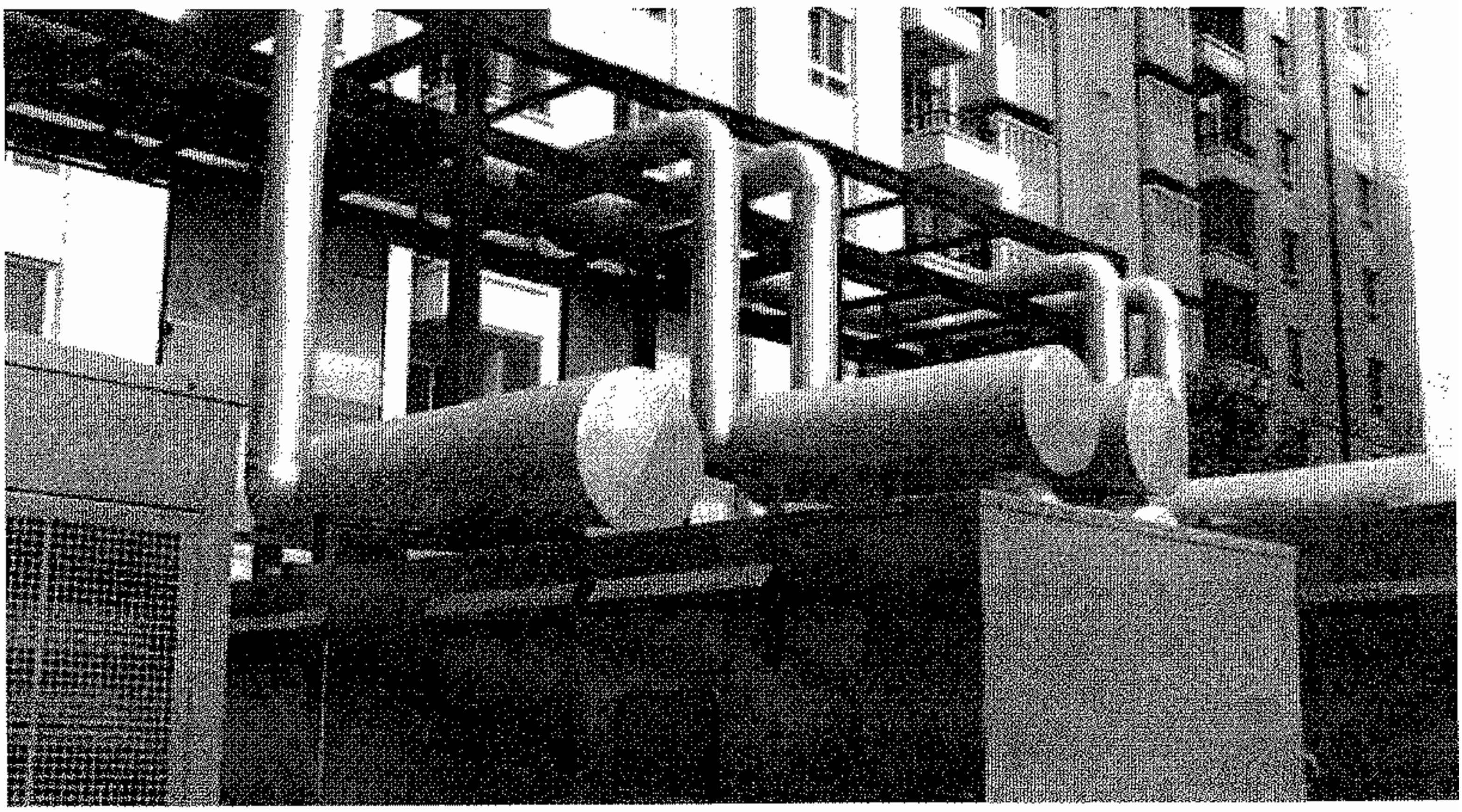
[7] As per observations by Central Pollution Control Board: SPM emissions decline from 517-1375 mg/Nm3 in FCBTK natural draft kiln setting to 155 mg/ Nm3 in zigzag natural draft kiln setting whereas the black carbon emission decline from 1.18 mg/ kg-fired brick in FCBTK natural draft kiln setting to 0.22 mg/ kg-fired brick in zigzag natural draft kiln setting.

term once the right infrastructure is in place. After a prolonged consultation with the brick kiln industry in NCR, the CPCB has issued directives to all bricks kilns in 22 NCR districts: Uttar Pradesh (7 districts), Haryana (13 districts) and Rajasthan (2 districts). These directives stipulate conversion of all brick kilns in NCR to zig-zag technology by October 2018; units based on the old technology will not be allowed to operate beyond July 2018 (CPCB 2018). As per the latest information, 35% of the brick kilns (1835 out of total 5240 units in 2018) in NCR lying in neighbouring states of Haryana, Rajasthan, Uttar Pradesh have converted to zig-zag technology while rest of the units; which haven't switched to new technology; are not allowed to operate (EPCA 2018).

3.2 Energy-related Emissions

Energy related emissions originate from diverse industrial subsectors and are related to-

- Use of DG set in various subsectors such as Telecom, IT, hospitality, real-estate, construction etc
- Gaseous (SOx and NOx) and particulate matter emissions from Coal-based thermal power generation units within 300 km of Delhi
- Use of coal and wood for firing tandoors in hotel and restaurant industry



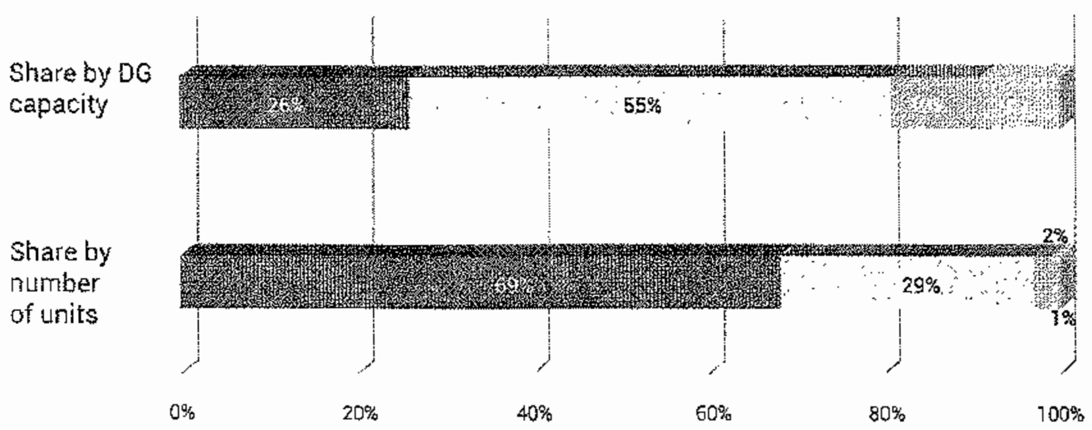
> Diesel generators contribute significantly to NOx emission in Delhi and their contribution to NOx within Delhi NCT is observed to be 6%.

3.2.1 Use of Diesel Generators in Buildings & Industry Subsectors

Diesel generators are used for maintaining reliable supply of power in various commercial and industrial activities where 24x7 power supply is critical. They also serve as source of primary power in locations where modern energy infrastructure is missing. DG sets are preferred option for power back up during outages despite very high cost of electricity per unit: INR 16 per unit from DG set compared to INR 3.5 per unit from coal power plant. Roughly about 85-90 % of DG set demand in India is for backup power whereas their demand for primary power is significantly lower: less than 15% (Oswal 2017). Major end-use sectors of DG sets are telecom towers, hotels, commercial complexes, hospitals, data centres, infrastructure (metro and road) and large industry such as power plants for black start.

Diesel generators contribute significantly to NOx emission in Delhi and their contribution to NOx within Delhi NCT is observed to be 6% (Sharma and Dikshit, 2016). It is expected that this contribution is higher for Delhi NCR as power outages are more frequent in peri-urban and satellite towns of Delhi. Various studies

Figure 7. Market Segmentation of DG Sets by Size Classes Including Major End-Users Across Size Classes



Key end-users across different size classes:

15-75 kVA	Telecom towers (56%), Hospitality (10%), Commercial complexes (10%), Small restaurants (6%), Small scale industry (5%), Petrol stations (4.5%)
75-375 kVA	Real estate (25%), Large industries (24%), Healthcare (21%), Hospitality (20%), Infrastrcuture (3.5%)
375-750 kVA	Large industry (31%), Hospitality (30%), Healthcare (19%), IT/ITES sector (16%)
>750 kVA	IT/ITES Sector including data centres (56%), large industry (34%)

Source: Adapted from Oswal (2017)

> SOx and NOx emissions from thermal power plants are eventually transformed into secondary pollutants and contribute to ultrafine PM range.

highlight that contribution of DG sets can be as high as 16% in case of satellite towns of Delhi and exposure to PM2.5 increases significantly within the residential areas in event of power outages (SCAPHRI 2015; CSE 2018).

Although, Delhi NCR specific market data is not available to our best knowledge, national level market report (Oswal 2017) indicates that these high horsepower DG sets (> 750 kVA) are merely 1% of total number of DG units and 9% of total DG capacity installed in India as shown in the Figure 7. It is found that large stock of existing DG sets, which are not covered under in-use emission norms need to be addressed on priority basis for clean air action in Delhi. Although improved reliability of power can lower the usage of DG sets for predominant backup application and resulting emissions, the usage of DG sets cannot be ruled out in case of power contingencies. As per the Graded response action plan (GRAP) for Delhi NCR, the DG sets were banned in Delhi for a period from 18 October 2017-28 February 2018 due to air quality slipping to very poor level (DPCC 2017, NCTD 2017). While this ban was executed in Delhi alone, it is not a permanent solution to address emissions from diesel generators. Hence, policy emphasis may be laid out at a national level on using proven options for control of emissions from DG set, which would ensure smooth running of economic activities.

Emission Norms for DG sets

Under the Environment (Protection) (Third Amendment) Rules, 2013, environmental standards exist in India for new generator sets with capacity up to 800 kW and specify emission limits for three different size classes: up to 19 kW, 19-75 kW and 75-800 kW (MOEFCC 2013). Emission limits for NOx + HC, CO and PM apply for type approval and conformity of production. On the contrary, in-use environmental standards apply to generators with capacity above 800 kW or 0.8 MW (or 1000 kVA), as applicable to diesel engines for application in power plants generator set applications and other requirements, under the Environment (Protection) Third Amendment Rules 2002. It is observed that under the current regulatory regime for control of in-use emissions which is applicable only to high horsepower capacity segment, load conditions are not mentioned during the periodic emission testing of DG sets. DG sets are installed to fulfil part load in building application and in-use emission standards can be improved by considering actual load conditions for testing of existing DG sets.

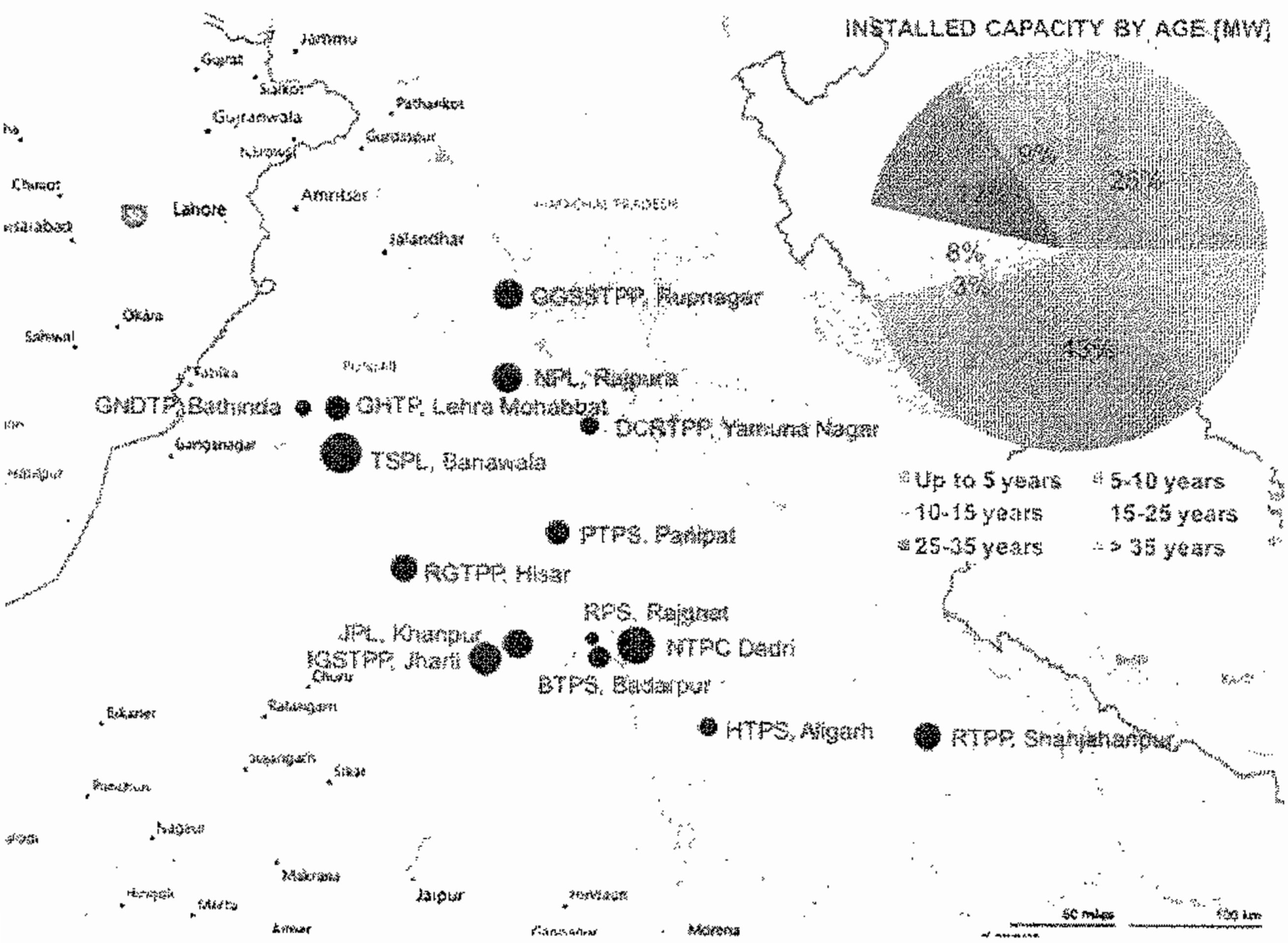
Currently the discussions for further reduction of emissions through next level norms for DG sets are underway. India needs to adopt stringent norms with global references to derive long term benefits of change rather than regular small step changes. The introduction of one universal norm instead of split by application, usage or territory is thus essential for ease of enforcement through good governance.

3.2.2 Coal-based Thermal Power Plants

There are fifteen existing coal-based thermal power stations in NCR and its vicinity which contribute to loading of SOx and NOx emissions in the city. Source apportionment study for Delhi establishes that power plants are largest sources of SOx and NOx emissions which are blown over the NCR region by prevalent North Western and South Eastern winds (Sharma and Dikshit, 2016). These emissions are eventually transformed into secondary pollutants and contribute to ultrafine PM range as given in the Figure 5. All thermal power stations within a radial distance of 300 km from Delhi are mapped in the Annex 8 along with details of individual units. These installed generation capacities (total

16,465 MW) are also mapped in Figure 8 below. Size of the bubble in Figure 8 indicates unit's installed capacity. Out of 15 existing coal-based power stations, two located in Delhi: BTPC Badarpur and RPS Rajghat face closure. Closure report for RPS Rajghat was submitted by its operator IPGCL to Govt. of NCT of Delhi (GNCTD) and decision of GNCTD is pending in this regard (CEA 2018). Units 1, 2 and 3 at BTPC Badarpur are going to be phased out by June 2018 (CEA 2018) whereas units 4 and 5 face closure due to unviability of flue gas desulphurisation for control of SOx emissions (NRPC 2017). All in all, there are total 56 coal-based thermal units in the region out of which 15 are in the process of being phased out and face closure in the near future due to unavailability of space for Flue Gas Desulphurisation (FGD) as described below. A total installed capacity of 3525 MW or 24 units are above the age of 25 years as highlighted in the Figure 8.

Figure 8. Map Showing Existing Coal-Based Power Stations within 300 km of Delhi



Source: CII-CESD (2018) analysis

Emission Control at Coal Thermal Power Plants

Government of India acknowledged the health hazards from the coal based thermal power plants and informed of certain steps in 2013 which included formulation of new emission standards. Other proposed steps included (GoI, 2013): use of beneficiated coal with ash content below 34%, emphasis on cleaner coal technologies such as supercritical and Circulating Fluidised Bed Combustion (CFBC) while granting environmental clearances to TPPs, pollution control systems on case to case basis (on the basis of ambient air quality and sensitivity of the area) and directive to TPPs for 100% utilisation of fly ash.

The new emission standards were notified for the first time in December 2015 with December 2017 as a deadline to meet these standards. New emission standards included standards for SOx and NOx emission which were previously non-existent in the country including more stringent standards for PM. All power plants in the country were supposed to meet the new emissions limits (as given in the Table 2) by December 2017 which in turn would have helped to improve the ambient air quality. Ministry of Power (MoP) constituted a committee under chairmanship of Central Electricity Authority (CEA) in September 2016 to prepare action plan for power plants to meet new emission norms.

CEA (2016)[8] estimated that FGD units are required for nearly 151 existing units (90 GW) and 73 new units under construction (72 GW) to meet the new norms whereas 430 units smaller than 500 MW in capacity (including few older 500 MW units) face space constraint for installation of FGD systems. Nearly, 302 existing units in the country would require modification in combustion processes (low NOx burners) to meet the targets of 600 mg/Nm^3. Denitrification systems such as Selective Catalytic Reduction (SCR) systems are required for 279 existing units (120 GW) and 73 upcoming units (72 GW) to meet the targets of 300 mg/Nm^3 and 100 mg/Nm^3 (CEA, 2016). The globally available SCR units are not proven for Indian coal with high ash content (~40%) and demonstration projects would be required for SCR system in India. MoP raised concerns of various power plant in country for compliance with new emission norms. It informed the

Table 2. Emission Norms for Power Plants as Amended by Government of India in December 2015

Installation Date	Before 31.12.2003	01.01.2003 - 31.12.2016	After 01.01.2017
Emissions limits [mg/ Nm^3]:			
Particulate matter	100	50	30
Sulphur Dioxide (SO_2)	<500 MW: 600		100
	>500 MW: 200		
Oxides of Nitrogen (NO_x)	600	300	100

Source: MoEFCC, 2015

[8]As of 31 Mar 2016, installed capacity of coal based thermal power was 185 GW with 75 GW additional capacity under construction

Ministry of Environment Forest and Climate Change (MoEFCC) that retrofitting additional fields in ESP units or replacement in existing units will require complete shut down for 4-6 months, and asked for 30-36 months required for arranging funds and implementing FGD in phased manner to avoid any grid contingencies. Following this, the MoEFCC undertook multiple consultations with stakeholders including MoP, CEA and NTPC in 2017. It was decided that action plan prepared by MoP for compliance in 7 years (up to 2024) was too long and should be implemented by 2022 considering the health impact on general public. Based on the revised action plan by MoP and prioritisation by MoEFCC for plants close to urban areas, new directions were issued to all coal-based thermal power plants by MoEFCC and CPCB in December 2017. According to these directions, the unit-wise phased plan for installation of emission control devices is given in Annex 8 along with mapping of all TPP units in NCR and surrounding region.

The revised unit-wise phase out schedule for installation of FGD in power plant located in the Northern regions, as shown in Annex 8, spans from year 2019 to year 2022. All power plants in this region are supposed to retrofit FDG by 2019 in order to meet SOX standards except RTPP, Shahjahanpur (Uttar Pradesh) which is supposed to meet the timeline for FGD installation in 2021. As recommended by MoP, same timelines apply for meeting NOx standards as well (MoEFCC 2017) whereas immediate upgradation of ESP is planned in most of these plants. MoEFCC directions prescribe immediate measures such as installation of low-NOx burners, providing Over Fire Air (OVA) etc. and achieving progressive reduction to comply to NOx emission limit in the stipulated year. As highlighted in the Figure A7-1 (See Annex 7), it is technically feasible to achieve emission reductions on par with combustion emission control options by modifying the combustion process and implementing a combination of in-situ abatement options such as low-NOx burners, OVA and flue gas recirculation. In addition to 15 old TPP units (1935 MW) which face closure, additional 8 TPP units (1380 MW) face closure by 2022 as FGD installation is not viable in these TPP units due to space constraint (MoEFCC 2017, NRPC 2017).

Coal and lignite used in these TPPs gives rise to fly ash and safe utilisation of fly ash is essential, making sure that ash does not become airborne (CEA, 2017b).

> More research and development will be required in future to utilise the bottom ash for value added products besides its application for road construction, mine filling and filling low lying areas.

According to the latest notification, MoEFCC (2016b), construction agencies (public or private) within 300 km of the location of TPP are mandated to use products based on fly ash[9]. For first 100 km, 100% cost of fly ash transportation is borne by TPP whereas beyond 100 km, the cost of transportation is equally shared by TPP and user. Since July 2016, all coal/ lignite TPPs are required to update information about the stock of ash on their website and update it every month (MoEFCC, 2016b). All thermal power plants in India are required to have a system in place for 100% management of fly ash in four years from the date of commissioning. The information on ash utilisation for power plant in NCR region is captured in Annex 8. The management and control options for fly ash are already covered under Annex 5.

Roughly, 20% of the total ash which gets generated during combustion at TPP is bottom ash: coarse ash that gets collected at the bottom of boiler. It has been highlighted by task force members that there is limited availability of viable options for utilising the bottom ash from TPPs. As per member inputs, at least one global technology player claims to have used the bottom ash and fly ash in a ratio of 3:1 but the technology is yet to be tested for Indian ash. More research and development will be required in future to utilise bottom ash for value added products besides its application for road construction, mine filling and filling low lying areas.

Existing Policy for Utilisation of Biomass in Thermal Power Plants

Surplus biomass is available in abundance in NW India. A detailed list of state-wise biomass potential in India is provided in Annex 10, which is based on the data from National Biomass Atlas. Ministry of Power (MoP), through its policy and advisory issued in November 2017 has urged all utilities and power plants[10] in the country to utilise 5-10% blend of biomass pellets through co-firing along with coal. The advisory issued by MoP notes that biomass co-firing is a proven technology and is recognised by UNFCC as a carbon neutral technology for mitigation of carbon emissions from coal-based power plants (MoP 2017a). It is estimated from the open sources of data that nearly 230 plants across the globe, majority of which are located in European and American countries, utilise biomass for co-firing with coal. NTPC's Dadri plant has successfully demonstrated 7% co-firing with biomass pellets and the advisory suggests that 5-10% co-firing with biomass pellets can be replicated[11] in- all coal fired TPP units (fluidised bed or pulverised coal units) having bowl mills, vertical roller mills, or beater mills (except those having ball and tube mills[12]) (MoP 2017a; MoP 2017b). The policy advises public/ private utilities to undertake technical feasibility, especially for safety aspects, prior to biomass co-firing.

Existing policy notes that paddy-straw that remain unutilised and burnt in the North West India has potential to generate about 6000-8000 MW or 45,000 million units (m-kWh) electricity annually (MoP 2017b). The policy also highlights the decentralised

[9]MoEFCC has established threshold for minimum fly ash content in order for construction materials to be classified as fly ash products such as 50% of raw material for fly ash blocks/ tiles/ bricks; 15% of the raw material for cement etc.

[10]fluidised bed or pulverised coal units having bowl mills

[11]0.25-0.3 million tonne of biomass pellets are required for 7% blending in a 1,000 MW coal-based plant

[12]Co-firing biomass pellets is deemed to be unfit for TPP units having ball and tube type mills due to higher risk of fire hazards (MoP 2017b)

infrastructure for biomass conversion (bales to pellets) as an opportunity for generating employment. Following institutional arrangements, are recommended in the policy-

1. Central Electricity Authority (CEA) will develop and issue specification for pellets, and additionally, it will provide technical assistance to public and private utilities for blending biomass pellets with coal.
2. Responsibility of devising suitable mechanism lies with the appropriate commission: The State Electricity Regulatory Commissions (SERCs) in respective states.

Existing policy suggests that appropriate commission (SERC) will determine the compensation to power utilities[12] for any incremental cost on account of using biomass pellets e.g. cost of pellets, increase in auxiliary power consumption, and plant heat rate. It also mentions explicitly that any increase in cost of generation will not be taken into account for merit order dispatch.

3.3.3. Hotel and Restaurant Industry

Hotel and restaurants among other eateries utilise tandoor (traditional North Indian oven made of clay) for cooking which are fired with solid fuels such as wood, coal and charcoal. Large hotels and restaurants mainly utilise charcoal as opposed to wood and coal. It is estimated that there are roughly 9000 tandoors (Sharma and Dikshit, 2016) in the city which contribute to fly ash. This figure is based on the conservative estimate that 25% of enterprises use tandoor for cooking. Delhi is known for its street food. Due to large number of unregistered enterprises, the actual number of eateries using tandoors is expected to be much higher.

The key reason for emission from these tandoors is not simply the usage of polluting fuels but also the inappropriate tandoor design which is not optimised for efficient burning. The community/commercial tandoors in India are unregulated with no standards, guidelines or labelling for either efficiency or emissions.

The cleaner options for tandoors include gas, electricity, and solid biofuels. Clean fuel options need to be promoted across the eateries in Delhi NCR. Biomass is a low sulphur option compared to coal (See Annex 9) and appropriately designed tandoor for solid biofuels can ensure significantly lower emissions compared to conventional tandoors in use today. CSIR-NEERI has developed a clean tandoor based on biomass pellets. Improved combustion chamber design for better air-fuel contact and heat transfer, reduced emissions as a result of improved burning, higher thermal efficiency are some of the proposed features of this efficient tandoor. The tandoor is under fabrication, testing and performance optimisation. It is reported to be available for INR 20,000-30,000 per unit based on the capacity and automatic pellet feeder option.

[12] Except plants whose tariff has already been determined under the Section 62 of Electricity Act.

4. RECOMMENDED ACTION PLAN FOR CLEAN INDUSTRY

Fugitive emissions (Dust, ash and VOCs) are generated from wide array of activities spatially distributed in the city as opposed to energy related emissions (PM, SOx and NOx) from specific discharge points, that is, exhausts or stacks. Therefore, two different sets of strategies are required for tackling these two broad categories of sources. Two sets of actions recommended for addressing these emissions at source are outlined below. A summary of recommended actions, along with the timelines and priorities, is presented in the Table 3.

4.1 Prevention and Control of Fugitive PM Emissions

Based on the discussions during task force meetings and review of best practices in India and internationally, a detailed guide on best practices and technologies for prevention and control of fugitive emissions (dust and ash) is prepared as part of this study. This guide is enclosed as Annex 5 along with the specific examples of prevention and control measures. These comprehensive measures are further summarised in the Box A5-1 (See Annex 5).

A comprehensive strategy is accordingly recommended to address particulate matter emissions from concerned subsectors. It encompasses prevention and control of fugitive emissions (dust and ash) across-

1. Construction activities at site (i.e. buildings and infrastructure projects)
2. Operation of various utilities (waste management, power, road/highways, water, electricity and gas) within NCR cities and towns
3. Allied construction industry (brick kilns, concrete batching plants, stone crusher etc.) predominantly located beyond Delhi NCT in the NCR region.

4.1.1 Promotion and Adoption of Clean Construction Practices

Organisational behaviour in NCR must shift in favour of cleaner construction practices. Civic agencies and construction industry need to proactively ensure implementation of appropriate measures for prevention and control of air pollution during construction and maintenance of infrastructure. A comprehensive strategy, involving multi-stakeholders is crucial in addressing these. Wide scale adoption of clean construction practices requires not only stringent enforcement, but also appropriate incentives or disincentives as recommended below.

a. Mandatory Contractual Obligations on Clean Construction for all Individuals/Organisations

Contractually binding obligations for clean construction need to be specified for individuals or organisations under the mechanism of 'building permits/approvals' by local bodies/authorities and 'environmental clearances' by Ministry of Environment Forest and Climate Change. To mitigate the impact of widely dispersed construction activities across the city, these contractually binding obligations need to apply to all scales of construction projects as listed in the Table A3-1 (See Annex 3). Comprehensive measures listed in the Box A5-1 are usually applied in combination to achieve desired control and it should be up to the individual/organisation to choose appropriate mitigation measures as per the site and local conditions.

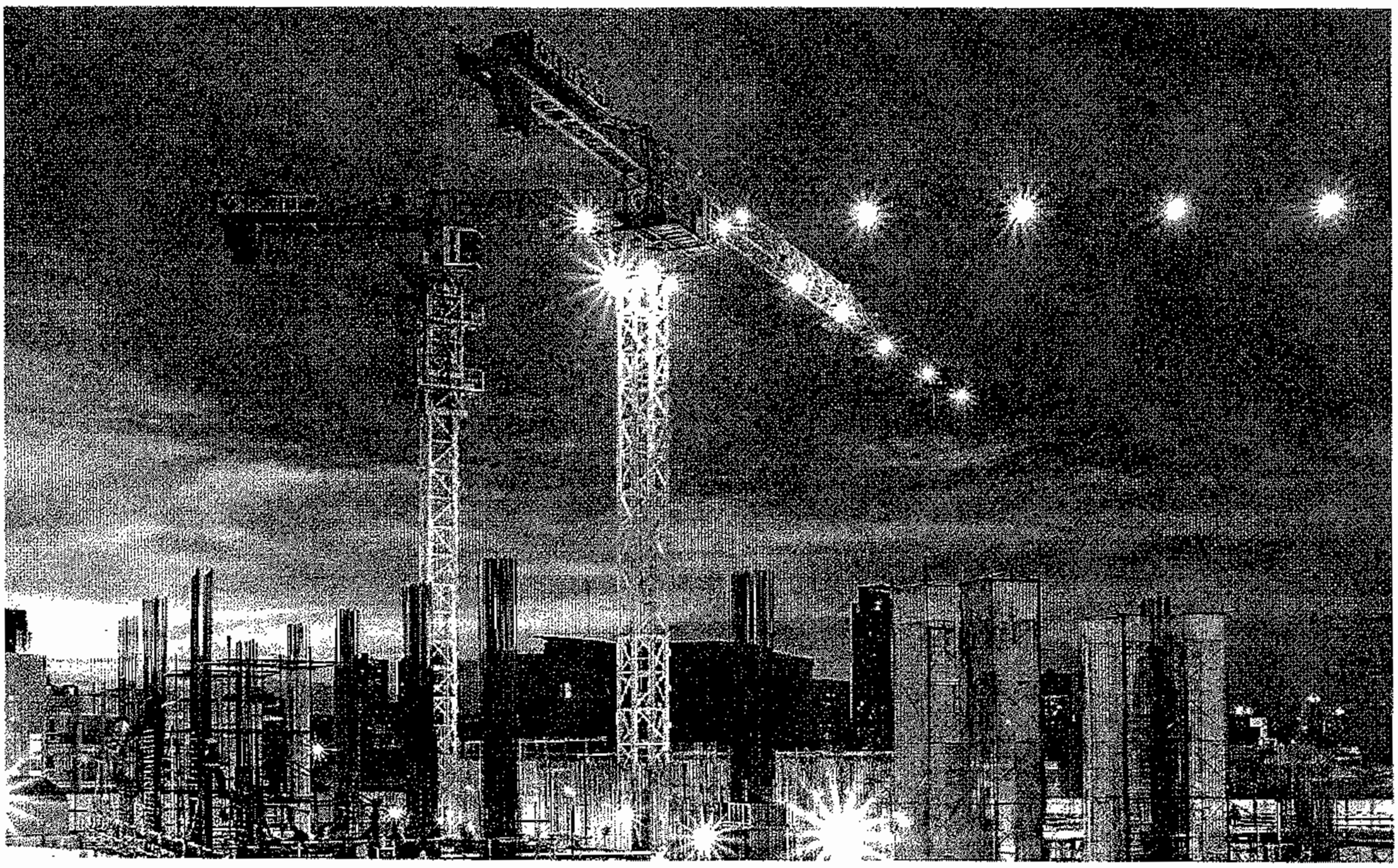
It is advised that, under these obligations, project proponents of- (1) buildings with BUA >20,000 m^2 and (2) all urban infrastructure projects need to conduct feasibility for using following in their projects and accordingly source the materials.

1. Conduct technical feasibility of using sustainable building/construction materials. The guidelines set forth in 'Part 11: Approach to Sustainability' of the 'National building code of India' (BIS 2016) can be used as a reference for this.
2. Mandatory use of multi-utility service ducts/corridors, along with ITC enabled platform for inter-agency coordination, in all infrastructure, township and area development/redevelopment projects
3. Technical feasibility of using prefabricated or modular construction elements in the infrastructure projects.

b. Linking of Green Incentives to Clean Construction Practices

Currently there are multiple incentives which are conferred to projects which are provisionally rated to be green by buildings rating systems such as GRIHA, IGBC, LEEDS etc. (See Annex 4.). It is recommended that following incentives can be reconsidered by local bodies/authorities/ state and union government ministries for construction projects only when it is demonstrated through obligatory contracts requirements and project feasibility reports that projects will follow clean construction practices in order to achieve the mitigation of ambient air quality impacts during the construction and end-of-life phase. These incentives include-

i. 10-20% reduction on permit fees by urban local bodies
ii. Additional Floor Area Ratio (FAR) of 5-10% for building projects
iii. Fast track environmental clearance by MoEFCC
iv. 100 % exemption of building scrutiny fee for projects by local bodies/authorities
v. Financial assistance offered to MSME sector projects at concessional rates from Small Industries Development Bank of India
vi. Capital subsidies on total fixed capital investment of the project, if any



c. Mandatory Funds Allocation for Ambient Air Quality Management Under Corporate Environmentally Responsibilities (CER) in Cities not complying to Ambient Air Quality Standards

It is recommended that for cities/towns which are non-compliant to National Ambient Air Quality Standards (102 cities as per CPCB in 2018), CER funds are spent for air quality improvement in the airshed. Fund allocation can be made towards the following and can be expanded based on specific requirements of the city/town.

i. Infrastructure with local bodies for random checks (mobile monitoring devices or PEMS) in the air shed

ii. Real-time monitoring of air pollution hotspot in the airshed

iii. Piloting and demonstrating technologies for ambient air quality improvement

iv. Developing capacities and resource base of urban local bodies

Also, it is suggested that for a city figuring as non-compliant in any particular year, 40% of the CER funds may be diverted toward indicative activities as listed above, based on the local requirements. The proportionate funding for the consecutive years, if the city is able to meet the standards again, can be lowered by 10%.

d. Strengthened Building Code and Building Byelaws for Ambient Air Quality

Buildings in India are governed by National Building code (NBC) and Energy Conservation Buildings Code (ECBC) (See Annex 4). It is recommended that unified building code is adopted at national level for addressing various aspects of building and promoting adherence to code across all commercial and urban residential buildings. More importantly, the building code needs to be strengthened in order to address the environmental footprint of 'construction' and 'end-of-life' phase of buildings. Environmental footprint during construction phase (fugitive dust emissions and diesel emissions from DG sets and construction equipment) receive a relatively little focus in existing building codes and their primary focus is use-phase of the building (building energy, structural integrity, water conservation, indoor air quality). Although the use-phase contributes to majority of environmental footprint of the building over its life cycle due to significant energy consumption over building's life, construction and demolition (end-of-life stage) activities take major toll on ambient air quality of local environment. Proposed unified code needs to have separate provisions and guidelines for ambient air quality management. Construction and demolition/end-of-life phases of building need to be considered for minimising environmental footprint of building. These provisions can further be adapted by local bodies into building byelaws as per their specific conditions. These specific conditions may include the carrying capacity of the local environment, population densities in in receptor area and ambient air quality conditions of the airshed. Specific action points under this recommendation include-

i. Mandatory provisions under the National Building Code for ambient air quality management during construction and end-of-life phase of buildings in accordance with specific criteria for population density in receptor area and ambient air quality data.

Measures in the proposed building code need to percolate down to the level of Buildings Bye Laws so that they could be implemented by concerned Local body and authority in their area of jurisdiction.

ii. Mandatory provisions for ambient air quality management at construction sites in the Urban Building Byelaws of all NCR cities/towns

iii. Unification of building codes: In order to ease adherence to building code, it is recommended that unified codes are adopted by bringing together all concerns related to buildings such as building structure, fire safety, building energy, ambient and indoor air quality, water conservation etc.

As pointed out by task force members, local bodies need the required resources and equipment in order to stringently enforce the environmental compliance in NCR.

e. Developing Capacity of Urban Local Bodies for Monitoring and Enforcement

Capacity of urban local bodies in NCR towns need to be developed for ensuring clean construction in their respective jurisdiction areas. Environmental concerns for construction projects above 20,000 m^2 are now integrated with the building permits/approvals (Annex 3). Therefore, the onus of ensuring clean construction lies with the local bodies. As pointed out by task force members, local bodies need the required resources and equipment in order to stringently enforce the environmental compliance in NCR. State legislation should allow ULBs in NCR region to collect fees for making their operations feasible. It is suggested that local bodies can monitor local sources of air pollution by using affordable infrastructure, such as-

i. Mobile monitoring devices for random checks such as Portable Emission Measurement Systems (PEMS)

ii. Low cost sensors for monitoring key pollutants such as PM, SOx and Nox.

f. Strengthened Monitoring and Penalties for Individuals/Organisations

It is recommended that monitoring for air pollution is strengthened and individuals/organisations are penalised for not complying to Ambient Air Quality Standards. As below, two levels of monitoring and enforcement mechanism is recommended.

i. Tier-1 monitoring and enforcement at local level

Random checks need to be conducted by local bodies at local hotspots of air pollution such as construction hotspots, poorly maintained road stretches, landfills etc. Individuals/organisations/utilities who own/service the building and any other infrastructure in NCR cities and towns may be penalised 5-10% of the project cost for not being able to comply with the ambient air quality standard.

ii. Tier-2 monitoring and enforcement at state level

Real-time monitoring needs to be strengthened by concerned SPCBs assisted by EPCA and CPCB. It is recommended that competent authority (CPCB) notifies under the Air (Prevention and Control of Pollution) Act, 1981 that the civic agencies (local bodies, authorities, landowning agencies etc) may be penalised for non-compliance in their area. Such sources include-

- Construction/demolition of urban infrastructure/buildings
- Maintenance of urban infrastructure
- Operations of public/private utilities

In addition to penalties for individuals/organisations as suggested earlier, civic or landowning agencies may be penalised based on the direct correlation of estimated health impact from air pollution and cost to society. The proposed notification under the Air (Prevention and Control of Pollution) Act, 1981 may suggest an appropriate mechanism for attributing social and environmental cost to these activities.

4.1.2 Sustainable Supply Chains for Construction Materials

Policies promoting circular economy, that is utilisation of waste streams (such as fly ash, C&D waste, road dust and surplus farm biomass) for sustainable buildings materials will be crucial for addressing air pollution in NCR. Several products from fly ash and C&D waste including finished and semi-finished products, are summarised in Box A5-2 (See Annex. 5). Using these as construction material or feeding them back into city's materials flows eliminates or significantly lowers the life cycle emissions from construction activities. Procurement of sustainable construction materials is advised under the two categories, material manufactured using-

- Finished or semi-finished products from waste streams such as C&D waste, fly ash, recycled waste aggregates, or agricultural waste
- Clean manufacturing practices, e.g. bricks manufactured in zigzag-type kilns or aggregates from stone crushers with proper dust suppression equipment

a. Fiscal incentives for Sustainable Building Materials

As per the inputs from task force members, key barriers for adoption of sustainable building materials (despite clear economic and environmental benefit) arise from sourcing of virgin materials from illegal mining (such as aggregates, sand etc.) Therefore, fiscal or tax incentives are crucial to promote sustainable bulling materials. GST can provide a level playing field for sustainable building materials and favorable taxation is recommended for all sustainable building materials.

b. Sustainable Public Procurement

It is recommended that sustainable public procurement is made mandatory for all government tenders in Delhi NCR and targets are set for public agencies to fulfil stipulated part of their total requirement from recycled products and products with lower environmental footprint. City Development authorities in NCR such as Delhi Development Authority (DDA), Haryana Urban Development Authority (HUDA), Ghaziabad Development Authority (GDA), New Okhla Industrial Development Authority (NOIDA) etc. including public utilities such as DMRC, NHAI, CPWD, PWD (Delhi, Haryana, Rajasthan and Uttar Pradesh) etc. have been identified as key public agencies which govern most of the urban infrastructure development projects. Key enablers would be-

- Building capacity of Small-Medium Enterprises (SMEs) for remanufacturing and clean production technologies
- Sectoral guidelines and best practices for setting up and operating allied construction plants: Zigzag-type brick kilns, ready-mix concrete batching plants and stone crushers
- Promotion of existing rating systems for construction/building materials (e.g. GRIHA, IGBC and USGBC certified products/materials)

c. Sustainable Supply Chains for Construction Materials

Initiatives can be taken by all large construction industry/ infrastructure companies (to begin with) in NCR for sustainable supply chain procurement and disclosure as part of their corporate social and environmental responsibilities. Following independent reporting frameworks/platforms can be used by industry to report progress on sustainable supply chains and procurement-

i. Global Reporting Initiative (GRI)
ii. Sustainability Report
iii. U.N. Global Compact
iv. SDG reporting
v. Dow Jones Sustainability Index

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Coal Thermal Power Plants with latest emission controls are most economical choice for enhanced biomass co-firing.

4.2 Mitigation of Energy-related Emissions

4.2.1 Prioritising Clean Fuels and Technologies

Efforts need to be made for Fuel Switch in diesel generators, brick kilns and thermal power plants. As recommended in the CII-NITI Aayog's Clean Fuel Report, prioritisation of clean power is required in NCR region and other dense urban areas suffering from severely degraded air quality. Gas-based capacities are under-utilised in NCR region. They can meet 50% of Delhi's power demand whereas they only cater to 20% of the demand presently (CII-NITI, 2018b). Nationally, gas-based generation suffers a huge economic loss and average plant load factor for gas-based generation is about 23% due to unviability of natural gas (CII-NITI, 2018b).

The dispatch of power from generation sources is governed by merit dispatch order principle, where generators of cheap power are prioritised over others, except renewable power plants[14] which are treated as must-run power plants. Prioritisation of clean power would require more comprehensive and conducive fiscal policies for clean power. CII-NITI Aayog Clean Fuel Report (2018) recommends priority dispatch of clean power requiring amendment to Indian Grid Electricity Code (2010) and other short-medium term actions (CII-NITI 2018b). Similarly, in the areas with availability of natural gas, use of fuel injection kits for existing DG sets, gas-based generators, and other clean fuel-based equipment need to be mandated by the competent authority.

Thermal power plants are main source of SOx emissions in the NCR region. Coal power units, in NCR and beyond, need to comply with the latest environment norms by 2019 and 2022 respectively. Environmental standards are key instrument for cleaning thermal power and certain control technologies have been prescribed to power generators in order to meet these standards.

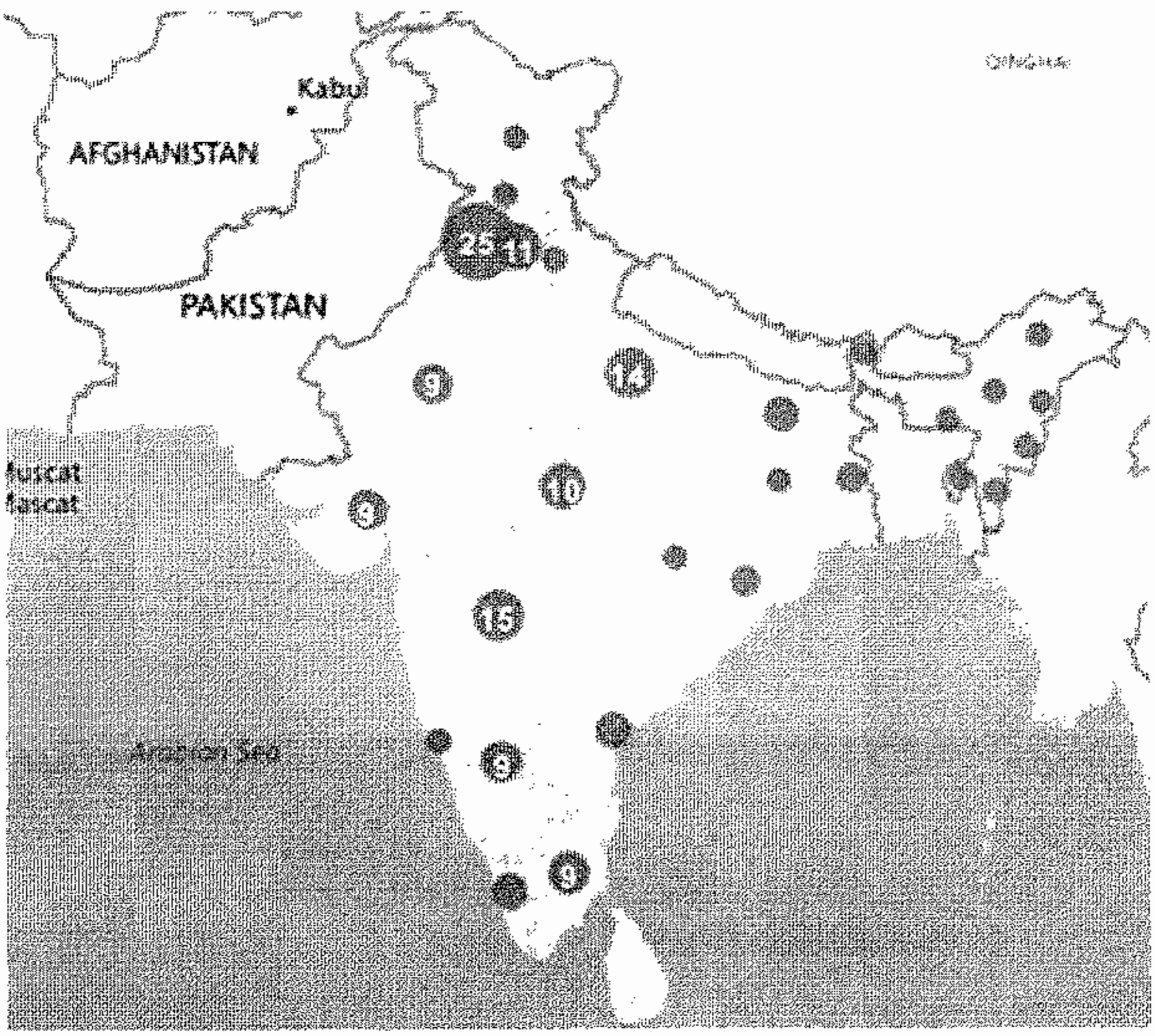
Coal TPPs with latest emission controls are the most economical choice for enhanced biomass co-firing. Power industry can make a leapfrog from 5-10% utilisation of biomass (Refer Section 3.2.2) to higher co-firing (See Annex 9: Business case: leapfrogging to 50% biomass co-firing in existing thermal power plants). As

[14] excluding biomass power and cogeneration plants

mapped in Figure 9, biomass potential from surplus biomass in Punjab, Haryana and Western U.P. can fulfil the demand for 50% biomass co-firing in thermal power units within 300 km of Delhi. New conversion technologies need to be utilised for enhancing co-firing in existing TPPs. As detailed out in Annex 9, multiple benefits of using enhanced soil biofuel from biomass include-

1. Enhanced fuel characteristics (energy density or caloric value) similar to coal
2. Low-sulphur biomass as feedstock implies reduction in SOx emissions and operational cost of SOx control
3. Better handling and storage characteristics compared to conventional pellets or straw bales
4. Avoided cost of coal transportation from pitheads or ports

Due to significantly lower sulphur content in biomass compared to coal, biomass as a feedstock is also an opportunity to cost-effectively reduce SOx emissions from coal-based thermal power plants (See Box A9-1, Annex 9). It is a carbon neutral energy resource for greening the coal power. Advanced biomass co-firing in existing thermal power plants would require clear policy signals and dedicated policy support to power generators from Ministry of Power, Government of India.



Source: CII-CESD (2018) analysis based on MNRE-IISc (2004); MoA (2014) and Kumar et al (2015)

> Task force recommends that power dispatch from thermal power plants is prioritised based on the cleanliness of power so that those using clean technologies are incentivised over the rest.

a. Priority Status to Clean Generation

As discussed, the dispatch of power from generation sources is governed by merit order dispatch principle, where generators of cheap power are prioritised over the rest, except renewable power plants which are treated as must-run power plants. Task force recommends that power dispatch from thermal power plants is prioritised based on the cleanliness of power so that those using clean technologies are incentivised over the rest. Accordingly, it is recommended that priority for clean power is provided in the merit dispatch for-

- Gas-based thermal power generation units
- Coal-based thermal power generation units which use advanced emission control technology for meeting emission levels of PM, SOx and NOx as prescribed in the latest emission norms

Prioritising clean power will entail following short-term and long-term actions-

i. Notification to Northern Region Load Dispatch Centre (NRLDC) to provide priority to clean power in merit dispatch order. (Short-term)

ii. Amendment to the Indian Grid Electricity Code (2010) giving priority to cleaner sources of power generation (Long-term)

Additionally, the cleaner power producers are to be allocated with the quantity of coal that can ensure the plant to operate at full load. This is important, because, even if a plant is high on merit order, without coal, it won't be able to operate, defeating the purpose. Specific interventions needed for this purpose are-

iii. Inter-ministerial Sub Group constituted by the Infrastructure Constraints Review Committee, headed by Joint Secretary (Coal), to release a guideline to Rail and Coal India to prioritise the allocation and transportation of coal to the cleaner power producers based on priority dispatch order requirement.

iv. Central Electricity Authority (CEA) may release an advisory to Railways and Coal India for prioritising the coal supply to the cleaner power producing TPPs to meet the priority dispatch order requirement.

v. Scheme for Harnessing and Allocating Koyala (Coal) Transparently in India (SHAKTI); can be amended to incorporate the prioritisation of coal allocation to the greener power producers to meet the priority dispatch order requirement.

b. Incentives for Co-firing Biomass in Existing Coal Power Units:

Power generators need to be incentivised for burning low-sulphur biomass which is also a renewable source of energy. Incentives may include- renewable energy certificates (RECs), tax benefits and priority dispatch based on the proportionate power generated from co-firing biomass. Existing policy from Ministry of Power recommends co-firing up to 5-10% biomass in existing coal thermal power units. Key Enablers for this would be the guidance document for biomass co-firing in existing coal-based power plants which is awaited from Central Electricity Authority (CEA) as per the existing policy of Ministry of Power.

c. Leapfrogging to Advanced Biomass Co-firing in Coal Power Plants in North West Region:

Leapfrogging to advanced biomass co-firing (more than 10% biomass) requires a long-term and comprehensive policy for promotion of biomass co-firing in thermal power plants. Commercial feasibility of enhanced co-firing is still being evaluated at this stage. However, in long term, this could potentially unlock a cost-effective strategy for greening the coal power and simultaneous reduction of emissions from stubble burning in North West region.

Department of Science and Technology (DST) is currently piloting torrefaction of rice-straw in Punjab in partnership with a Swedish agency. Torrefied biomass, once piloted and proved in existing coal power stations in region, can pave way for large scale utilisation of Biomass (up to 50% without significant cost to retrofit technology).

d. Fuel Switch for Diesel Generators and Hotels/Restaurants industry:

Diesel engines are utilised in hospitality, healthcare, real estate, IT and telecom sectors. As discussed in the Clean Fuel Report, fuel injection kits or gas-powered generator are commercially feasible option in places with availability of gas, a clean fuel (CII-NITI 2018b). Central Pollution Control Board or Concerned State Pollution Control Board may issue a directive mandating the use of gas kit at all such locations. Similar to suggestion for DG use, gas or electricity-based tandoors may be mandated at locations where electricity and Piped Natural Gas (PNG) infrastructure is available. Availability of natural gas and physical infrastructure, benchmarking of available clean fuel options (gas, electricity, solid-biofuels for tandoors) and clean fuel pricing and taxation strategy are key enablers for adoption of clean fuel options in these sectors.

4.2.2 Adoption of Best Available Technology for Emission Control

Available abatement technologies or end-of-pipe solutions need to be promoted across industry subsectors. It is found that commercially proven options are available for addressing emissions from DG sets (See Annex 6 and Annex 7), but they are not being utilised due to absence of in-use emission standards for > 1000 kVA DGs, lack of proper inspection and monitoring system for DG sets and lack of capacity with the regulatory agencies for implementing DG set in-use emission standards.

Available options need to be promoted equally by public and private agencies through a combination of appropriate policies, voluntary commitments, environmental regulation, and emission standards. Diesel generators, a major component of non-road engines, is an identified source of health-related ultrafine PM fractions and NOx emissions. Retrofit solutions for existing DG sets can only thrive in presence of strictly enforced in-use environmental standards for all DG sets.

Apart from comprehensive coverage of emission norms for all DG sets, guidelines and minimum requirements (e.g. technical life) for the end-of-pipe retrofit products need to be formulated by the regulator. Due to inherent technological challenges as discussed in Annex 6, it needs to be ensured that retrofit devices perform up to certain level for a minimum number of years (as prescribed by regulator). Innovative retrofit technologies can only thrive in presence of strict in-use emission standards for DG sets and recommended actions include- (1) Notification of appropriate environmental standards and guidelines covering all DG sets and retrofit products; (2) Certification of all retrofit devices by CPCB recognised laboratories in line with the independent type approvals and conformity of production requirements for NG and LNG kits (See Annex 6). As highlighted earlier, India needs to adopt stringent emission norms for DG sets by considering global benchmarks to derive long term benefits from imminent transition. Adoption of suggested actions can pave way for the most advanced regulations in the country.

a. Strict In-use Emission Norms for all Diesel Generators

To ensure uptake of best available technology for emission control in DG sets, regulation should also include specification of minimum requirements for DG retrofit device e.g. control efficiency and life of device. Key enablers for this action are certification of available retrofit options in the market by CPCB certified laboratories; and benchmarking studies for control efficiency, life and cost.

b. Extend and Adopt a Strengthened Pollution-Under-Control System to Non-Road Diesel Engines

Monitoring of in-use emissions from DG sets can be initiated in line with the recommendations of Task force for Clean Transportation. It recommends a strengthened real-time Pollution-under-control (PUC) regime involving innovative and cost-effective monitoring/compliance measures such as random checks using portable emission measurement system (PEMS), standardised software, crowdsourcing of compliance (citizen helpline for reporting visibly polluting diesel equipment). Cost effective strategies for monitoring existing DG sets include-

- Random checks for DGs and other non-road diesel engines by using PEMS
- Citizen helpline to report visibly polluting DG sets or other non-road equipment

Table 3. Summary of Actions Recommended by the Task Force on Clean Industry

Action Area	Recommended actions	Priority	Timeline	Implementation	Supplementary Notes
Promotion and Adoption of Clean Construction Practices	Mandatory contractual obligations on clean construction for all individuals or organisations Additional mandatory conditions to (1) buildings with BUA >20,000 m^2 and (2) all urban infrastructure projects for- • Technical feasibility for sourcing smart and sustainable materials/infrastructure • Mandatory use of multi-utility service ducts/corridors, along with ICT enabled platform for inter-agency coordination • Technical feasibility of using prefabricated or modular construction elements	High	Immediate	Urban local bodies & Ministry of Environment Forest and Climate Change	1. Refer to Annex 5 for guidelines on comprehensive measures and Table A5-1 (Annex 5) for overview of these. 2. Refer to Part 11: National building code (BIS 2016) and guidelines in Annex 5 for sourcing sustainable materials.
	Linking of green incentives to Clean Construction Practices: incentives conferred to projects which are provisionally rated as green by building rating systems such as GRIHA, LEEDS, IGBC etc)	Low	Immediate	Urban local bodies, Development authorities & State Governments in NCR; Ministry of Environment Forest and Climate Change	List of incentives provided in Section 4.1.1 (b).
	Mandatory funds allocation for ambient air quality management under CER in cities not complying to Ambient Air Quality Standards	High	Long term	Ministry of Environment Forest and Climate Change	Indicative set of activities and suggested allocation in Section 4.1.1 (C).

Action Area	Recommended actions	Priority	Timeline	Implementation	Supplementary Notes
	Strengthened Building Code and Building Byelaws for addressing ambient air quality during 'construction & end-of-life' phase of projects- I. Mandatory provisions under the National Building Code for ambient air quality management during construction and end-of-life phase of buildings/infrastructure in accordance with specific criteria for population density in receptor area and ambient air quality data. ii. Mandatory provisions for ambient air quality management during construction and end-of-life phase of buildings/ infrastructure in the 'Unified Building Byelaws' for NCT Delhi and building byelaws of other NCR cities/towns iii. Unification of building codes (NBC and ECBC)	High	I. Immediate ii. Immediate iii. Long term	I. Bureau of Indian Standards, Ministry of Consumer Affairs, Food and Public Distribution ii. Development authorities & ULBs in NCR iii. Bureau of Indian Standards, Ministry of Consumer Affairs, Food and Public Distribution; Bureau of Energy Efficiency, Ministry of Power	Refer to Annex 4 for review of building codes.
	Developing capacity of urban local bodies for monitoring and enforcement: Monitoring local sources using portable emission monitoring devices and low-cost sensors	High	Long term	Ministry of Housing and Urban Affairs; Ministry of Environment Forest and Climate Change	List of incentives provided in Section 4.1.1 (b).
	Strengthened Monitoring and Penalties for Individuals/Organisations- I. Penalties by ULBs worth 5-10% of the project cost to individuals/organisations ii. Penalties by SPCBs in NCR to local bodies/authorities in lieu of the estimated cost of damage	High	Immediate	Central Pollution Control Board; State Pollution Control Boards and Urban local bodies in NCR	Refer Section 4.1.1 (f) for more details.

Action Area	Recommended actions	Priority	Timeline	Implementation	Supplementary Notes
Sustainable Supply Chains for Construction Materials	Fiscal incentives for Sustainable Building Materials	High	Immediate	GST Council, Ministry of Finance	Refer to Box A5-2 under Annex 5 for different waste streams which can be utilised for sustainable building/ construction materials
	Mandatory sustainable public procurement for construction/building materials in all government projects/tenders in NCR	High	Immediate	Ministry of Housing and Urban Affairs and public agencies such as DMRC, NHAI & CPWD; State Governments in NCR and its agencies; local bodies/developm-ent authorities in NCR	Refer to Part 11: National building code (BIS 2016) and guidelines in Annex 5 for sourcing sustainable materials.
	Sustainable supply chains for building materials: third-party verification or independent reporting frameworks/ platforms to be used by large construction/infrastructure companies in NCR to report progress on sustainable supply chains and procurement	High	Immediate	Large construction and infrastructure companies in NCR	List of reporting frameworks/platforms is available in the section 4.1.2 (c).
Prioritising Clean Fuels and Technologies	Priority status to cleaner generation- (1) Gas-based thermal power units & (2) coal-based thermal power units with advanced emission controls for SOx, NOx and PM, in order to incentivise/disincentivise clean power.	High	Immediate	Ministry of Power; Central Electricity Regulatory Commission; and Ministry of Coal	

Action Area	Recommended actions	Priority	Timeline	Implementation	Supplementary Notes
	i. Notification to Northern Region Load Dispatch Centre (NRLDC) to provide priority to clean power in merit dispatch order. (Short-term) ii. Amendment to the Indian Grid Electricity Code (2010) giving priority to cleaner sources of power generation (Long-term) iii. Inter-ministerial Sub Group constituted by the Infrastructure Constraints Review Committee, headed by Joint Secretary (Coal), to release a guideline to Rail and Coal India to prioritise the allocation and transportation of coal to the cleaner power producers based on priority dispatch order requirement (immediate) iv. Central Electricity Authority (CEA) may release an advisory to Railways and Coal India for prioritising the coal supply to the cleaner power producing TPPs to meet the priority dispatch order requirement (immediate) v. Scheme for Harnessing and Allocating Koyala **(Coal)** Transparently in India **(SHAKTI)**; can be amended to incorporate the prioritisation of coal allocation to the greener power producers to meet the priority dispatch order requirement (immediate)				
	Incentives for biomass co-firing in existing coal power units	High	Immediate	Ministry of Power; Central Electricity Regulatory Commission & State Electricity Regulatory Commissions in North Western States	Refer to Section 3.2.2 for existing policy from Ministry of Power

Action Area	Recommended actions	Priority	Timeline	Implementation	Supplementary Notes
	Leapfrogging to advanced (up to 50%) biomass co-firing in coal power plants in North West region	High	Long-term	Ministry of Power	Refer to Annex 9 for business case on leapfrogging to 50% Biomass Co-firing in Existing Thermal Power Plants
	Fuel switch in diesel generators, hotels & restaurants	High	Immediate	Central Pollution Control Board; State Pollution Control Boards and Urban local bodies in NCR	Refer to Section 3.2.1 and Annex 6 on existing regulation and control options for DG sets
Adoption of Best Available technology and Emission Standards	Strict in-use emission norms for all diesel generators along with minimum performance requirements (for instance life and efficiency) for retrofit devices	High	Immediate	Central Pollution Control Board	Refer to Section 3.2.1 and Annex 6 on existing regulation and control options for DG sets
	Adoption of a strengthened Pollution-under-control system to non-road diesel engines	High	Medium-term	Central Pollution Control Board; State Pollution Control Boards and Urban local bodies in NCR	Refer to Section 3.2.1 and Annex 6 on existing regulation and control options for DG sets

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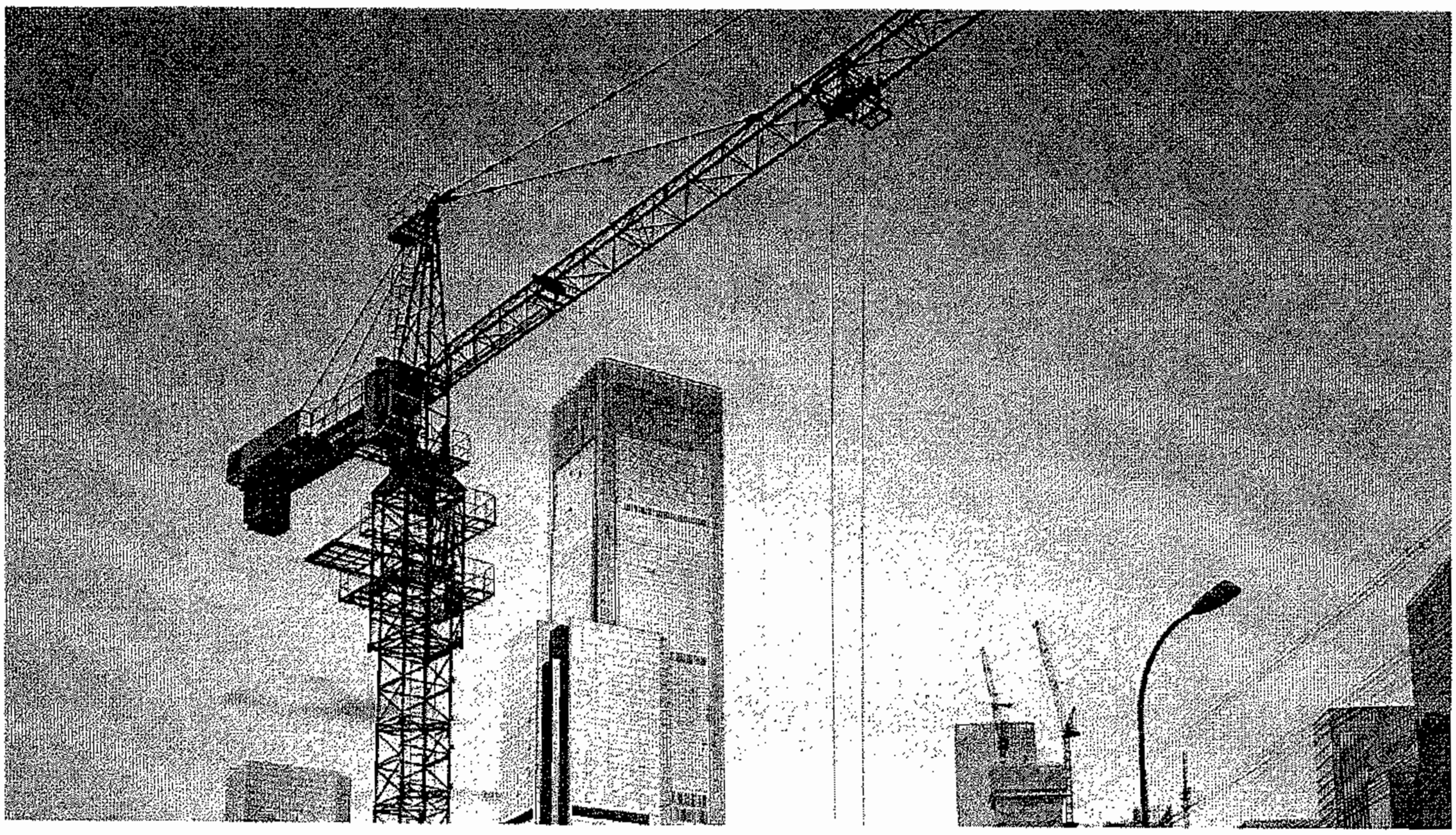

ANNEXURES

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Annex 10
Biomass Potential Across India's State

ANNEXURE 1

Emission Inventory for Delhi

	Emissions [tonne/ day]				
Sources	PM10	PM2.5	NOx	SO2	CO
Industrial Stack	13.7	6.6	161.8	128.8	11.6
Vehicle	12.9	11.6	113.4	1.2	322.4
Road Dust	79.6	22.2	0.0	0.0	0.0
Hotels/Restaurants	3.5	1.8	1.1	2.7	6.2
Domestic	7.4	6.9	7.7	1.2	25.4
Aircraft	0.1	0.1	5.4	0.4	4.1
Industries Area	1.6	1.4	1.9	5.6	0.2
DG Set	1.4	1.2	19.6	1.3	4.2
MSW Burning	2.0	1.8	0.7	0.1	10.3
Cremation	0.3	0.3	0.1	0.0	2.1
Construction/Demolition	5.2	1.3	0.0	0.0	0.0
Concrete Batching	14.4	3.6	0.0	0.0	0.0
Agricultural Soil Dust	1.4	0.0	0.0	0.0	0.0
Medical Incinerators	0.0	0.0	0.1	0.3	0.0

Source Sharma and Dikshit (2016)

ANNEXURE 2

Dust Control Regulation for Construction

Construction activities happening rampantly and in an unregulated manner are main causes of concern in Delhi NCR (NGT, 2015). The National Green Tribunal (NGT) issued guidelines for dust control in Delhi NCR in the years 2014 and 2015 covering construction activities and road/soil dust. In January 2018, the Ministry of Environment Forest and Climate Change (MoEFCC) issued the Environment (Protection) Amendment Rules, 2018 which apply to cities and towns where level of PM10/PM2.5 exceeds the limits prescribed in the National Ambient Air Quality Standards. Overview of these directions, along with guidelines by Central Pollution Control Board (CPCB) in December 2017, is enclosed in subsequent boxes (Box A2-1, Box A2-2, Box A2-3). It is worth noting that multiple violations have been reported by public and private agencies alike in NCR such as Delhi Development Authority (DDA), Delhi Jal Board (DJB), Delhi Metro Rail Corporation (DMRC), National Highway Authority of India (NHAI), NBCC, Public works Department (PWD), Central Public Works Department (CPWD), and Tata Power Delhi Distribution Limited (TPDDL) (NGT 2016; GNCTD 2016; GoI 2018). There is an urgent need for organisational behaviour changes across public and private organisations working in NCR.

Box A2-1 National Green Tribunal Directions in 2014 and 2015

Construction

1. It is the responsibility of every builder, contractor or owner (NGT, 2014) to cover the construction materials and install wind breakers on all sides of plot or area so dust does not get dispersed during the construction activity or storage of materials.
2. Use of wet-jet in grinding/cutting operation is compulsory as per NGT guidelines (NGT, 2015)
3. Storage of construction material on the roads or streets is prohibited (NGT, 2015).
4. Every builder and owner is mandated to use tarpaulin on the scaffolding around the building or area of construction (NGT, 2015)
5. During the transportation of construction material, proper coverage precautions are required. The vehicles or trucks carrying the construction materials like cement, sand and allied materials are required by NGT to be fully covered.
6. After the unloading operation, the vehicles need to be properly cleaned before they are permitted to ply on the road
7. Vehicles not complying to these directions are not permitted to enter NCR Delhi (NGT, 2014)
8. NGT demands strict vigilance of the stone-crushers by all concerned State Pollution Control Boards (SPCBs) and Environment Departments of State
9. All builders, building commercial or residential complexes, covered under the EIA notification 2006, are mandated to provide green belt cover around the constructed buildings. Compliance is to be ensured by respective authorities before issuing the occupancy certificate.

Road/soil dust	1.	Executive engineer of each PWD in NCR is personally responsible for compliance of NGT guidelines for construction and demolition activities which equally applies to construction of roads and highways and is required to report to chief engineer every week.
	2.	The city corporations/ councils (MCDs, NMDC, DCB, MCG etc.) and development authorities (DDA, HUDA, NOIDA, Greater Noida Authority etc.) including the state departments are expected to make efforts of increasing the tree-cover in NCR by planting the right kind of plants/trees species depending on the soil quality and other natural settings.
	3.	During the maintenance of roads, it is required from DDA, PWDs and other concerned agencies that coal-tar, bitumen or asphalt mix is brought in molten condition without the fire to melt these materials on the open road.
	4.	All the concerned utilities or service providers are required to formulate comprehensive waste management plans for C&D waste generated within their jurisdiction. Plan should cover segregation, storage, collection, reuse, recycling, transportation, and disposal of this waste.

Source: Adapted from NGT (2014; 2015)

Box A2-2. Environment (Protection) Amendment Rules (2018) for Dust Mitigation in Construction and Demolition Activities

Mandatory Implementation of Dust Mitigation in projects requiring Environmental Clearance	Mandatory Implementation of Dust Mitigation Measures for all Construction and Demolition Activities
1. No building or infrastructure project requiring Environmental Clearance shall be implemented without approved Environmental Management Plan inclusive of dust mitigation measures.	1. Grinding and cutting of building materials in open area shall be prohibited.
2. Roads leading to or at construction sites must be paved and blacktopped (i.e. metallic roads).	2. Construction material and waste should be stored only within earmarked area and road side storage of construction material and waste shall be prohibited.
3. No excavation of soil shall be carried out without adequate dust mitigation measures in place.	3. No uncovered vehicles carrying construction material and waste shall be permitted.
4. No loose soil or sand or Construction & Demolition Waste or any other construction material that causes dust shall be left uncovered.	4. Construction and Demolition Waste processing and disposal site shall be identified and required dust mitigation measures be notified at the site.
5. Wind-breaker of appropriate height i.e. one third of the building height and maximum up to 10 meters shall be provided.	
6. Water sprinkling system shall be put in place.	
7. Dust mitigation measures shall be displayed prominently at the construction site for easy public viewing.	

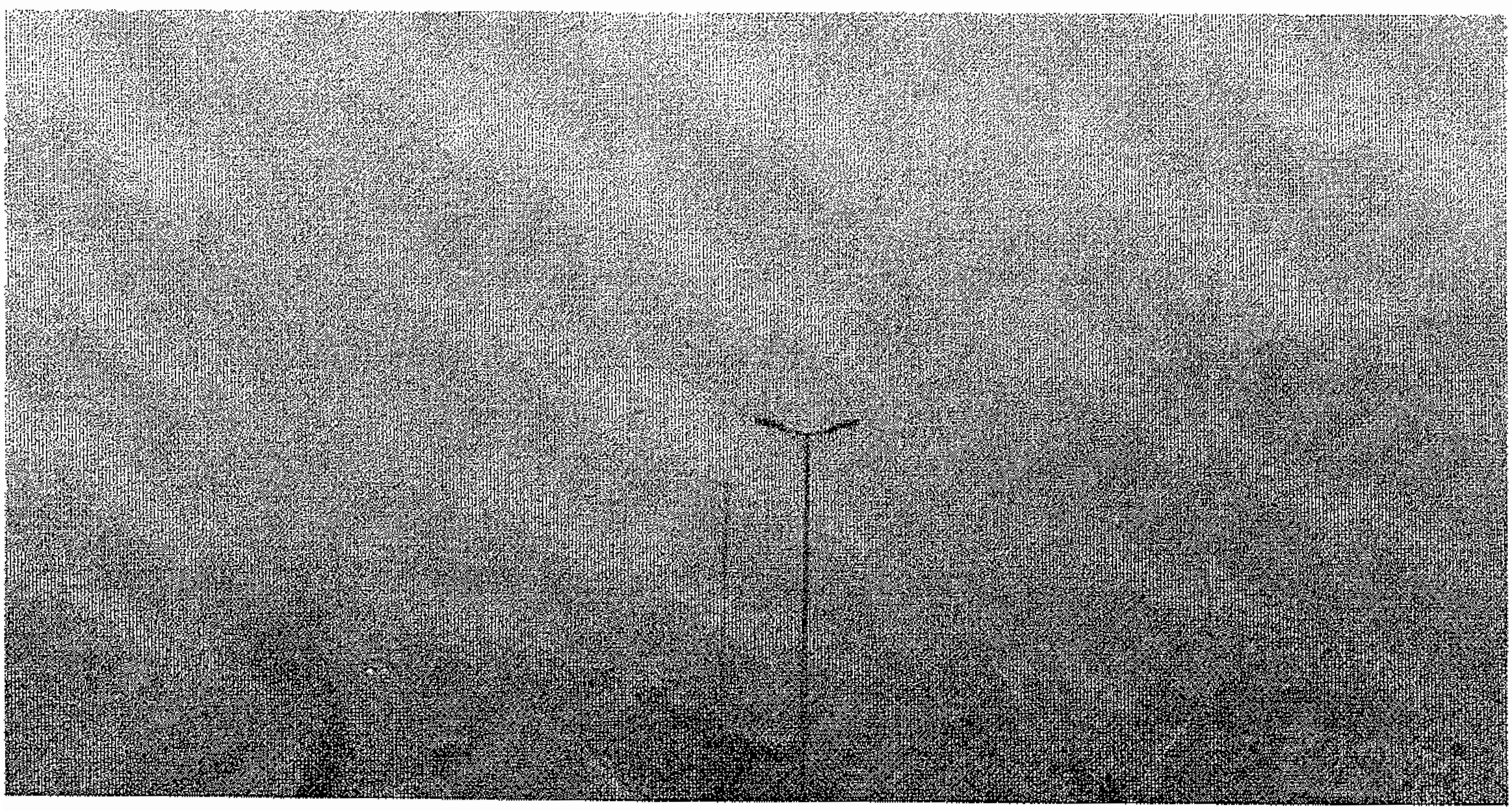
Source: Adapted from MoEFCC (2018)

Box A2-3. Central Pollution Control Board Guidelines for Dust Control (2017)

Transportation of construction, and C&D waste materials	1.	Transportation routes to be identified for avoiding sensitive receptors
	2.	Proper covering of materials
	3.	No overloading of vehicles to avoid overflow of materials
	4.	Transportation to be generally during night, transport permit to include details on material type, quantity and transfer points
	5.	Location of all temporary/intermediate C&D storage sites to be placed in public domain
	6.	Dampening of dust by water spray or wind breakers at all temporary/intermediate C&D storage sites
	7.	All construction material loading/ unloading activities at on-site or off site to ensure dust suppression using location, water spraying and proper cover
	8.	Road surfaces to be maintained well to avoid spillage from transport vehicles
	9.	Regular sweeping of roads to avoid resuspension of dust on roads
Storage of construction and C&D waste materials	1.	Off-site: Prohibition from storing/ dumping material on metalled roads
	2.	On-site: a. location of sites should be such that dispersal of dust is minimum during handling b. Contractor/ builder to synchronise availability of material with its utilisation so that storage period is minimum c. Site of demolition to be cordoned off and adequate measures to prevent dust beyond site limits d. Reducing dust particles in air by storing the fine materials such as sand, gravel and cement in demarcated area with cover (cement bags in enclosed areas, loose cement to be stored in silos)
Dust control measures at site- Construction/ demolition/ renovation	1.	Raise barricade along the perimeter depending on the nature of adjoining area (alternate to wet suppression)
	2.	Mount dust barrier sheet on scaffolding around the construction/ construction building- particularly side facing residential building
	3.	Selective mechanisation of handling material/ waste helps in better management and reduction of dust generation at site

Additional measures mentioned in CPCB guidelines	1.	Operations of equipment / machineries include transporting (conveyor belt) crushing / hammering etc. deployed at site generate dust - these areas need to be bounded (enclosed) and use of water sprinklers to suppress dust emissions
	2.	DG sets to be well maintained to ensure low emissions
	3.	The transport vehicles engaged be well maintained (PUC compliance)
	4.	Routes of transport vehicles within construction site be damped by water (preferably treated waste water) sprinklers
	5.	Dry sweeping of work areas to be prohibited
	6.	For construction activities, simultaneous development of green buffer would assist in arresting dispersal of dust (preferably shrubs & trees that have low uptake of water)
	7.	All builders / contractors engaged in construction & demolition activities to submit an undertaking to the concerned government department on measures adopted to control dust
	8.	Sale of construction material from road sides to be prohibited
	9.	Dumping (unloading) and storage of construction material for use in ongoing projects on public road sides is prohibited
	10.	Construction projects to be encouraged to utilize products manufactured from C&D waste processing– this step improves organised collection of C&D wastes, stops indiscriminate dumping of C&D wastes thereby reducing dust load escaping into the atmosphere during dry weather
	11.	Inclusion of condition(s) by concerned agencies for adoption of dust mitigation measures in approvals / permits / consent provisions / environmental clearances for construction projects

Source Adapted from CPCB (2017)



ANNEXURE 3

Building Permits and Environmental Clearance

Besides existing regulation discussed above, provisions in buildings byelaws and codes check environmental pollution over the course of construction. A risk-based classification is used by Delhi Development Authority (DDA) for approval of building plans in Delhi. Different types of approvals and environmental clearances for building projects are summarised in Table A3-1. Model building Bye-Laws by the Ministry of Housing and Urban Affairs (MoUD 2016) stipulate specific conditions to be met for environmental safeguard before and during the course of building construction. These conditions now apply to building projects with total built up area (BUA) between 5,000-50,000 square metre which do not require separate environmental clearances from Expert Appraisal Committee (EAC) of the Ministry of Environment (MoEFCC) or the State Expert Appraisal Committees (SEACs). MoEFCC has integrated the environmental concerns into building plan approval process, empowering the concerned local body or development authority to approve and certify compliance of stipulated requirements (MoUD 2016, DDA 2016). Depending on the size of project, specific conditions require project proponents plan mitigation measures. As per the Unified Building Byelaws notified by DDA on March 2016 and subsequent notification by MoEFCC in 2018, project proponents under all categories of building projects need to meet stipulated environmental conditions (DDA 2016; MoEFCC 2018b). As per the latest notification, these environmental conditions for all building categories with BUA above 20,000 m^2 include-

1. Roads leading to or at construction sites must be paved and blacktopped (i.e. metallic roads). No uncovered vehicles carrying construction material and waste shall be permitted.
2. No excavation of soil shall be carried out without adequate dust mitigation measures in place. Water sprinkling system shall be put in place. Unpaved surfaces and loose soil shall be adequately sprinkled with water to suppress dust.
3. No loose soil or sand or Construction & Demolition Waste or any other construction material that causes dust shall be left uncovered. Construction material and waste should be stored only within earmarked area and road side storage of construction material and waste shall be prohibited.
4. Wind-breaker of appropriate height i.e. 1/3rd of the building height and maximum up to 10 meters shall be provided.
5. C&D waste processing and disposal site shall be identified and required dust mitigation measures be notified at the site.
6. Grinding and cutting of building materials in open area shall be prohibited. Wet jet shall be provided for grinding and stone cutting.
7. Dust, smoke and other air pollution prevention measures shall be provided for the building as well as the site.
8. Dust mitigation measures shall be displayed prominently at the construction site for easy public viewing.
9. Exhaust pipe of the DG set, if installed, must be, at least 10 metres away from the building, or else an exhaust pipe must be provided at least 3 metres above the building.
10. A minimum of one tree for every 80 sqm of land to be planted and maintained, with preference to native species. Wherever the existing trees need to be cut, compensatory plantation in the ratio of 1:3 (i.e. planting of three trees for every one tree that is cut) to be done with the obligation to provide continued maintenance for such plantations.

Additionally, use of fly ash bricks as per the latest Fly ash notification by MoEFCC is mandatory for all construction projects with BAU >20,000 m² (DDA 2016). According to latest amendment by MoEFCC, all construction agencies within a radius of 300 km from thermal power plants (TPPs) need to utilise fly ash products (MoEFCC 2016b). In addition, the state authorities have been asked by MoEFCC to amend the building byelaws of the cities (with population ≥1 million) to ensure mandatory use of fly ash-based bricks. Further, the use of fly ash in infrastructure projects is emphasised in the latest notification. Concerned authorities are advised to link the payment to contractor with certification of supply of fly ash or fly ash based products. Cost of fly ash transportation to the user is to be borne by TPPs within a distance of 100 km and shared equally between them for transportation between 100 km to 300 km.

All construction projects with BAU > 20,000 m² also need to prepare and implement an Environment Management Plan (EMP) for addressing environmental concerns (DDA 2016). EMP ensures that mitigation measures specified in EIA (or stipulated as environmental conditions to be met for buildings permission by local authority), are actually complied with during implementation of projects. It covers the mitigation measures and monitoring undertaken by project proponent at the site and nearby receptors. EMP applies to all environment infrastructure which is kept operational through administration of Environment Monitoring Committee with defined functions and responsibility.

50 CLEAN INDUSTRY

Table A3-1. Overview of the Building Approvals and Environmental Clearance

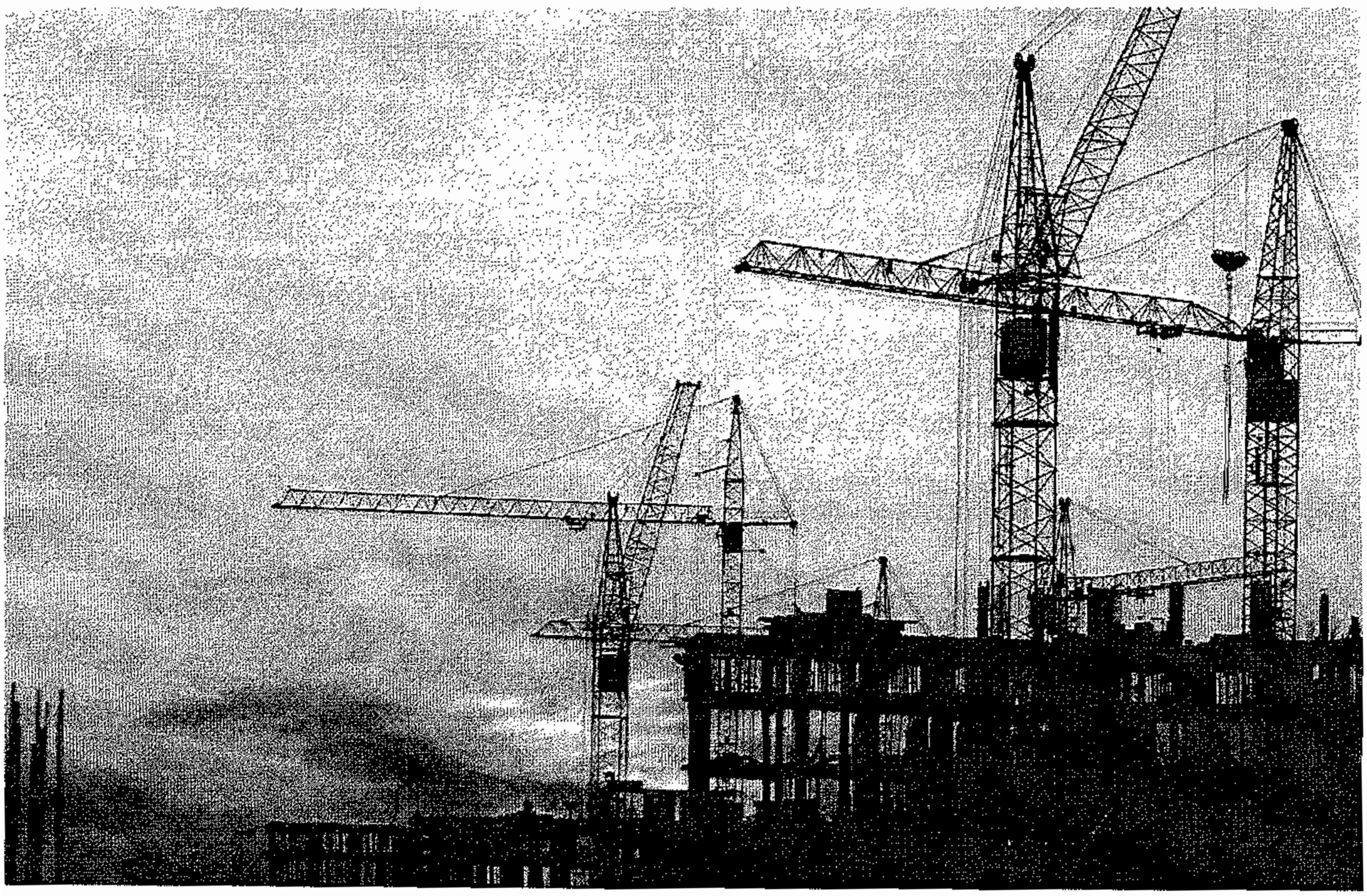
Type of approval	Building categories	Built up area (BAU)	Approval Process
Risk-based fast track procedure for building approvals by local bodies/ authorities	Very-low risk residential buildings	≤ 105 m² height < 15 m	• Owner gives an undertaking for intimation of construction start & completion to the concerned authority or local body along with building permit fee[1] • Approval in accordance with the 'General Building Requirements' of building byelaws and 'Development Control Regulation' by the development authority
	Low risk residential buildings	105-500 m² height < 15 m	• Qualified engineer/architect provides building permit upon submitting permit fees to local body or owner can apply for sanction from local body • Permit from local body is provided within 10 days
	Moderate risk residential buildings	> 500 m² height < 15 m	• Qualified engineer/architect to submit building plans for approval from local body along with requisite documents and fees • Permit from local body is provided within 20 days.
	High risk residential buildings	≥ 3000 m² height > 15 m	• Mandatory clearance from Delhi Fire Service • Qualified engineer/architect submits building plans for approval from local body along with requisite documents and fees • Permit from local body is provided within 30 days
Building projects not requiring Environmental clearances	Category 'A' building projects	5,000-20,000 m²	• Local bodies to ensure compliance of the stipulated conditions to address environmental concerns
	Category 'B' building projects	20,000-50,000 m²	
	Category 'C' building projects	50,000-1,50,000 m²	• Local bodies to ensure compliance of the stipulated conditions to address environmental concerns • Mandatory Environment Management Plan (EMP)
Building projects requiring Environmental clearances	Townships & area development projects	> 1,50,000 m²	• Mandatory conditions for environmental safeguard • Mandatory Environment Impact Assessment (EIA) & Environment Management Plan (EMP) • Development of green belt around the site

Source: DDA (2016), MoEFCC (2018b)

[1] Buildings permit fee levied in Delhi NCT varies from Rs.1500-5000 per m² depending on localities.

All major infrastructure and building projects with built up area more than 1,50,000 square metre require Environmental Impact Assessment (EIA) for environmental clearance and approvals. EIA addresses the impact of project on the environment by drawing up an Environmental Management Plan (EMP) and integrating it with the any measures proposed by the government (See Annex 2 and Annex 3). From May 2018 onward, project proponents are also required to submit a plan for Corporate Environment Responsibility (CER) along with the EIA report as specified by the MoEFCC in May 2018. CER is only required in greenfield or brownfield projects where the pollution load is expected to increase. Cost of CER is in addition to the cost of control measures envisaged under EIA/EMP. The actual fund allocation under CER will be decided in the EAC, SEAC or District-level Expert Appraisal Committee (DEAC). The maximum percentage of CER, as prescribed by MoEFCC is 0.25%-2% for greenfield projects and 0.125%-1% for brownfield projects depending on the capital investment (MoEFCC 2018a). EAC based on appraisal, can suggest the activities to be carried out under CER, restricted to the affected area around the project.

It is mandatory for project proponents to submit half-yearly compliance reports with respect to the stipulated terms and conditions of the environmental clearance granted to them. Specific motoring reports may also be required from the project proponents as part of any specific environmental conditions mentioned in the EC letter. These reports are public documents and the latest compliance/monitoring reports are uploaded at MoEFCC website.



ANNEXURE 4

Buildings Codes and Green Buildings' Rating Systems

There are two different building codes which govern the residential and commercial buildings in India-

1. National Building Code (NBC) of India by Bureau of Indian Standards (BIS) under the Ministry of Consumer Affairs, Government of India
2. Energy Conservation Building Code (ECBC) by Bureau of Energy Efficiency (BEE), a statutory body under the Ministry of Power, Government of India.

The National Building Code (NBC) is a model code for adoption by all agencies involved in building construction. The focus of NBC is primarily the structural integrity, material sustainability, fire safety, facility/asset management and building services. Energy Conservation Building Code (ECBC) is a building energy code. It deals primarily with the energy efficiency of the building envelope and building energy services such as lighting, thermal comfort and water heating. Literature review of NBC indicates that there are two ways in which ambient air quality concerns are addressed under the NBC and these are briefly described below.

1. Sourcing of buildings materials with low embodied energies
2. Construction practices and environmental management

National Building Code of India (2016) notes that construction in busy localities of cities need special considerations and meticulous planning due to restricted space, adjoining structures, underground utilities, traffic restrictions, noise and environmental pollution and other specific site constraints (BIS 2016).

To address the environmental footprint of construction, considering the whole lifecycle of building materials is crucial. Lifecycle also encompasses the extraction of virgin materials, allied construction activities for manufacturing of building materials and transportation of materials to the site which contribute to total embodied energy of building material. NBC recommends minimising environmental footprint of building construction by considering construction materials with low embodied energies. Embodied energy of recycled materials from C&D waste, fly ash and agricultural waste are typically in the range of 1-5 GJ/ tonne compared to high embodied energy (5-50 GJ/ tonne) for cement, steel, glass etc (BIS 2016). In addition to environmental footprint during the construction phase, there are other frequently used building materials like reconstituted wood products, paints, glues, paints, carpets and upholstery, which may release gases/fumes commonly classified as volatile organic compounds (VOCs) from the chemical composition used, even long after installation (BIS 2016).

NBC (2016) also stresses the role of contractual obligations towards sustainable construction. It notes that use of materials and technologies deployed at site may impact the environment, especially the ambient air quality. Such scenarios include (BIS 2016)-

- Use of inefficient construction equipment/ technologies
- Suboptimal use of equipment/technologies and suboptimal transportation of materials
- Processing of materials such as cutting, mixing, and fabrication.

As per the building code, such materials and technologies need to be identified and procedures need to be planned accordingly to mitigate their impact (BIS 2016). Contracts determine obligations of individuals and organisations. Therefore, contracts shall make it obligatory on the part of suppliers of materials and equipment/services to follow sustainable processes and practices. Contractually binding obligations ensure system-wide responsibilities so that necessary mitigation resources may be budgeted within the project scope (BIS 2016). Responsibilities for sustainability practices during construction may be clearly assigned, explicitly assigning liabilities (including contingencies for risks known as well as management reserves towards unknown risks) that may accrue on account of lapses (BIS 2016).

Building code also specifies the requirement for ambient air quality monitoring depending on the project size, location and type of activities. SPM, $SO2$, NOx and CO need to be monitored twice a week at representative locations at site and study area adopting a schedule of 24 hours. The monitoring locations need to be considered on the basis of predominant wind directions, land use patterns and height of proposed stacks. At least one monitoring locations needs to be at maximum pollution deposition area due to proposed deposition of stacks of generators. The number of air quality monitoring locations should be at least five including at least one at project site (BIS 2016).

In addition to buildings codes, there are independent building rating systems which are voluntarily adopted by owner or developers. These rating systems assess how green the buildings are and have their own set of requirements for doing so. Prevalent rating systems in India include-

1 Green Rating for Integrated Habitat Assessment (GRIHA)

2 Indian Green Building Council (IGBC)

3 Leadership in Energy and Environmental Design (LEED)

These rating systems focus on various aspects of building systems, mainly-

1. Energy efficiency of building envelope and associated energy services
2. Sustainability of building architecture and design
3. Sustainability of building materials and resource efficiency
4. Quality of indoor environment
5. Water efficiency and conservation

A comparison of different rating systems and their focus on management of ambient air quality is provided in the Table A4-1. Although use of sustainable building materials is covered well under all rating systems, footprint of construction activities on the ambient air quality is not emphasised enough. It is observed that the focus of existing rating systems is dominantly the post-construction use or operational phase of the building system.

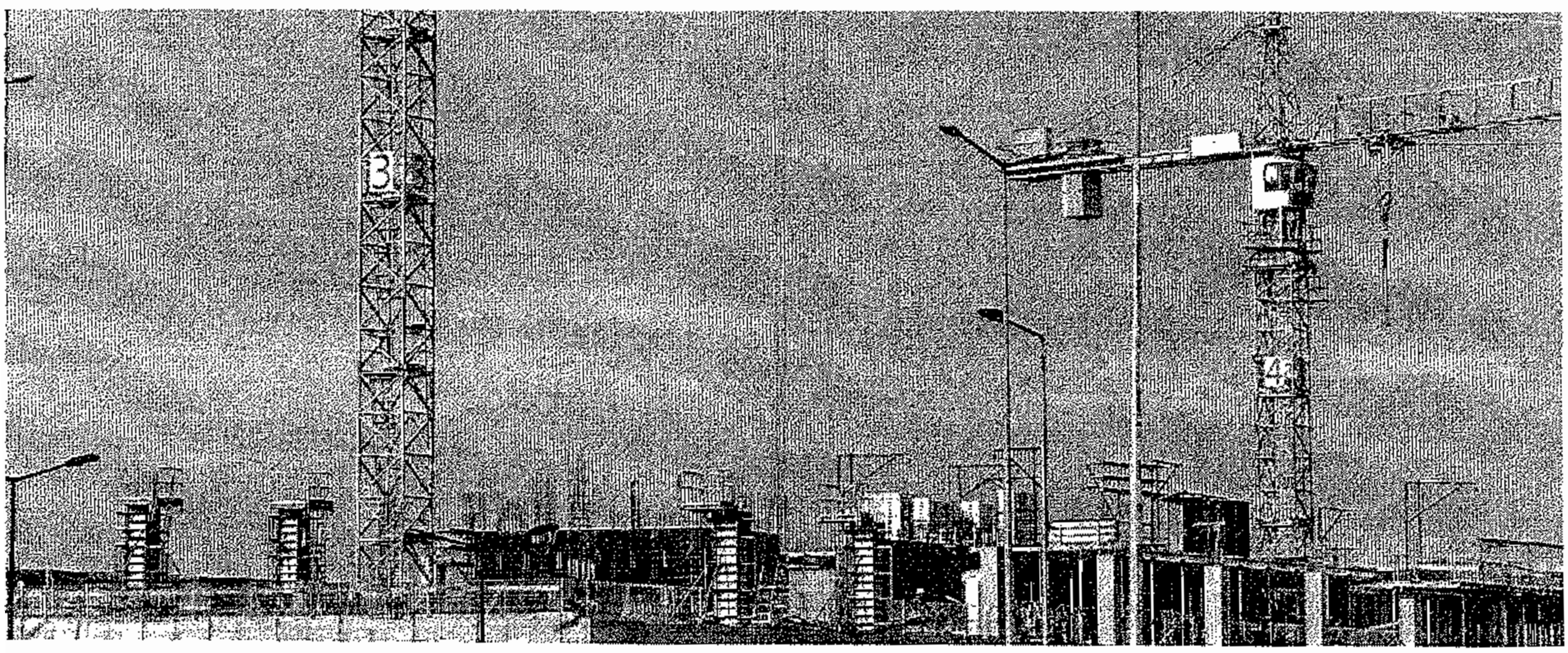


Table A4-1. A Comparison of Focus on Ambient Air Quality Management During Construction Across Different Building Rating Systems in India

Building Rating Systems	Specific Criteria Linked to Ambient Air Quality Improvement	Remarks
GRIHA (Maximum 104 points)	1. Reduce air pollution during construction as per GRIHA clauses **(Mandatory- 2 points)** 2. Proper stabilization of soil & topsoil laying for vegetative growth **(Mandatory- 1 point; Optional- 4 points)** 3. Preserve and protect landscape during construction **(Mandatory- 1 point)** 4. Consolidation of utility corridors **(Optional- 1 point)** 5. Utilization of fly ash in building structure **(Optional- 6 points)** 6. Reduce volume, weight, and construction time by adopting efficient technologies such as pre-cast **(Optional- 4 points)** 7. Reduction in waste during construction **(Optional- 1 point)**	• GRIHA requires provision in the contract document that the contractor will undertake the responsibility to prevent air pollution • It also requires a narrative explaining the air pollution preventive measures (site photographs showing different stages of construction along with preventive measures to support the claim).
IGBC (Maximum 100 points)	1. Indoor air quality management during construction' **(Optional- 1 point)** 2. Preservation or transplantation of trees **(Optional- 1 point)** 3. Natural topography or vegetation **(Optional- 2 points)** 4. Sustainable building materials **(Optional- 8 points)** 5. Handling of waste materials during construction **(Optional- 1 point)** 6. Use of certified green building materials, products & equipment **(Optional- 5 points)**	• Ambient air quality is partially addressed under the 'Indoor air quality management during construction' • Credit for air quality management is not eligible for exemplary performance
USGBC/LEED (Maximum 149 points)	1. Construction indoor air quality management plan **(1 point)** 2. Building life-cycle impact reduction **(5 points)** 3. Environment product declarations **(2 points)** 4. Building product disclosure and optimization: sourcing of raw materials **(2 point)** 5. C&D waste management planning **(2 points)** 6. On-site restoration using native or adapted vegetation **(2 points)**	• Ambient air quality is partially addressed under the 'Construction indoor air quality management plan

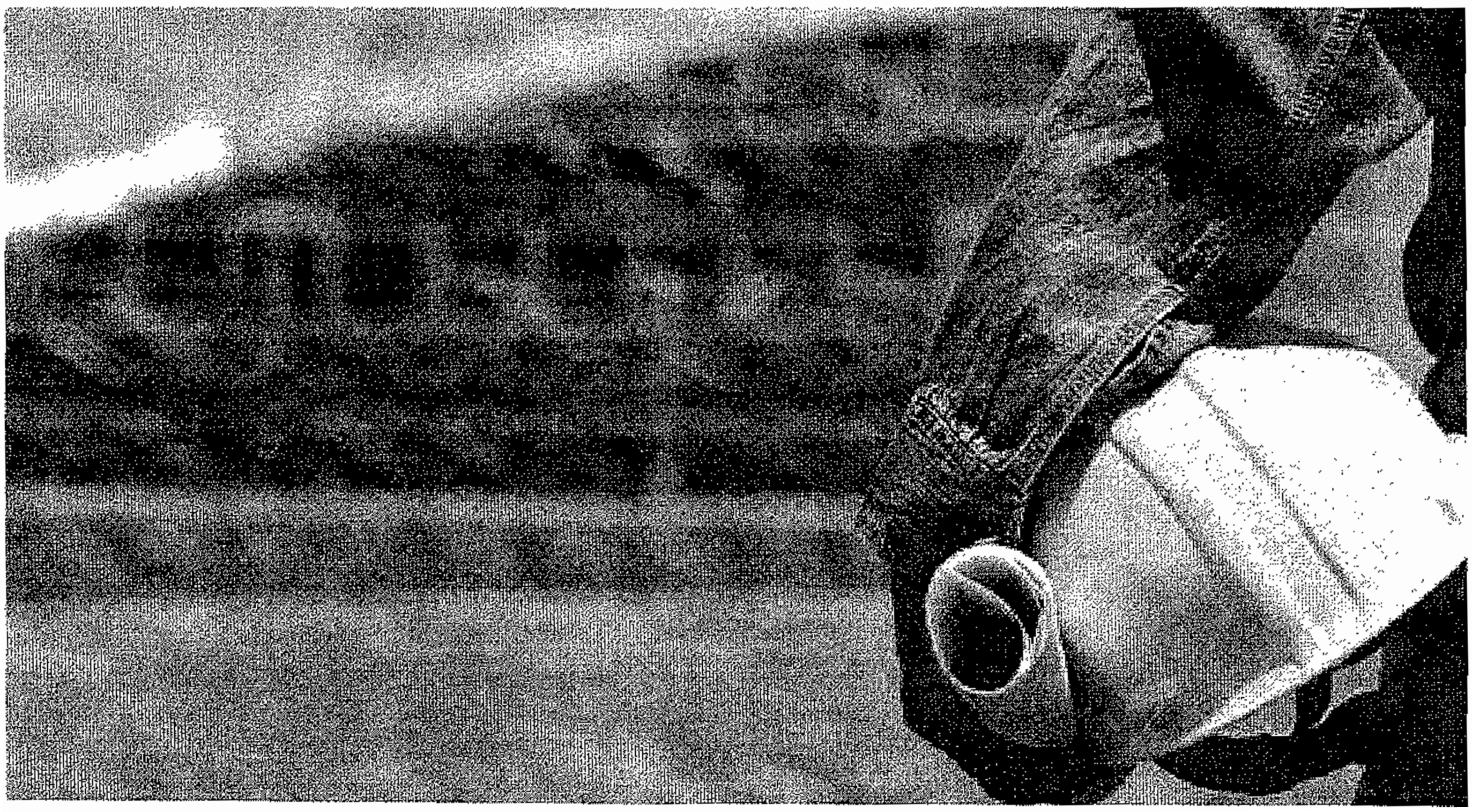
Source: GRIHA (2010), IGBC (2016), USGBC (2018)

ANNEXURE 5

Best Practices Guide: Prevention and Control Measures for Fugitive Emissions

Introduction

Depending on the nature of source and local conditions, technological and management options are available for keeping fugitive PM emissions under check or eliminating them altogether. Particularly, the dust suppression techniques can be broadly classified into-the dry suppression and the wet suppression. Wet suppression requires water to neutralise the dust. Fresh water is a scarce resource and wet suppression can only be applied in areas with sufficient availability of treated water. Prevention of dust generation at the first place and dry suppression techniques are therefore preferable to wet suppression as they do not require water to suppress dust. Having said that, wet suppression is the only practical choice for many activities/sources generating dust e.g. unpaved roads and large stockpiles. Different options for control of dust are outlined and briefly described in the following text along with their advantages and limitations in Delhi-NCR's context. These control options are broadly classified as- (1) Smart construction materials, (2) Modern multi-service utility corridors, (3) Surface improvements, (4) Site/plant layout and design (5) Wet suppression and chemical stabilisation, (6) Best management practices for control of emissions, and (7) Best available technology for dust suppression. Dust prevention combines those techniques and management practices which eliminate dust generation. These options need to be considered at the early stages of the project, i.e. the planning and design stages.



Box A5-1 Comprehensive Measures for Prevention and Control of Fugitive Emissions in Delhi NCR

S.N.	Category	Measures
1	Smart and Sustainable Construction Materials	Prefabricated, pre-casted and modular construction elements
		Building materials with low-embodied energy: finished or semi-finished products from waste streams including C&D waste, fly ash, road dust and rice straw
2	Multi-utility service corridors/ducts with ITC enabled system for inter-agency coordination	Multi-utility service corridors/ducts
		ITC enabled system for inter-agency coordination for minimal disturbance during utility maintenance operations
3	Surface improvements	Revegetation on road edges using industrial techniques (geo-textiles, hydro-seeing etc)
		Flexible/open grid paving and gravelling on exposed surfaces around roads/sites
		Vegetation drives in abandoned fly ash pounds (decorative and aromatic plants)
4	Site or plant layout and design features	Tree-lines for dust/ash interception at existing fly ash ponds or various other sites/plants
		wheel-wash facilities for transportation vehicles
		Optimal location of plants/sites with respect to transportation of construction materials
		Paved access roads at sites/plants
		Hoods and other enclosures around conveyers and hoppers
		Conveyers or chutes with adjustable height
		Hopper load systems with a good match for truck sizes

S.N.	Category	Measures
5	Wet suppression	Simple wet suppression techniques including gravity and mechanical sprinklers which are relatively inefficient and require more water (treated water)
		More efficient techniques including dry fog suppression system (covering relatively larger area for the same amount of water), chemically-aided wet suppression (more efficient agglomeration of particles) or combinations of these
6	Best management practices	Monitoring and housekeeping for all potential leakages points of dust/ash (Refer Annex 5)
		Best practices for handling materials at site/storage facilities/plants (Refer Annex 5)
		Best practices for transportation e.g. load size limitations, speed limits etc. (Refer Annex 5)
		Planning and optimising transportation of construction materials
7	Dust/ash Suppression Systems	Construction equipment with dust suppression technology: cyclone separators, bag filters, ESP etc. for capturing dust/ash
		Vacuum cleaning of roads/streets with 'segregation and binding' of dust into fine aggregates

Source: CII-CESD (2019) analysis

A 5.1 Smart and Sustainable Construction Materials

Smart construction and building materials eliminate fugitive dust emissions during the construction phase at site and are therefore one of the most effective strategies for dust control. Smart construction materials include pre-fabricated modular construction materials, recycled building materials, flexible pavements and advanced road construction materials such as recycled plastics and geopolymer concrete.

Smart and pre-fabricated modular constructions reduce pollution at the construction site caused by transportation and handling of raw material. Fugitive dust emissions can be controlled more effectively in industrial environments where these modular units are fabricated. Pre-fabricated modular constructions are already common in urban infrastructure projects. These modules (precast/prefabricated/partially prefabricated concrete elements) are used in construction in the form of building elements which are assembled at site and made monolithic by pouring in-situ concrete. They break the structural elements down into smaller segments resulting in ease and economy in construction (BIS 2016).

Recycling C&D waste ensures that waste materials feed back into the material flows in the city and are utilised in new construction projects. Re-utilisation of C&D waste is expected to curb illegal dumping of C&D waste and dust generation as a result. Currently, the installed C&D processing plants can process the C&D waste at 2500 tonne per day (GNCTD 2018a) and can handle 50% of the C&D waste generated within NCT Delhi. Enhancement in capacities of C&D waste recycling plants is required in Delhi NCT and other NCR towns where such infrastructure is non-existing. The Burari plant by IL&FS was set up under the Public-private partnership (PPP) model and recycles 2000 tonne C&D waste per day into construction-grade aggregates (with recycling rate of 95%). These aggregates are further converted into products such as RMC, cement bricks, hollow bricks, pavement blocks, kerb stones, concrete bricks and manufactured sand, thereby reducing the consumption of virgin materials such as fresh stones and sand, and mitigating pollution arising in the processes of quarrying and mining (IL&FS 2018).

Similar to C&D waste, fly ash is another major waste stream which can feed back into the material flows to the city. Low cost fly ash based permeable concrete provides hard surface (for moving heavy vehicles etc.) and can seep water. It also has the added advantage of significantly lower cost as compared to the conventional bitumen roads. 100% recycled materials can be promoted for urban infrastructure projects and civic authorities can be mandated to source 100% recycled materials. The various commercially established products and applications of fly ash are summarised in Box A5-2.

NTPC has recently demonstrated use of fly ash from its coal thermal power plant in Dadri (NCR Delhi) for road construction (NTPC 2017). This specific use case demonstrates use of fly ash in the form of high strength geopolymer concrete (meeting IRC specifications for road construction) and it was implemented by NTPC Energy Technology Research Alliance (NETRA) and CSIR laboratory- Central Buildings Research Institute (CBRI). Geopolymer concrete is typically made up of waste products such as fly ash, granulated blast furnace slag (GGBS), fine/coarse aggregates and catalytic liquid system (BIS 2016). As per NTPC, geopolymer road does not need water curing as required by cement concrete road and paves the way for bulk fly ash utilization. NTPC is now inviting expression of interest from Indian firms and contractors for building geopolymer concrete based roads at NTPC projects or stations across India (NTPC 2018d).

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Box A5-2. Finished & Semi-Finished Recycled Products from Different Waste Streams

C&D Waste	1. Recycled Concrete Aggregates (RCA) 2. Ready Mix Concrete (RMC) 3. Cement bricks 4. Hollow bricks 5. Pavement blocks 6. Kerb stones 7. Concrete bricks 8. Manufactured sand
Road/street Dust	1. Road paving blocks using road dust as fine aggregate 2. Road paving bricks using road dust as fine aggregate 3. Road paving tiles using road dust as fine aggregate
Fly Ash	1. Light-weight Aggregates (LWAs) 2. Geopolymer concrete 3. Clay-fly ash bricks, blocks, tiles, roofing tiles (manual 60% fly ash; mechanised 85% fly ash) 4. Fly ash-lime-gypsum-cement bricks and blocks (50% fly ash) 5. Fly ash bricks (90% fly ash) 6. Manufacturing of Cement 7. Part substitution of cement in concretes including RMC, SCC, high strength & structural concretes (up to 50% fly ash) 8. Construction of roads, embankments & bridges including pavement interlocking block, kerb stones etc. 9. Stowing in underground mines, backfilling of open cast mines 10. Construction of haul roads & other construction / development activities in mine sector 11. Construction of dams & water management structures
Rice straw	1. Straw-bales for building insulation in alternate building designs 2. Eco-panels made from rice-straw for building indoors

Source: CBRI (2018), CFARM (2018), IL&FS (2018), BIS (2016), NTPC (2017, 2018d) and other stakeholder inputs

Recycled concrete aggregate (RCA) is the primary product of C&D waste recycling plant which is further processed into products as shown in box A5-2. The production of concrete for buildings and roads in India is governed by BIS (IS 456, IS 1343) and IRC codes (IRC 112) respectively (CPWD 2014). All these codes further conform to BIS code: IS 383 for use of aggregates in concrete. This standard has been revised for use of RCA in concrete in the year 2016. As per the revised specifications (IS 383, 2016), maximum allowable RCA content in concrete is-

a. Plain cement concrete (PCC): ≤ 25% coarse & fine RCAs

b. Reinforced cement concrete (RCC): ≤ 20% coarse & fine RCAs

c. Lean concrete: 100% RCAs for non-load bearing structures using lean concrete

As per the National Building Code of India, recycled aggregates may be used in concrete for bulk fills, bank protection, base/fills of drainage structures, pavements, sidewalks, kerbs and gutters etc. (BIS 2016). Up to 30% of the natural coarse aggregate can be replaced by the coarse recycled aggregate, in fresh concrete. This percentage can be further increased up to 50% for pavements and other areas which are under pure compression (BIS 2016).

In addition to above standards and codes, there are specific mandates for utilisation of C&D waste in new projects in Delhi. The Government of National Capital Territory of Delhi (GNCTD) has issued advisory to all its Departments for a mandatory clause in their tenders requiring use of 2% and 10% of recycled C&D waste products in building and road projects respectively (GNCTD, 2018b). It also categorically mentions that C&D waste should be reutilised in-situ for all big redevelopment projects of government worth more than INR 500 Crores. GNCTD notice also advises 500 tonne per day processing units to be set up across the city with one such unit by a major government stakeholder. A similar notice was also issued by Central government agencies: Ministry of Urban and Housing Affairs (MoHUA) and Central Public Works Department (CPWD) in March 2016.

A 5.2 Modern Multi Utility Service Corridors

Multiple agencies and departments are involved in maintaining the utility lines (gas, sewage, fresh water, electricity, telecommunications etc.) along the roads. Actions of different departments or utilities are not synchronised, and this leads to dust generation on roads which is further suspended in the air due to vehicular movement. Modern utility corridors are essential for curbing emissions from day-to-day activities of utilities across the city.

Separate utilities corridors and demarcations are required across NCR (on the lines of ongoing project under smart cities) so that only relevant utility lines are disturbed during renovation work and dust generation is minimum. Table A5-1 shows ongoing smart city projects (above INR 100 Crore) under the category of utility works. 13 out of total 17 cities have opted for multi-utility ducts, trenches or tunnels. This indicates significant interest among cities for implementing common utility corridors. But it must be noted that all projects under smart cities are area-based development and do not cover the entire city. As clear from Table A5-1, cost for project varies from INR few crores to INR few hundred crores per kilometre depending on the type and number of utility lines. It will therefore be a good idea for NCR towns to learn from implementation of smart cities projects and accordingly implement a cost-effective model after assimilating the learnings from ongoing projects.

Advanced Information and Communications Technology (ICT) system can be deployed at common utility corridors to ensure inter-departmental or inter-agency coordination. ICT system ensures that information is shared with all the relevant departments or agencies whenever a particular activity is undertaken. It can be seen in Table A5-1 that few cities have opted for advanced ICT systems to integrate utility operations. ICT system may include advanced metering infrastructure for urban utilities such as water and energy.

The only operation utility corridor in the country is a 1.25 km long underground utility tunnel (Figure A5-1) at Connaught Circle, New Delhi developed as part NDMC's city redevelopment plan.

Figure A5-1. Common Utility Tunnel in Connaught Place, New Delhi

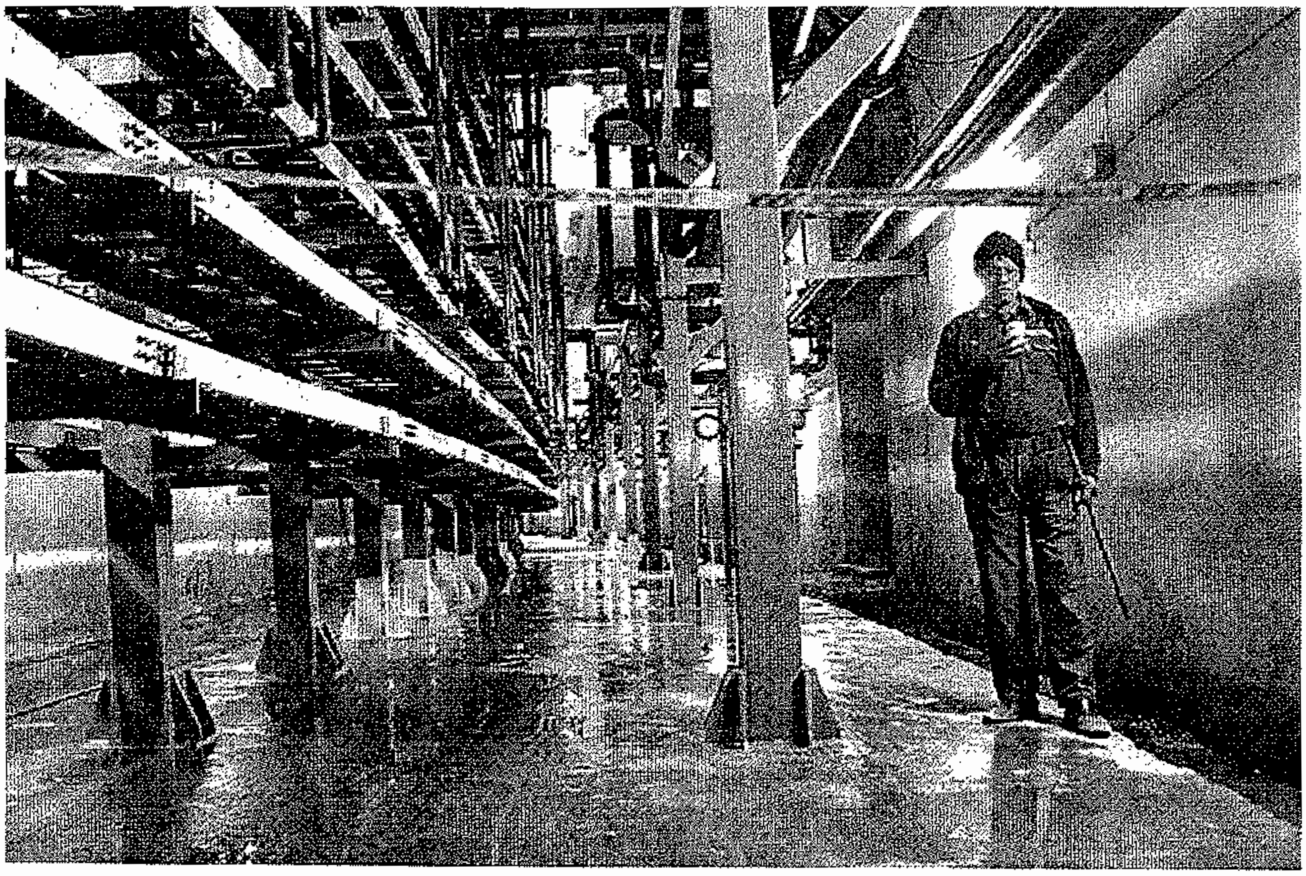


Image source: Mail Today (2016)

Table A5-1. Smart City Projects Worth INR 100 Crore and Above Being Implemented Under Utility Works as per the Smart City Proposals

S. No.	City	Project details in the smart city proposal	Cost (INR, Crore)
1.	Agartala	Utility Trench	333.95
2.	Ahmedabad	Utility Network (Water, sewerage, drainage, roads, street lighting etc.)	385.00
3.	Belagavi	City Gas Distribution (CGD)	150.00
4.	Bhopal	Miscellaneous (Landscaping, Flyovers to approach site, Development of public utilities)	627.00
5.	Dharamshala	Underground cabling	111.00
6.	Faridabad	Underground cabling	276.00
7.	Jalandhar	Water, Waste Water, Power and Utility Ducting	262.51
8.	Kanpur	Utility Duct (Electricity, Water, Sewer, OFC, Telecom, PNG)	147.15
9.	Kohima	Multi services utility duct	112.99
10.	NDMC	Sensor based Common Service Utility Duct	150.00
11.	Port Blair	Service core trench	175.00
12.	Shivamogga	Underground ducting	264.00
13.	Thanjavur	Underground utility trunk - 27 km	108.17
14.	Tumakuru	Underground Ducting	196.00
15.	Udaipur	Drains, Relaying road & utility duct	148.00
16.	Vadodara	Multi utility duct	122.50
17.	Varanasi	Underground wiring to reduce unwanted clutter on the streets through and implementation of smart metering	431.96

Source: Information extracted from smart cities project database (GoI, 2018)

A 5.3 Surface Improvement

Surface improvement includes various techniques like revegetation, gravelling or flexible pavements on exposed surfaces. Revegetation can be implemented by developing green covers around road stretches. To ensure efficient implementation of revegetation wide scale, industrial techniques such as hydro-seeding, geo-textiles can be used to stabilise road sides and edges. Green covers are one of the most effective ways to control dust from exposed surfaces and permanently addresses the fugitive dust emissions along roads, highways and streets where dust control is very important from the perspective of exposure on the roads and road safety.

Different paving options including flexible pavements, gravelling, open grid or grass pavers etc. can be considered for exposed surfaces. An important consideration for paving materials is their durability so as to minimise the repairs and disturbances to paved surface.

Surface improvements are also crucial for curbing the fly ash emissions discussed in Section 3.2.2. The most effective and permanent control method is growing vegetation in the fly ash pond. Nutrient rich soil is normally required for growing grass and plants in fly ash. As fly ash is laden with toxic metals, growing fruits and medicinal plants is not advisable. Only the flowering or decorative plants can be grown in the fly ash pond, supplemented by nutrients/soil.

A 5.4 Site or Plant Layout and Design

Design strategies are important for curbing air pollution during construction phase of various projects (buildings or infrastructure). Transportation and handling of materials is a major source of dust at the project site during the construction phase. Therefore, minimising travel distances through appropriate plant/site layout and design is an important strategy for preventing fugitive dust emissions. One of the most common practices at the construction site is to prepare an unpaved road for transportation of construction materials to and from the site. This leads to majority of fugitive dust emissions during construction phase. Paving the access roads at construction sites is an important strategy for control of PM emissions. Other design approaches that can be integrated into layout and design include- concrete bunding and using natural features of the land or local topography. To ensure effectiveness, bund walls need to be at least one third higher the stockpile height.

Wind breakers can also be built at the site using horticulture cloth supported on poles, or by planting trees, that provide green cover around the site (considering prevailing wind conditions). Besides control of dust from road, green covers are also very effective for containing dust originating at construction sites. It is estimated that a single row of trees may bring about a 25 percent reduction in airborne particulates and complete dust interception can be achieved by a 30-metre belt of trees (ASCI 2010). Growing dense green-covers around the fly ash ponds prevents blowing of ash by wind to the surrounding area. It should be noted that certain species of trees may be chosen for their pollution abatement qualities including dust trapping. To avoid reliance on a single species, a combination of trees, shrubs, grass should be grown (MoUD 2014). Choice of tree is important and evergreen trees are a preferred choice for an effective windbreaker (BIS 2016). The building code GRIHA (GRIHA 2018) provides a reference list of native or naturalised species of flora which can be grown in accordance with different agro-climatic zones (climatic conditions and soil types) prevalent in India.

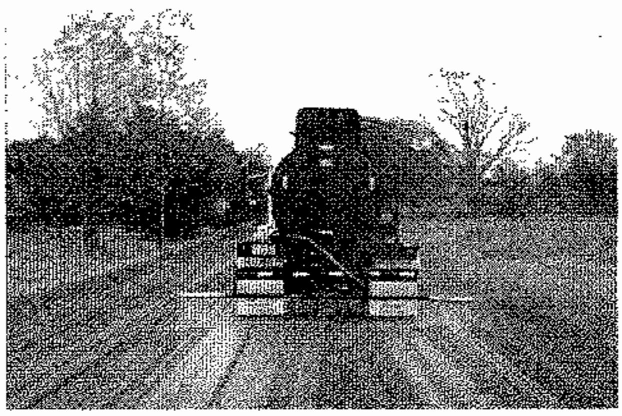
A comprehensive set of design measures for construction sites including waste management facilities and allied construction industry include-

1. Optimal location of plants/sites with respect to transportation of various finished/semi-finished construction/demolition materials
2. Paving the access road for transportation of construction/demolition materials to and from the site/plant
3. Integrating natural features into the building layout and design e.g. tree lines around site/plant. Consideration should be paid to the prevailing wind conditions and tree species.
4. Enclosures around conveyers and hoppers (hoods and other enclosures) for transferring fine materials. In absence of enclosures, wet suppression using water sprinklers is required and might not be suitable for all materials and processes.
5. Use of adjustable conveyors that can be raised and lowered in order to minimise drop heights and avoid spillage of materials
6. Hopper load systems should be designed to ensure a good match with truck size and should be fully enclosed on the sides

A 5.5 Wet Suppression and Chemical Stabilisation of Particulate Matter

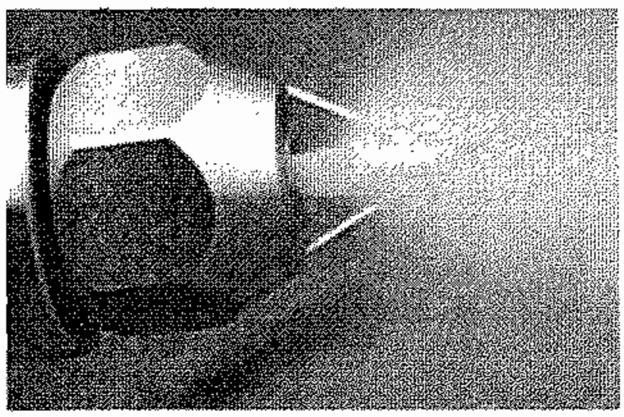
Wet suppression involves applying water onto road surfaces, material stockpiles, transportation vehicles and other vulnerable locations for supressing dust. Wet suppression techniques can be broadly classified into three types- (1) Simple wet suppression using gravity or mechanical sprinklers, (2) Dry fog suppression (3) Chemical stabilisation of particulate matter during wet suppression.

Figure A5-2. Wet Suppression on Road Using Water Tanker and Mechanical Sprinkler



Source: manufacturer's website

Figure A5-3. Dust Suppression Nozzle Used in Dry Fog Systems for Suppression of Airborne Particles



Simple wet suppression can be achieved by using gravity or mechanical sprinklers as shown in the Figure A5-2. Applications include paved/unpaved road, pavement, exposed surfaces and unused material/waste stockpiles, landfills, wet jet in grinding/cutting operations and wash down facilities for transportation vehicles. Water sprays/ sprinklers are also used at conveyors and other transfer points in allied construction industry and waste management facilities, depending on the process and materials. Before using wet suppression technique, assessment of dust suppression water demand and supply is important in the locality. Water demand depends on the surface area for treatment, and rate and frequency of application required at the location. Application rates are in turn based on inputs such as local meteorological forecasts and traffic volumes in case of application on the roads. Water conservation strategies are important to reduce water footprint of dust suppression activities.

Dry fog suppression systems can be used to enhance water use efficiency of wet suppression. Dry suppression nozzles as shown in the Figure A5-3 can be designed for suppressing PM of particular size range. Dry fog suppression is also utilised to cover large control areas as opposed to simple mechanical means which are attached to diesel operated vehicles for providing coverage to large areas. High frequency applications by mechanical means or simple wet suppression, therefore need to be carefully planned considering the emissions from diesel vehicles. Application of dry suppression technique has limited utility for suppression of fugitive PM due to wide range of ultrafine particles suspended in urban airshed. This would otherwise require custom designed dry suppression nozzles for ultrafine PM ranges and might be practically impossible to implement[2]. Additionally, wet particles are hydrophobic (water repellent) and resist agglomeration of finer particles in air. Both of these techniques are therefore not effective for supressing fugitive PM unless targeted surfaces are fully covered with water and are ineffective for controlling air borne PM. Also, local climatic conditions (high temperature and dry weather) render the wet suppression ineffective as water evaporates quickly from surfaces under high temperature conditions.

Chemical stabilisation of particulate matter during wet suppression ensures much higher control efficacy, which can be further enhanced in combination with dry fog suppression. This can significantly reduce requirement of water and are more effective than wet suppression or dry fog suppression systems used in isolation. In this technique, control agents are added to water for facilitating binding of particulate matter through particle agglomeration. Chemical stabilisation also has an added advantage of improving visibility and safety conditions on the road. Calcium chloride ($CaCl_2$), Magnesium chloride ($MgCl_2$) and Organic Polymer-plus-Binders (OPBs) are common dust suppressants used traditionally around the world but are not advisable due to corrosion of vehicle parts and environmental impacts caused by run off from the road after excessive application. A new family of chemical stabilisers have been developed that consist of long-chain hydrocarbons which are biodegradable and have no reported environmental impact. This solution has been developed indigenously by Syntron Industries in India in collaboration with the Central Institute for Mining and Fuel Research (CIMFR). These stabilisers have only been used for dust control in the mining industry so far and there is a huge potential to use them in urban environment. Additives not only lower the water surface tension to create the smaller droplets of water, they also produce interfacial tension between particles. This permits dust to penetrate the surface of water droplets and form agglomerates, making the suppression more effective with less moisture requirement.

[2]Dry fog suppression system was recently tried by Delhi government and DPCC at Anand Vihar in the form of fog guns but it had limited or very little impact for control of PM (HT, 2017) due to possible reasons explained in text but no documented data or information on the same is available in the public domain

In an example provided under the Box A5-3, three different applications of chemically assisted wet suppression technique are described: (A) road dust, (B) material stockpiles and (3) airborne PM, based on the inputs provided by the solution provider. Interventions below can achieve PM suppression with control efficiency of 90-95% as opposed to simple suppression with water which is resource intensive and can only achieve a control efficiency up to 20%. Key considerations for application (time, rate and frequency) of chemical stabilisers include: local meteorology, traffic volumes on the road, aggregate or unpaved road (binder content is higher for gravelled roads). Application can be optimised based on the experience in the city environment. Evidence for control efficacy of these agents can be established in NCR through pilots and demonstrations.

Box A5-3. Example of a Proposed Pilot for Chemically Assisted Wet Suppression of Particulate Matter in NCR Under Three Different Conditions

Based on interview[3] with one of the solution providers three applications of chemical additives are suggested for pilots in city environment to suppress fugitive PM-

A. Application on the roads with vehicular movement

Chemical stabilisation can be used for wet suppression during road maintenance and for application on unpaved roads/surfaces. Recommended mixing ratio is 1 kg compound for 2500 litres of water. One litre of water and additive can cover up to 3-4 m^2 and 1.5-2.5 m^2 area for mechanical and manual gravity spray pattern respectively. Cost of chemicals is estimated to be INR 0.39 per m^2. To begin with, solution provider recommends three applications in a 24 hour period.

B. Application on loose materials with no movement

Potential applications under this category could include- inactive fly ash ponds, illegal dumps of C&D waste, landfills and stockpiles of loose and fine materials including construction materials at project sites or plant locations. Recommended mixing ratio for these applications is higher: 1 kg compound for 50 litres of water. Application rate for this category is recommended at 3-4 litres of water and additive per square metre. The suppressant is applied using a mechanical sprayer to which water is pumped from a stationary water tank at the site. Recommended frequency of application is once per month, costing up to INR 20 per m^2.

C. Control of airborne PM in pollution hotspots

In addition to above applications, the technique can be adapted for PM control in specific areas which suffer from critically polluted air due to rampant construction activities, rapid vehicular movement on roads, illegal dumping/burning of waste etc. Mixing ration of 1 kg chemical for 10,000-15,000 litres of water is suggested for this application. The dry fog suppression system with high jet pump is recommended for this category to cover wide areas for suppression of fugitive dust and PM. Recommended application rate is once in 24 hours with midnight being the most suitable time for its application.

[3]conducted on 24 April 2018, New Delhi

A 5.6 Best Management Practices

Role of management options and best practices is extremely important for PM suppression. Adopting best practices requires a fundamental shift in behaviour of organisations/industry. Ensuring best practices therefore would require sensitisation of stakeholders in NCR region and high level of inter-departmental coordination.

1. **Best practices for moving sources: material transportation-**
   a. Restricting transportation vehicles to specified roads and time of the day
   b. Speed limits for vehicles in designated areas (say, up to 10-15 km/ hour)
   c. Load size limitations for avoiding material spillages
   d. Proper covering of transportation vehicles e.g. with tarpaulin/bins
   e. Monitoring traffic for transportation vehicles carrying construction and demolition material

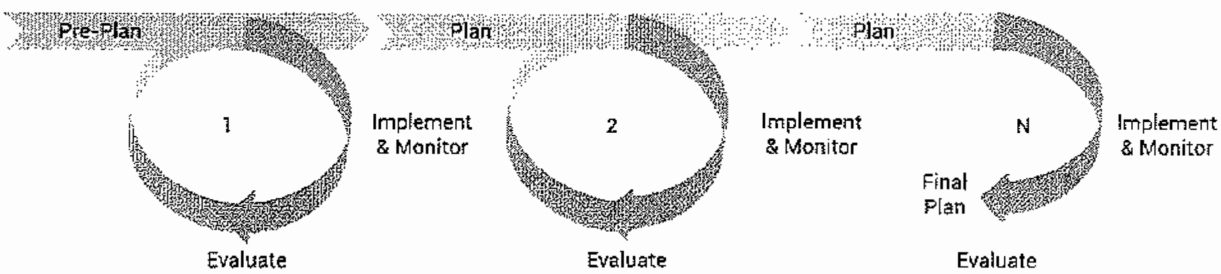
2. **Best practices for stationary sources: sites, plants and storage facilities-**
   a. Limitation on stockpiles' size: height & slope. For instance, flat and shallow stockpile is preferred over tall conical stockpiles in order to reduce wind entrainment.
   b. Wind breakers, shelter belts or temporary screening at construction site
   c. Location of wind breakers from stockpile is critical (at a least distance which is equal to the height of pile)
   d. Proper cover (tarpaulin/ bins) for fine materials such as sand, gypsum & cement
   e. Maintaining minimum drop heights for equipment transferring materials to/ from stockpiles
   f. Regular clean-up of spillages and covering of potential spillage areas
   g. Regular maintenance of hydraulic grabs to ensure complete closure
   h. Operating plants/facility at times when meteorological conditions are not conducive to producing large dust plumes (for plants which do not run 24x7)
   i. ITC enabled systems and protocols for inter-departmental and inter-agency coordination among utility operators to ensure minimal dust generation during regular maintenance operations
   j. In-situ utilisation of excavated soil at construction projects

Box A5-4. Suggested Air Quality Monitoring and Implementation Framework

Control measures need to be designed considering features of local area and accordingly implemented across urban settlements in the NCR region. Availability of treated water is one of the deciding factors for achieving dust control via wet suppression. Road traffic conditions, such as traffic volumes and time of day are important for deciding the best time of the day for application of chemical aided wet suppression. Dust control is crucial in construction hot spots which are in close proximity to sensitive receptors such as schools, hospitals and residential areas. Low-cost sensor-based monitoring can be used in such areas which are critical from the perspective of exposure and would require monitoring in order to design suitable local interventions.

Figure below illustrates variables and parameters related to sources of air pollution, local area, environment and control measures. Optimising these using available information is crucial for achieving desired reductions in air pollution. Instead of applying arbitrary control measures in an ad-hoc manner and temporarily suspending activities, evidence needs to be generated continuously though action and it needs to feed into management and planning processes. This requires a comprehensive management and control programme involving multiple stakeholders. Control strategies need to be improved though an iterative process as shown below and standard operating procedures (SOPs) need to be established based on tested efficacy of control measures under local conditions.

Framework for Continuous Improvement of Management and Control Strategies at Local Level Through Evidence



CONTROL VARIABLES

- Location of key sources e.g. construction hotspots, identified highway/road stretches
- Location of sensitive receptors e.g. hospitals, schools and residential areas
- Local meteorological factors e.g. predominant wind directions
- Frequency and time of activities
- Availability of treated water at site

CONTROL STRATEGY

- Type of control measure (e.g. wet or dry suppression)
- Rate & frequency of application
- Best time of day for application
- Control efficiency
- Capital cost of equipment/ infrastrcuture
- Operational cost: fuel, chemicals, and maintenance of infrastructure

key parameters for devising air quality management strategies vis-s-vis area specific control variables

Source: CII-CESD (2018) analysis

At the evaluation stage, the tested efficiency of control measures under given conditions can be established with the help of a transparent monitoring and data ecosystem. This not only helps choosing or discarding options based on concrete evidence, it also scientifically ascertains and helps understanding why specific control measure failed under given conditions and how it can be improved in the next planning stage by adjusting few variables or discarded particular measure due to unsuitability in certain location.

Monitoring and robust data ecosystem is essential for controlling dust emissions. Testing efficacy of control options would require regular inspection, sampling and monitoring of sites with high generation of dust and other fine particulate matter emissions, for instance, the construction hotspots, landfills, stone crushers etc. Monitoring of SPM and PM using low cost infrastructure can be mandated at such sites. Emphasis should be on continuous improvement of management practices and control strategies based on these findings as illustrated by Figure 9. Random monitoring of different sources responsible for fugitive emissions, as in listed table A4.2, is prescribed, along with the online monitoring by industry, utilities and civic agencies along key locations in NCR cities. Online monitoring for SPM, PM and local meteorological conditions can be set up voluntarily by public and private agencies across region and would supplement the existing monitoring capabilities.

A 5.7 Best Available Technology for Dust Suppression

Dust can be collected from hard surfaces, such as roads, streets and pavements, by mechanised/vacuum sweeping but it is ineffective compared to other options discussed above due to inherent problems with municipal solid waste management system in NCR. As of now, a fraction of road dust is being collected by mechanical sweepers employed by local bodies and PWD (Government of Delhi). Dust is predominantly collected by manual sweeping of the roads or streets by sanitation workers of municipality. Sweeping the roads itself generates a lot of dust. Besides this, segregation does not take place at source in Delhi NCR. Unless collected dust and other fine particulate matter are bound using an agent and disposed using scientific methods, mechanised or vacuum cleaning is not advisable for addressing air pollution. It could in turn lead to higher ultrafine PM emissions from diesel engines if emissions from these vehicles are not monitored and controlled properly.

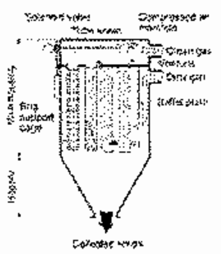
With the initiative of Department of Environment (GNCTD), Central Building Research Institute (CBRI) has carried out investigation on the utilization of road dust, also called silt, for development of building components. Various value-added building components like road paving blocks, bricks and tiles have been developed using road dust as fine aggregate and this option may reduce burden of road dust on Delhi's airshed.

Containment of particulate matter and other air emission such as VOCs is especially relevant for construction and small-scale industry in Delhi NCT and other NCR towns. Some of these air emissions can be contained at the source using mechanical extraction and collection. Depending on the intensity and scale of these processes, extracted air can be routed to one of the emission control devices (for containment of PM): (1) Cyclone separator, (2) Bag/ fabric filter, (3) Electrostatic precipitator, and (4) Wet scrubber. The relative advantages and disadvantages which might help the user choosing the right emission control device are summarised in the Box A5-5.

Box A5-5 Proven Technologies for Containment of Particulate Matter Emissions

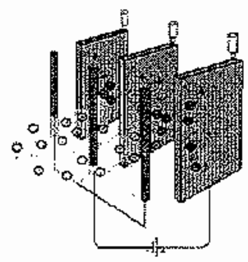
Cyclone separator (~70% collection efficiency)

- Low cost
- No moving parts
- Relatively lower efficiency
- Wide temperature/pressure applications
- Low space requirement
- Dry operation
- Efficient operation requires high pressure drops



Bag/ fabric filters (~95% collection efficiency)

- Higher efficiency with use
- Up to 99.9% collection efficiency
- High collection of coarse and fine PM
- Multiple configurations and wide capacity rang
- Limited to temperatures below 290°C
- Maintenance against corrosion
- Lower efficiency after cleaning filters



Electrostatic precipitators (ESP) (60-90% collection efficiency)

- High capital and low operational cost
- Dry and wet types
- Multiple fields
- High efficiencies achievable
- very low pressure drop
- Minimal maintenance (non-corrosive materials)
- Large space requirement
- Sensitive to fluctuations in gas flow

Wet scrubbers (40-99% collection efficiency)

- Moderate pressure drop
- Can handle corrosive and acidic gases/mists
- Limited to gas inlet temperatures < 50-85°C
- Relatively low capital cost
- Small space requirement
- Wet collection

Source: EPA (2008)

Table A5-2 Example of Prevention and Control Options for Various Sources of Fugitive PM Emissions in NCR

S. No.	Key Sources	Description of Sources	Area of intervention	Prevention and control options
1	Building construction	a. Township or area development projects b. Large building construction projects for which environmental clearance is required including commercial/public buildings and residential complexes c. Building construction projects including renovation of existing buildings where environmental clearances are not required	• Construction hotspots in NCR region • Material handling during construction and demolition	• Best practices for dust preventions and minimisation during material handling at site • Chemically assisted wet suppression methods • Site layout and design e.g. integrating natural features in design for dust prevention and minimisation of travel distances through proper site layout • Green covers and wind screens • Paving the access road
2	Urban infrastructure projects	Urban infrastructure projects including construction of roads, flyovers, intersections, bridges, footpaths, lighting poles etc.	• Large infrastructure projects e.g. DMRC • Construction and demolition of roads/highways, pavements, bridges, flyovers etc.	• Best practices for dust preventions and minimisation during material handling at site • Chemically assisted wet suppression methods • Re-vegetation on exposed surfaces, paving the access road and other surface improvements
3	Utility operations	Utility operations across the city involving digging on/along the roads. Utilities include electricity, gas, water, roads, municipal solid waste etc.	• Day-to-day activities carried out by utilities such as NHAI, PWD, IGL, BSES, DJB and urban local bodies • Inter-departmental coordination among different agencies/departments	• Modern multi-utility service corridors along roads with a provision for inter-departmental coordination
4	Demolition	Various demolition activities across the city including buildings demolition	• Demolition of buildings • Demolition of roads, bridges, pavements etc. in city	• 100% recycling of C&D waste • Best practices for dust preventions and minimisation (during storage, transportation and use at site) • Chemically assisted wet suppression methods

S. No.	Key Sources	Description of Sources	Area of intervention	Prevention and control options
5	Material Transportation	Transportation of materials	• Transportation of construction materials • Transportation of C&D waste	• Speed limits in designated areas • Best practices for vehicle loading and transfer of materials • Wash down facilities at sites/plants
6	Vehicular movement on roads	Resuspension of dust due to vehicular movement on paved/ unpaved roads, especially due to poorly maintained road/ highway stretches	• Roads and highways, especially poorly maintained road stretches in NCR • Repair/maintenance of roads/ highways stretches	• Chemically assisted wet suppression using mechanical/gravity/fog suppression spray systems • Monitoring and management of road traffic, especially for heavy-duty vehicles: speed limits on designated roads • Re-vegetation on exposed surfaces along roads, paving roads and other surface improvements • Mechanised sweeping with proper disposal of collected dust from paved roads
7	Soil and other exposed surfaces	Wind erosion from exposed surfaces and loose soil	Unpaved roads and exposed surfaces along roads/highways	• Surface improvement: paving, gravelling, re-vegetation on exposed surfaces etc. • Chemically assisted wet suppression using mechanical/gravity/fog suppression spray systems
8	Waste handling and disposal	Collection and handling of Construction and Demolition (C&D) waste, Municipal Solid waste (MSW), and fly ash Landfills and fly ash pond in NCR	• MSW collection from streets/roads • Management of landfills, fly ash ponds and illegal dumping sites in NCR • Waste handling units (C&D waste and MSW)	• Plant design and layout • Best practices for dust preventions and minimisation during waste handling • Chemically assisted wet suppression
9	Allied construction industry	a. Bricks kilns (fly ash) b. Stone crushers c. Ready mix concrete (RMC) batching plants	• Material handling • Improved Kiln designs • Fuel switch at these plants	• Plant design and layout • Best practices for preventions and minimisation of dust/fly ash • Chemically assisted wet suppression

Source: CII-CESD (2018) analysis

ANNEXURE 6

Best Available Technologies for Diesel Generators

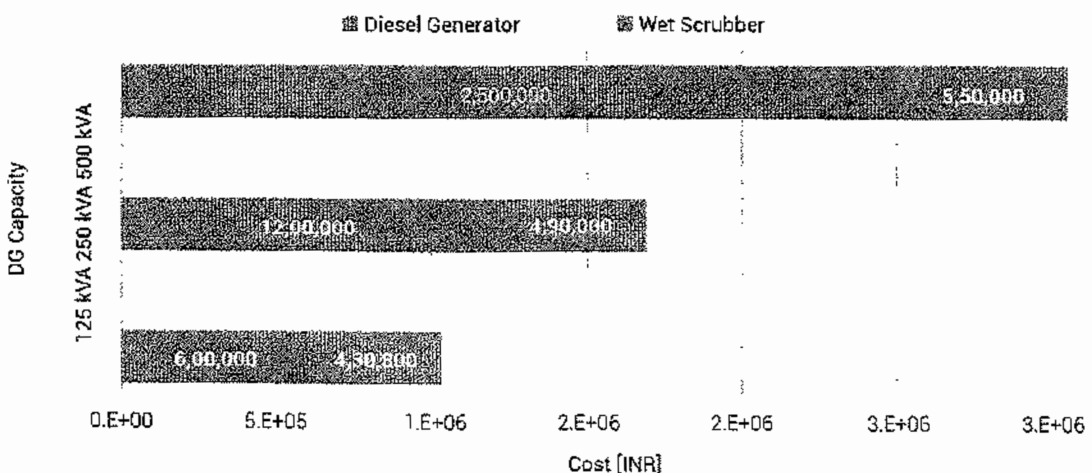
Available options in the market can be classified as-

1. End-of-Pipe Retrofit
2. Fuel Substitution in Diesel Generators
3. Energy Storage

A 6.1 End-of-Pipe Retrofit Technologies

Emission control devices for DGs work on the same principle as in the diesel engines. Emission control methods for these are broadly classified as- wet scrubbers, diesel particulate filters (DPF), continuous regenerative trap (CRT). Low-cost retrofit options at approximately 10% of the DG's capex are available in the market with a minimum collection efficiency of 70%, although the auxiliary energy consumption is observed to be significant. Hospitality sector in India utilises wet scrubbers in order to keep the PM emissions from DG sets under check. The Figure A6-1 below gives a comparison of wet scrubber options for three different size classes available with an equipment vendor in Delhi. Three key components of wet scrubber: stainless steel ducting, water cooler and venture scrubber constitute about 8%, 27% and 65% of the total cost respectively. As evident from Figure A6-1, wet scrubber is cost-effective retrofit option for mid to high capacity segments. For a 500-kVA diesel generator, wet scrubber constitutes about 18% of the total capex. Although options are available in the Indian market, they need to be benchmarked to understand their relative advantages/disadvantages (collection efficiency, back pressure impact, energy requirement etc.) for different capacity segments.

Figure A6-1. Cost of Indigenous Wet Scrubber of Different Capacities Available Commercially in the Indian Market



Source: CII-CESD (2018) analysis from market brochures

In addition to the above said technologies for retrofit options for DGs, on-road original equipment manufacturers (OEMs) currently have experience on other low cost proven solutions like Diesel Oxidation Catalyst (DOC) and Partial Flow Filters (PFF). The technology has capability to reduce PM between 30-60% depending on the organic fraction of diesel particulates: soluble organic fractions (SOF) or insoluble organic fractions (IOF) observed at the engine outlet conditions. The DOC on its own can be used as a retrofit solution having the ability to oxidize CO, HC and SOF (PM). When combined with downstream PFF, the Partial Oxidation Catalyst (POC) architecture can reduce PM close to 50-60%.[4] The key driver for this technology to perform is engine exhaust temperature. One should maintain temperature higher than 250°C at minimum 50% duty cycle on periodic basis to aid the passive soot oxidation. PFF traps soot within and on the walls, converting trapped carbon to form CO_2 up on reaction with incoming NO_2 (from DOC). This technology has been in practice in commercial vehicles in India and China since the introduction of BS-IV and NS-IV norms respectively. As per the inputs received from stakeholders, the product quality and reliability has been good with the right level of integration measures. The product cost of this solution is around INR 30-100 thousand depending on the product requirement. The industry experience of this technology has been on electronic architecture which would be able to react if there are any choking or plugging issues. For DG retrofit, the engines currently in the field are primarily based on mechanical architecture. These engines have their own set of limitations in terms how they would be able to react if technologies are deployed downstream. Backpressure, vibration, noise and durability should be well understood before this could be mass deployed.

Furthermore, several indigenously designed end-of-pipe retrofit devices that capture PM and that turn it into useful products (such as ink, paint) are currently under development in India. These options are currently being piloted at sites for large corporates, real estate players, oil and gas companies, etc. in Delhi NCR and other metropolitan areas; but are yet to be certified by CPCB approved laboratories. Such devices are able to capture significant amount of particulate matter emissions from diesel generators based on age and condition of the generator. The cost of such retrofit options is fractional as compared to the capital expenditure on diesel generator and varies with capacity (12-16% of the DG capex). The devices work by cooling the exhaust in most optimized manner to cause rapid agglomeration of soot particles. Capturing of soot particles is realised by slowly passing the exhaust gases through contours and meshes while interacting with solution, that traps the soot. The solution ensures continuous cleaning of the meshes and contours in real time, collecting soot at the bottom of collection bin.

A 6.2 Fuel Substitution

Dual fuel injection kits are readily available for existing DG sets (CII-NITI 2018b). Gas injection kits may be mandated by competent authority to existing DG sets in areas with availability of CNG and piped natural gas (PNG) infrastructure. Additionally, efforts maybe ramped up to improve availability of cleaner fuels in commercial segment. Recommendations for the same have been made in CII-NITI Aayog task force report on Clean Fuel (CII-NITI 2018b). Existing and new DGs in commercial sector: 82%, 65-70% and 56% of the low, med-high and high-horsepower capacity segments

[4] Data based on certified commercial products by ARAI India & MIC China for light duty vehicles.

respectively (contribution of different sectors as shown in Figure 6) can be prioritised for retrofit in this regard. All major manufacturers have gas-based DGs or multi-fuel injection models available in the market. Similar to gas, other clean fuel options such as liquid bio-fuels and bio-CNG can also be explored in Delhi NCR based on the availability of bio-fuels and by promoting waste-to-energy.

A 6.3 Energy Storage

Using electric batteries/ invertors for energy storage can partially address the emissions from diesel generators in urban areas. Inverters or battery storage can only fulfil the energy requirements for small appliances: lighting, fan etc. Standalone electric storage is therefore a long-term measure currently available in market and can fulfil the energy requirements for energy intensive applications such as air conditioning for thermal comfort.

Thermal energy storage is a separate set of solutions available to fulfil the needs for thermal comfort in the buildings in case of power outages. In addition to providing back up power during power contingencies, TES enables businesses to manage peak electricity demand by storing electricity as thermal energy during non-peak hours and utilising it during peak hours[5]. This is especially relevant in case of the commercial and industrial users of electricity for whom time of day tariffs are applicable. While invertor backs up small appliances such as lights, TV and computer; TES backs up the installed cooling system. TES options available in the market today utilise- (1) Chilled water, (2) Ice storage[6], (3) Phase changing material (PCM), and (4) Molten salt energy storage. Most thermal energy storage systems are partial storage systems. This implies that thermal storage capacity accounts for about 30% of the total cooling required. This reduces the required floor space to about 0.25% of the conditioned space (Bijli Bachao 2015). TES is commercially established in India and is utilised as a demand side management (DSM) tool by Tata Power. Tata power offers its commercial and industrial consumers incentives for using TES and launched the first of its kind TES incentive programme under its DSM Initiative in 2014 (AICHE 2014; IIFL 2014). It not only helps large consumers meet their peak cooling demand cost-effectively but also enables the utility to manage peak power. TES has been widely adopted in cities, including Delhi. It is reported that installed capacity of TES is about 12 MW in major metropolitans such as Bangalore, New Delhi and Chennai (Calmac 2015). This constitutes only a fraction of peak power demand in Delhi which was all time high at 6934 MW on 08 June 2018 (6% higher from the previous year). As per the information available for the year 2015, that is peak power of 5925 MW (BSES 2015), installed capacity of TES was just 0.2% of the total peak power.

From discussion above it is clear that energy storage has huge potential to solve energy management challenges but also to address air quality to the extent DG set are used in commercial and large residential complexes for thermal comfort. It is proposed that integrated solutions/services, combining electric and thermal energy storage, can be provided by utilities/DISCOMs, energy service companies (ESCOs) etc. with the focus on energy management as well as air quality.

[5]Time of Day (TOD) tariffs are applicable to industrial and commercial users with differentiated tariff structures for peak and non-peak hours
[6]latent heat of fusion of water is used to store energy, with the help of charging fluids/anti-freeze agents added to water

"Industry experts agree that incremental cost of emission control is comparatively low and is speculated to be INR 5/ bag for cement industry and INR 0.50-0.60/ unit for the power industry".

ANNEXURE 7

Emission Control in Coal Thermal Power Plants

An overview of different emission control technologies available to TPPs is presented in the Figure A7-1 listing two types of technologies: (1) in-situ abatemnt technologies and (2) post-combustion abatement technologies. In-situ abatement technologies involve plant modifications in order to ensure more efficient burning of fuel and include change in boiler deisgn, e.g. Fluidised Bed Combustion (FBC), limestone injection, Over Fire Air (OFA), low-NOx burners, flue gas recirculation. Post-combustion abatement technologies include Flue Gas Desulphurisation (FGD); selective catalytic/non-catalytic process for NOx reduction; and PM control options (ESP, bag filter and wet scrubber). High upfront capital requirement has been a major impediment for installation of emission control systems in addition to other factors described below. It has been established that health benefit far overweighs these investments in clean technology (CSTEP 2018). Industry experts agree that Incremental cost of emission control is comparatively low and is speculated to be INR 5/ bag for cement industry and INR 0.50-0.60/ unit for the power industry.

Figure A7-1. Available Technologies for Control of SOx, NOx and PM Emissions in Coal-Based Thermal Power Plants with Respective Control Efficiencies

		In-situ abatement			Post-combustion abatement	
SO_2 Control Technologies	Fluidised Bed Combustion (FBC)	Circulating FBC	90-95%	Flue Gas Desulphurisation (FGD)	Seawater FGD (Seawater-based)	≤ 90%
		Bubbling FBC	70-90%		Semi-dry FGD (Lime-based)	≤ 94%
		Dry Sorbent Injection	55-60%		Wet FGD (Limestone-based)	≤ 98%
NO_x Control Technologies		Low-NOx Burner	30-40%		Selective Catalytic Reduction (SCR)	80-95%
		Over Fire Air	20-50%			
		Flue Gas Recirculation	20-50%		Selective Non-Catalytic Reduction (SNCR)	30-50% · 50-70-% (FBC)
PM Control Technologies					Electrostatic Precipitator (ESP)	96.5%
					Fabric Filter	99.6%
					Wet Scrubber	98.6%

Source: Adapted from CSTEP (2018), Tata Power (2017), CPCB (2012), IFC (2008) and Word Bank (1998)

ANNEXURE 8

Coal Thermal Power Plant Units within 300 km of Delhi

S.No	Thermal Power Station	State	Plant operator & owner	Installed Capacity (MW)	Technology	Unit number	Installed Capacity (MW)	Year of commissioning	Phase out date	MOEFCC Directions (December 2017) FGD upgradation	NOx upgradation	ESP upgradation	Fly ash utilisation
1	BTPS Badarpur, New Delhi	Delhi	NTPC			1	95	1973	Jul-2018	...	...	...	100%
						2	95	1974	Jul-2018	...	...	...	
						3	110	1975	Jul-2018	...	...	...	
						4*	210	1978	Jul-2018	...	...	...	
				720	Subcritical	5*	210	1981	Jul-2018	...	...	...	
2	Rajghat TPS, Delhi		IPGCL			1	67.5	1989	Closure report submitted	...	...	...	N.A.
				135	Subcritical	2	67.5	1990		...	...	...	
3	NTPC Dadri, Dist. Gautam Budh Nagar	Uttar Pradesh	NTPC			1	210	1991	...	Dec-2019	Dec-2019	Immediate	100%
						2	210	1992	...	Dec-2019	Dec-2019	Immediate	
						3	210	1993	...	Dec-2019	Dec-2019	Immediate	
						4	210	1994	...	Dec-2019	Dec-2019	Immediate	
						5	490	2010	...	Dec-2019	Dec-2019	Immediate	
				1820	Subcritical	6	490	2010	...	Dec-2019	Dec-2019	Immediate	
4	Harduaganj Thermal Power Station (HTPS), Harduaganj, Aligarh		UPRVUNL			7*	110	1978	Dec-2022	...	...	...	
						8	250	2012	...	Dec-2019	Dec-2019	Immediate	
				610	Subcritical	9	250	2013	...	Dec-2019	Dec-2019	Immediate	
5	Rosa Thermal Power Plant (RTPP), Shahjahanpur		RPSCL; Reliance Power			1	300	2010	...	Dec-2021	Dec-2022	...	71%
						2	300	2010	...	Dec-2021	Dec-2022	Dec-2021	
						3	300	2011	...	Oct-2021	Dec-2022	Dec-2021	
				1200	Subcritical	4	300	2012	...	Oct-2021	Dec-2022	...	
6	Panipat Thermal Power Station (PTPS), Panipat	Haryana	HPGCL			1	110	1979	Closed	...	...	...	100%
						2	110	1980	Closed	...	...	...	
						3	110	1985	Closed	...	...	...	
						4	110	1987	Closed	...	...	...	
						5*	210	1989	Dec-2018	...	...	...	
						6	210	2001	...	Dec-2019	Dec-2019	...	
						7	250	2004	...	Dec-2019	Dec-2019	Dec-2019	
				920	Subcritical	8	250	2005	...	Dec-2019	Dec-2019	Dec-2019	
7	Rajiv Gandhi Thermal Power Project (RGTPP), Khedar, Hisar		HPGCL			1	600	2010	...	Dec-2019	Dec-2019	Dec-2019	92%
				1200	Subcritical	2	600	2011	...	Dec-2019	Dec-2019	Dec-2019	

*APC is 50% NTPC, 25% HPGCL and 25% IPGCL

S.No	Thermal Power Station	State	Plant operator & owner	Installed Capacity (MW)	Technology	Unit number	Installed Capacity (MW)	Year of commissioning	Phase out date	MOEFCC Directions (December 2017) FGD upgradation	NOx upgradation	ESP upgradation	Fly ash utilisation
8	Indira Gandhi Super Thermal Power Project (IGSTPP), Jharli, Dist. Jhajjar	Haryana	Aravalli Power Corporation (APC)'	1500	Subcritical	1	500	2010	...	Dec-2019	Dec-2019	Dec-2019	76%
						2	500	2011	...	Dec-2019	Dec-2019	Dec-2019	
						3	500	2013	...	Dec-2019	Dec-2019	Dec-2019	
9	Jhajjar Power Plant (JPP), Khanpur, Dist. Jhajjar		Jhajjar Power, CLP India	1320	Supercritical	1	660	2012	...	Jan-2019	Dec-2019	Immediate	80%
						2	660	2012	...	Jan-2019	Dec-2019	Immediate	
10	Deenbandhu Chhotu Ram Thermal Power Plant (DCRTPP), Yamuna Nagar		HPGCL	600	Subcritical	1	300	2008	...	Dec-2019	Dec-2019	Dec-2019	
						2	300	2008	...	Dec-2019	Dec-2019	Dec-2019	
11	Guru Gobind Singh Super Thermal Power Plant (GGSSTPP), Roopnagar	Punjab	PSPCL	1260	Subcritical	1	210	1984	Dec-2017	...	...	...	167%
						2	210	1985	Dec-2017	...	...	...	
						3	210	1988	Dec-2022	...	...	...	
						4	210	1989	Dec-2022	...	...	...	
						5*	210	1992	Dec-2022	...	...	...	
						6*	210	1993	Dec-2022	...	...	...	
12	Guru Hargobind Singh Thermal Power Station (GHTP), Lehra Mohabbat		PSPCL	920	subcritical	1	210	1999	...	Dec-2019	Dec-2019	Dec-2019	100%
						2	210	1999	...	Dec-2019	Dec-2019	Dec-2019	
						3	250	2008	...	Dec-2019	Dec-2019	Dec-2019	
						4	250	1010	...	Dec-2019	Dec-2019	Dec-2019	
13	Guru Nanak Dev Thermal Plant (GNDTP), Bathinda		PSPCL	440	subcritical	1	110	1974	Dec-2017	...	...	...	100%
						2	110	1975	Dec-2017	...	...	...	
						3*	110	1978	Dec-2017	...	...	...	
						4*	110	1979	Dec-2017	...	...	...	
14	Rajpura Thermal Power Plant (RTPP), Patiala		NPL, L&T	1400	Supercritical	1	700	2013	...	Dec-2019	Dec-2019	Immediate	
						2	700	2014	...	Dec-2019	Dec-2019	Immediate	
15	Talwandi Sabo Power (TSP), Mansa		TSPL (Vedanta)	1980	Supercritical	1	660	2014	...	Dec-2019	Dec-2019	Immediate	
						2	660	2015	...	Dec-2019	Dec-2019	Immediate	
						3	660	2016	...	Dec-2019	Dec-2019	Immediate	

Source: Operators' websites (APCPL 2018, CLP 2018, HPGCL 2018, IPGCL 2018, L&T 2018, NTPC 2018a, NTPC 2018b, PSPCL 2018, Reliance Power 2018, TSPL 2018, UPRVUNL 2018), NRPC (2017); MoEFCC (2017), and CEA (2018)

Notes:

1. MoEFCC (2017) prescribes immediate measures such as installation of low-NOx burners, providing Over Fire Air (OVA) etc. and achieve progressive reduction to comply to NOx emission limit in the stipulated year.
2. Thermal power plant units, marked with asterisk (*) in the table, face the space constraints for installing FGD system and are required to be phased out by 2022.
3. Near-term additional capacity of 2.12 GW is expected in this region. There is a provision of 1320 MW (2x660 MW) under stage -II of HTPS, Harduaganj, including 800 MW capacity high efficiency supercritical thermal power unit is planned by way of simultaneous phasing out of old and less efficient units (unit 1 to 4) at PTPS, Panipat.

ANNEXURE 9

Business Case: Leapfrogging to 50% Biomass Co-firing in Existing Thermal Power Plants

Besides air pollution emanating from large thermal power plants in NW India, a huge quantity of surplus biomass is currently burnt in open fields by farmers as its extraction is not an economically attractive value proposition to farmers. Open burning of surplus biomass is responsible for large scale impact on regional air quality in North India and this issue has been the focus of the CII-NITI Aayog task force report on biomass management. The report (CII-NITI 2018a) suggest a multipronged strategy for managing paddy straw in North West region, including use of biomass in the field for enhancing crop productivity and outside the field for waste-to-energy applications.

A large part of this biomass, especially paddy straw is burnt in fields along with the standing stubble. The practice of stubble burning is not only limited to paddy straw. Significant number of fire incidents are reported this year for burning of wheat straw in April-May across the country, especially in the North-Western region (NASA, 2018). It has, in fact, been estimated that more than 80% of paddy straw (18.4 million tonnes) and almost 50% wheat straw (8.5 million tonnes) produced in the state of Punjab is being burnt in fields (Sidhu and Beri, 2005; kumar et al, 2015). As mapped in Figure 9, a huge amount of surplus biomass is available across North Western states which presents a lost opportunity for improving environmental performance of coal power plants in the region as farm waste is a carbon neutral source of energy. It is estimated that total biomass power potential from surplus biomass in Punjab, Haryana and Uttar Pradesh can fulfil the demand for 50% biomass co-firing in power plants located in a radial distance of 300 km from Delhi. Total 6.375 GWe biomass potential against 50 million tonne surplus biomass in a year is estimated in these three states whereas total installed capacity of active TPP units as mapped in Figure 8 is 14.53 GW. Out of this, 13.15 GW is planned to continue operations after installation of advanced emission controls for SOx, NOx and PM whereas an additional capacity of 2.12 GW is planned to be expanded in near future at two of the existing locations (PTPC Panipat and HTPS, Harduaganj).

Pelletisation is simple densification of biomass involving- shredding, hammering, drying and densification. Final product is compressed biomass in 6:1 ratio compared to original biomass (in the form of bales). Pelletisation enables biomass to be easily transported to the end-users. The surplus biomass needs to be baled in order to be transported cost-effectively to biomass conversion units. Extraction and collection of biomass into bales at the farm requires employing- (1) chopper/shredder or superSMS (attached to combine harvesters for chopping standing stubble), (2) rakers (for collecting straw) and (3) balers (for baling the raked straw). Farmers can offer fields for clearing to the Farmer Producer Organisations (FPOs) or private collection agencies engaged by businesses. To prevent the incidents of stubble burning, Government of India formulated a special scheme on air pollution in 2018 (GoI 2018). The central government scheme subsidises the farm equipment required by farmers in this region for chopping the standing stubble and mulching/collection of surplus biomass/ crop-residues. Under this scheme individual farmers and farmer groups (farmer producer organisations, farmer co-operatives etc.) can avail a capital subsidy of 50% and 80% respectively towards farm equipment for crop-residue management. There are two proven technologies available for energy densification of biomass so that it could be utilised in industry boilers- (1) pelletisation/briquetting of biomass (2) torrefaction of biomass. Surplus biomass is picked from fields and baled for transportation to biomass conversion units where it undergoes physical transformation to more suitable energy carriers. Transformation of biomass bales to two different energy carriers is highlighted in the Figure A9-1.

Co-firing biomass is competitive for plants located in North Western States due to their proximity to origin of surplus biomass from agricultural activities. Major challenge highlighted by various experts and stakeholder in the utilisation of surplus biomass for power generation are- (1) high operational cost of dedicated bio-power plants and (2) the low calorific value of biomass feedstock available for co-firing, especially the paddy-straw 80% of which is currently burnt by farmers in NW India. Based on the inputs provided by solution providers, it is estimated that an equivalent of 18% of the total capital required for setting up dedicated bio-power plants need to be pumped every year in the form of operational subsidies to make the plant operations viable (CII-NITI 2018a). Although, the capital expenditure for torrefaction is much higher, the operational cost is lower compared to pelletisation, mainly because modern torrefaction reactors have been designed to utilise the waste heat (in the form of torrefaction gas) and it is near net zero energy process.

Torrefaction is a thermochemical process involving heating of biomass in the absence of air at 200 to 300° C temperature (Acharya et al 2012). As the volatilisation of biomass takes place in this temperature range, 30% mass of the original biomass is reduced. Torrefaction is near net zero energy process where 10% energy released in the form of a combustible gas (torrefaction gas) is re-utilised in the process for pre-drying the biomass feedstock. In the pre-drying step, free water is evaporated from biomass at a constant temperature of 100 ° C using the torrefaction gas (DTI 2012). Global experience shows us that efficiency of co-firing biomass in large coal-based thermal power plants is much higher than utilising the same biomass in the dedicated bio-power plant with 100% energy supply from biomass (IEA 2013, IEA 2017). Also, incremental investment required for co-fired plants are lower than dedicated bio-power plants which are designed for 100% firing of biomass. As per International Energy Agency, the capacity of biomass co-fired power plants in OECD countries already exceeds the dedicated biomass power plants (IEA 2017). Various benefits of torrefied biomass over traditional biomass pellets are highlighted in Box 4.

TPP units in the region are located far away from pitheads and ports. This leads to very high cost of raw material transportation to these plants. Landed price of domestic and imported coal at TPP in Punjab is as high as INR 4500/ tonne and INR 9000/ tonne[8]. Clean energy cess is charged on coal purchase for power consumption and it has increased eightfold from INR 50/ tonne to INR 400/ tonne presently. It is estimated that the most recent hike in the Clean energy cess from INR 200 per tonne to INR 400 per tonne in 2016 has increased power tariffs by 10-12 paisa / unit (BCG-CII 2017). Also, the freight charges for coal are among the highest in the world. It constitutes about 20-30% of total landed cost of coal for TPPs and rail freight has increased by ~50% over the last 5 years (BCG-CII 2017).

Based on simple energy-mass balance of torrefaction process (i.e. 10% energy reduction and 30%mass reduction), the energy density of biomass increases by ~1.3 in the process. This implies that torrefied paddy straw[9] (GCV=4500 Kcal/kg) nearly exceeds the energy density of domestic bituminous coal used in power plants (~ 4000 Kcal/ kg). Torrefied biomass therefore overcomes challenges of the low energy value associated with traditional paddy straw pellets. Based on estimated capital and operational cost for a typical 200 thousand tonne biomass torrefaction unit[10], the cost comparison of torrefied biomass, biomass pellets including domestic and imported coal based on their energy value is presented in Figure A9-2. Although the capital cost of torrefaction is as much as 3 times higher than traditional pellets, it is cost effective mainly due to high energy value of finished product and near net zero energy process[11].

[8]Based on consultations with power generators in the region

[9]Similarly, the energy value of torrefied wheat straw is estimated to be 4886 Kcal/ kg

[10]The capex for torrefaction unit is INR 207.5 Crore (14% for collection infrastructure) and opex is estimated to be INR 39 Crore out of which 38% is operational expenditure towards biomass collection. The reminder opex is mainly for procurement of the biomass feedstock.

[11]The opex for wheat straw torrefied biomass and pellets is comparatively higher due to higher market value of wheat straw compared to paddy

Box A9-1. Favourable Properties of Torrefied Biomass over Traditional Biomass Pellets

Torrefied biomass has greater bulk density and is more homogenous compared to biomass pellets/ briquettes. Torrefied biomass has combustion characteristics similar to coal and it also looks exactly like coal (is therefore termed as bio-coal alternately) but offers significant environmental advantages over coal and traditional solid bio-fuels due to its improved fuel characteristics such as high energy density, low moisture content, near-zero sulphur content. Additionally, it has water repelling properties which address the storage issues inherent with farm waste. Standard pellet press is utilised to compact the torrefied biomass. Energy requirement for grinding and compacting biomass feedstock reduces significantly (~80%) as a result of torrefaction of biomass. Salient features of bio-coal vis-à-vis coal and conventional solid biofuels are described as below.

- **Enhanced Fuel characteristics**

Due to partial thermal decomposition in torrefaction reactor, energy density of torrefied biomass is higher than conventional solid biofuels i.e. pellets/briquettes (25-30% higher energy density than conventional biomass pellets) (IEA 2013) and is found to be comparable to high grade coal. In a typical torrefaction process, the energy content of biomass is reduced by 10% whereas the mass is reduced by nearly 70% (Acharya et al, 2012). Net effect of this energy conversion is energy densification of torrefied biomass by nearly 1.3 times the original biomass. Also, the moisture content in torrefied coal is lower compared to conventional pellets and briquettes. Torrefaction additionally improves the grindability of biomass rendering it more suitable to co-firing (Rokni et al 2017). Due to these favourable characteristics, up to 50% co-firing with torrefied biomass is possible in thermal power plants.

- **Improved emission characteristics**

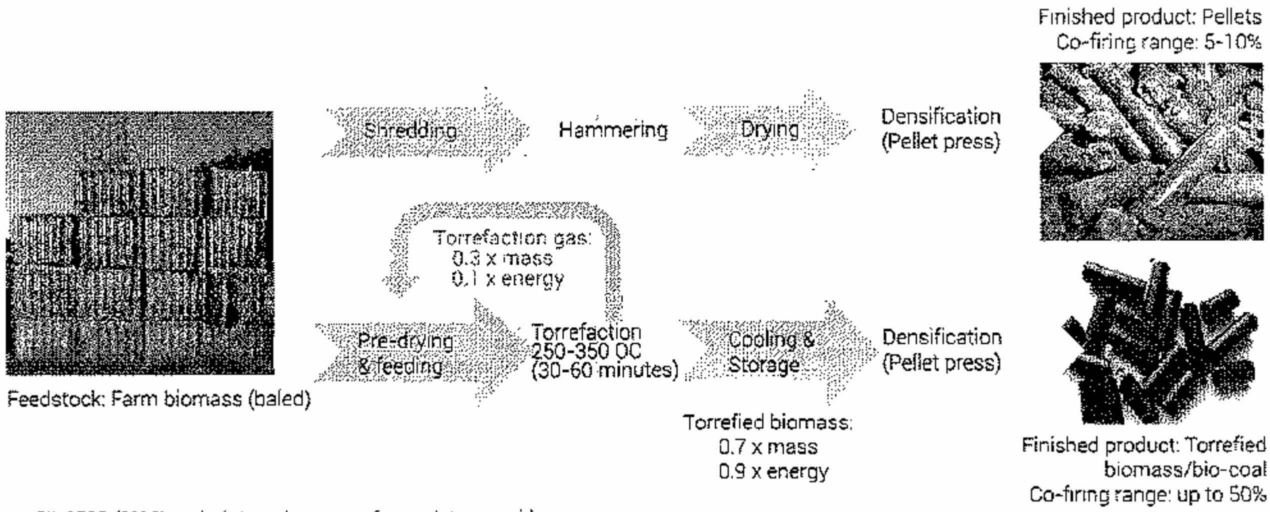
SOx emissions from power plants occur as a result of high sulphur content of coal. Co-firing biomass in general leads to beneficial synergies for SO_2, NOx and HCl emissions depending on the characteristics of individual biomass. Torrefaction process additionally reduces the sulphur (30-80%) and chloride (20-70%) content[14] of the biomass (Rokni et al 2017). An addition to the evident effect of co-firing low-sulphur biomass feedstock with high-sulphur coal, SOx emissions further reduce due to high alkali metal content of biomass that can capture the gas-phase SO_2 heterogeneously in the ash (Rokni et al 2017). Sum effect of all these in turn leads to lower operating cost (lime stone for FGD units) at thermal power plants.

- **Better handling and storage characteristics**

Material characteristics of biomass improve significantly in the torrefaction process. Torrefied coal particles are hydrophobic in nature (i.e. they repel water) compared to biomass pellets/bales which are hydrophilic (Thrän et al 2016). Therefore, unlike straw bales, they are far less prone to degradation from longer storage periods and weather conditions. It is observed that in case of torrefied coal, energy content remains stable even after longer storage periods. Transport and material handling is less expensive and torrefied biomass had longer storage life without fuel degradation.

[14] The release of chloride in low-temperature torrefaction reactor is less problematic than inside high-temperature boilers.

Figure A9-1. Pelletisation and Torrefaction Processes Enabling Densification of Biomass for Co-Firing in Existing Power Plants



Source: CII-CESD (2018) analysis based on inputs from solution providers

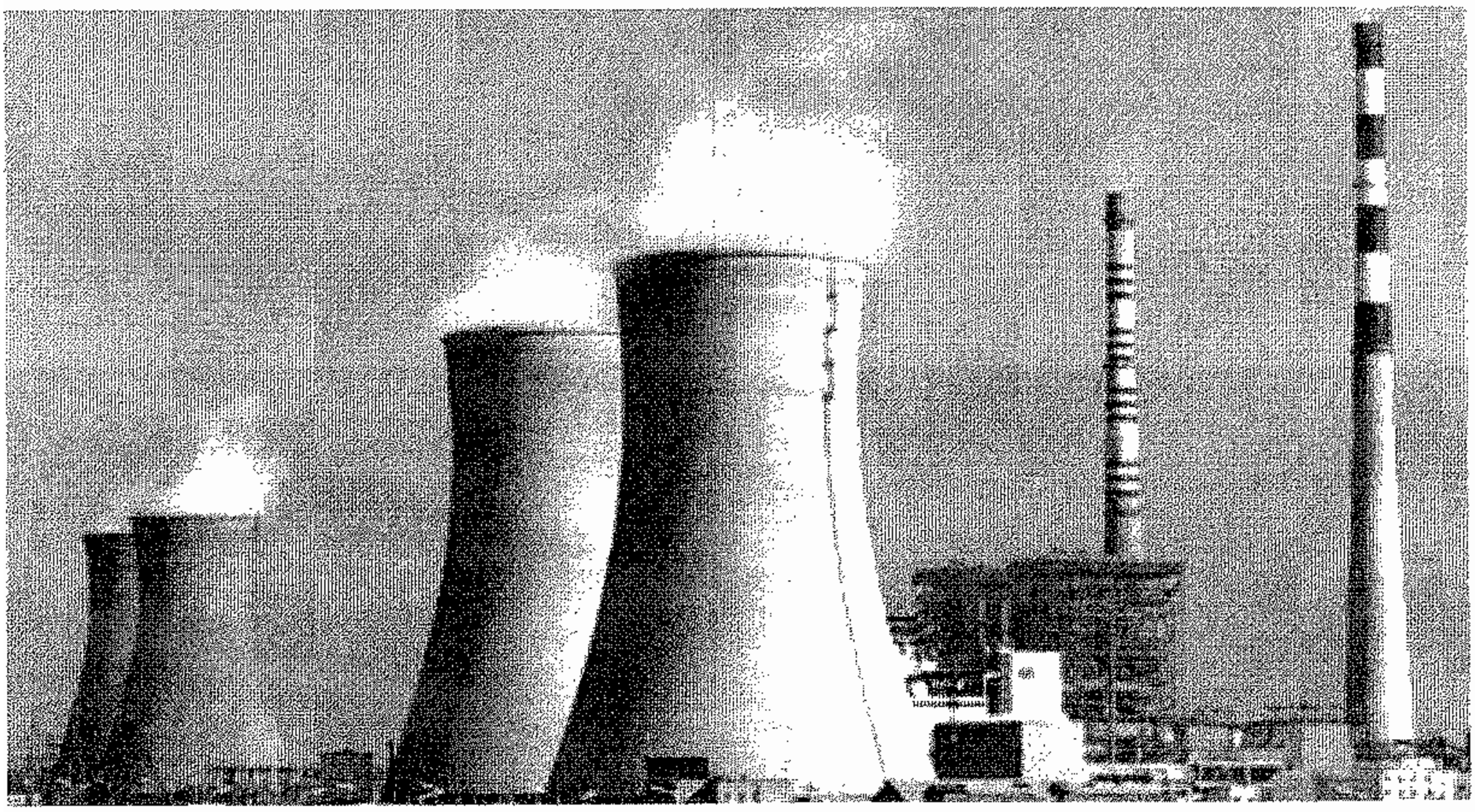
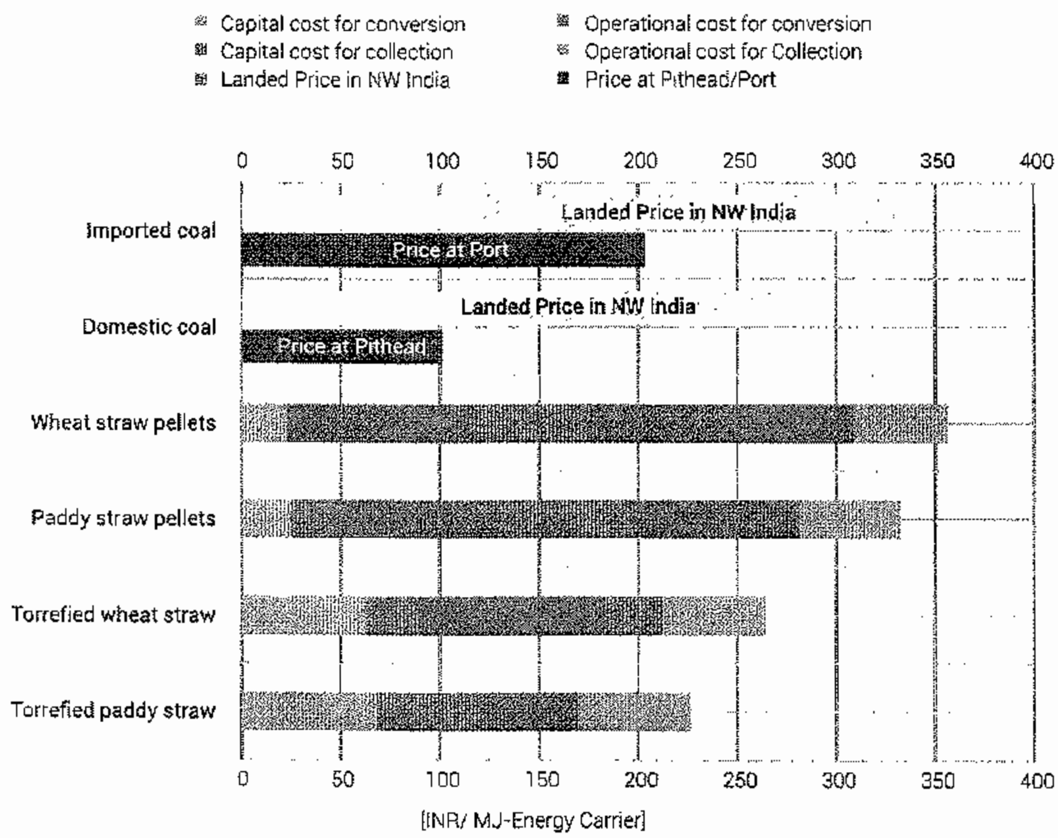


Figure A9-2. Cost Comparison of Different Energy Carriers for Co-Firing in Thermal Power Plants Based on Their Inherent Energy Value



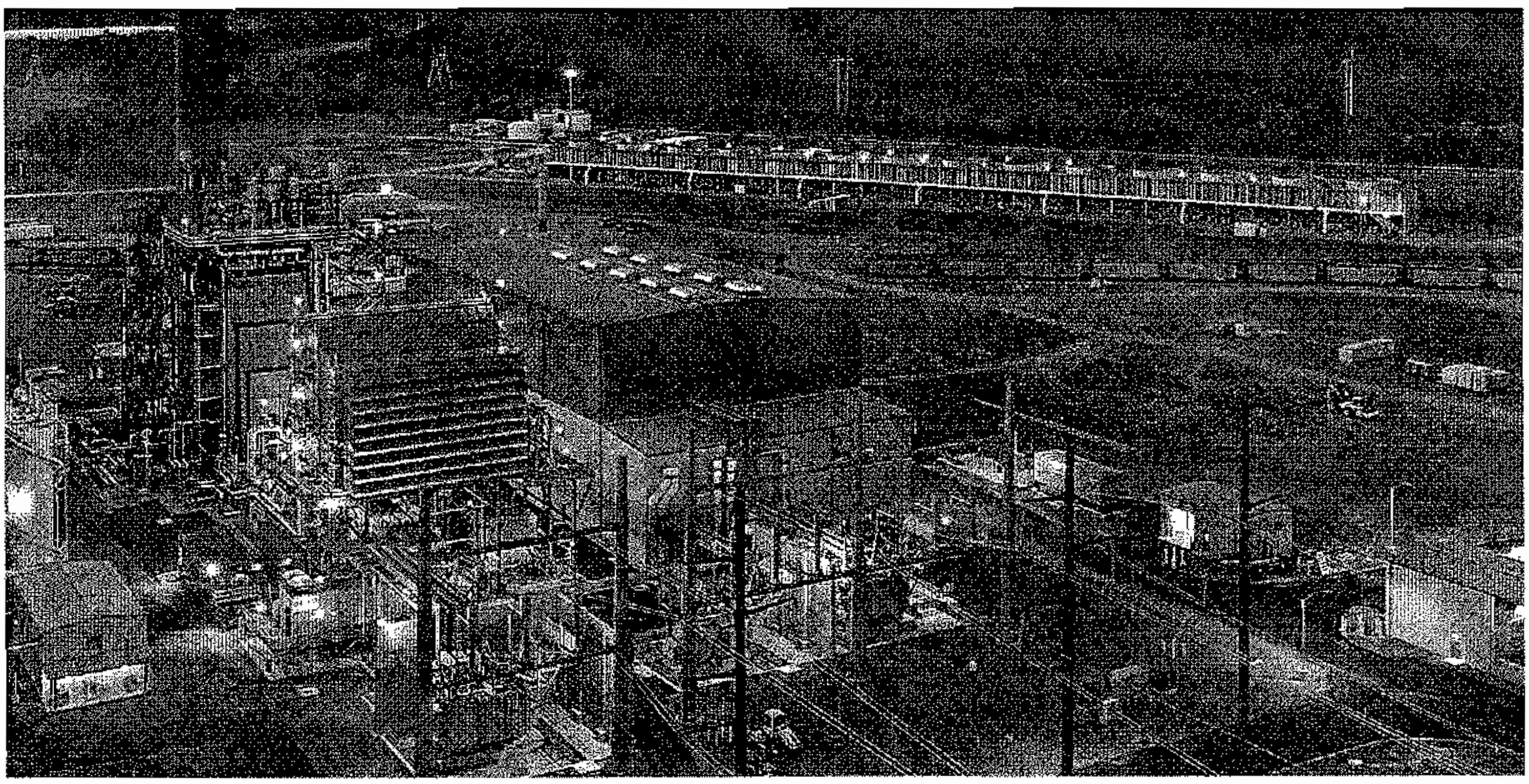
Source CII-CESD (2018) analysis based on secondary information and consultation with solution providers

Notes on keys assumptions:

1. Cost of feedstock or farm biomass is assumed to be: INR 1200 / tonne-paddy straw and INR 2000/ tonne-wheat straw. This forms a key component of operational expenditure of biomass conversion units.
2. Capex includes capital cost of collection equipment, torrefaction and densification units
3. Opex includes recurring cost of feedstock, fuel, labour and maintenance
4. Landed price for coal at TPP located in Punjab is used for above calculations: INR 4500/ tonne for domestic coal and INR 9000/ tonne for imported coal. The price of domestic and imported coal in the spot market was found to be INR 1700/ tonne and INR 5376/ tonne respectively. (ET 2017, OGI 2018)
5. Thermal coal with Gross calorific value (GCV) ranging 3400-4600 k Cal/ kg constitutes about 69% of India's domestic coal supply (Coal India, 2018) whereas calorific value (GCV) for imported coal is assumed to be 6300 kCal/ kg.
6. Calorific value of biomass feedstock: paddy straw and wheat straw is assumed to be 3500 and 4000 Kcal/kg respectively

India can leapfrog from 5-10% biomass co-firing to up to 50% biomass co-firing by using proven technology which is commercially established. For this, surplus biomass needs to be seen an opportunity rather than a burden. Opportunity for power generators to utilise low-sulphur biomass feedstock enhancing environmental performance and image of coal power needs to be tapped by a set of more comprehensive policies promoting biomass in existing TPPs. There are multiple benefits of co-firing biomass in existing TPPS units in NW region including-

1. Improved environmental performance and image of TPPs units as biomass is a renewable and carbon-neutral source of energy. Additionally, compared to bituminous coal from domestic sources and high-Sulphur imported coal, torrefied biomass is low-Sulphur fuel. Also, it is established that co-firing leads to positive synergies for NOx reduction in TPPs.
2. It reduced power generators' supply risks associated with the imported coal. Reduced operational cost of compliance to SOx and NOx standards, especially in the case of FDG units for SOx control.
3. India is second largest importer of coal after China and imported about 200 million tonne coal in 2016 (World Coal Association, 2018). Reduced dependence on imported coal is important for national energy security and reducing government's import bill.
4. There are significant costs and emissions involved in transporting the coal from pithead and ports in case of domestic and imported coal respectively. Emission reduction from avoided transportation of domestic and imported coal from pitheads and ports respectively to TPP units in NW India.
5. Coal prices are bound to increase in future whereas in case of torrefied biomass the cost of conversion is only going to come down in future. Investment in torrefied coal technology therefore presents significant opportunities for power generators to reduce the cost of fuel supply.
6. Utilisation of biomass by power producers will result in reduced instances of stubble burning in NW India through utilisation of surplus biomass and associated air quality/health benefits in the region. It will also lead to significant job opportunities in rural NW.



ANNEXURE 10

Biomass Potential Across India's State

Table A9-1. Biomass Generation, Surplus and Biomass-to-Power Potential Across India's States

State	Biomass Generation [million tonne/year]	Biomass Surplus [million tonne/year]	Potential [MWe]
Punjab	50.85	24.84	3172.20
Maharashtra	47.62	14.79	1983.70
Uttar Pradesh	60.32	13.74	1746.20
Haryana	29.03	11.34	1456.90
Madhya Pradesh	33.34	10.33	1373.30
Gujarat	29.00	9.09	1224.80
Karnataka	34.17	9.03	1195.70
Tamil Nadu	22.51	8.90	1160.00
Rajasthan	29.85	8.65	1126.70
Kerala	11.64	6.36	864.40
Andhra Pradesh and Telangana	43.89	6.96	863.30
Bihar	25.76	5.15	641.10
West Bengal	35.99	4.30	529.30
Orissa	20.07	3.68	429.30
Assam	11.44	2.35	283.90
Chhattisgarh	11.27	2.13	248.50
Himachal Pradesh	2.90	1.03	132.60
Jharkhand	3.64	0.89	106.70
Uttaranchal	2.90	0.64	80.90
Jammu & Kashmir	1.59	0.28	37.10
Goa	0.67	0.16	20.90
Manipur	0.91	0.11	14.30
Meghalaya	0.51	0.09	11.30
Nagaland	0.49	0.09	10.00
Arunachal Pradesh	0.40	0.07	9.20
Tripura	0.04	0.02	2.94
Sikkim	0.15	0.02	2.29
Mizoram	0.06	0.01	1.12

Source: Adapted from MNRE-IISc (2004), MoA (2014) and Kumar et al 2015

ANNEXURE 11

List of Stakeholders Consulted

S.N.	Category	Name	Organisation
1	Government & Regulators	Jitendra Kumar	NITI Aayog
2		Sanjay Kumar	NITI Aayog
3		L Gopinath	NITI Aayog
4		Harendra Kharkwal	Ministry of Environment Forest & Climate Change
5		S K Paliwal	Central Pollution Control Board
6		Nazimuddin	Central Pollution Control Board
7		R K Ratra	Punjab Pollution Control Board
8		Vivek Kumar Tripathi	South Delhi Municipal Corporation
9		Vikas Gautam	South Delhi Municipal Corporation
10		Sandeep Kumar	South Delhi Municipal Corporation
11		Shashi B Kumar	South Delhi Municipal Corporation
12		Izhar Ahmed	North Delhi Municipal Corporation
13		R.K Mehta	North Delhi Municipal Corporation
14		BirenderPahil	Municipal Corporation, Faridabad
15		ChanderDutt Sharma	Municipal Corporation, Faridabad
16		Dinesh Yadav	National Highways Authority of India
17	Scientific Bodies	Mukesh Sharma	Indian Institute of Technology, Kanpur
18		N. Gopalakrishnan	CSIR- Central Building Research Institute
19		Anuradha Shukla	CSIR- Central Road Research Institute
20		SoumitraMaiti	CSIR- Central Building Research Institute
21		Neeraj Jain	CSIR- Central Building Research Institute
22	Civil Society	R Suresh	The Energy Research Institute
23	Industry	Sandeep Shrivastava	Ambuja Cement
24		Taruna Saxena	Tata Power
25		K N Rao	ACC Cement
26		Asha Sharma	Shvaas Consulting
27		Gaurav Bhatiani	IL&FS
28		Shantanu Satapathy	CLP India
29		Devendra Mahajan	Supertech
30		Shrenik M Trivedi	Syntron Industries
31		Ajay Kumar	Syntron Industries
32		Anant J Talaulicar	Cummins India
33		Sandeep Sinha	Cummins India
34		Ashish Aggarwal	Cummins India
35		Harsh Doshi	Cummins India
36		Khagender Kumar	Cummins India
37	Confederation of Indian Industry	Seema Arora	Confederation of Indian Industry
38		Sachin Joshi	Confederation of Indian Industry
39		Kamal Sharma	Confederation of Indian Industry
40		Mohit Sharma	Confederation of Indian Industry
41		Priyanka Yadav	Confederation of Indian Industry
42		Punit Agarwal	Indian Green Building Council

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CII

Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering industry, Government, and civil society, through advisory and consultative processes.

CII is a non-government, not-for-profit, industry-led and industry-managed organization, playing a proactive role in India's development process. Founded in 1895, India's premier business association has more than 9100 members, from the private as well as public sectors, including SMEs and MNCs, and an indirect membership of over 300,000 enterprises from 291 national and regional sectoral industry bodies.

CII charts change by working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for industry through a range of specialized services and strategic global linkages. It also provides a platform for consensus-building and networking on key issues.

Extending its agenda beyond business, CII assists industry to identify and execute corporate citizenship programmes. Partnerships with civil society organizations carry forward corporate initiatives for integrated and inclusive development across diverse domains including affirmative action, healthcare, education, livelihood, diversity management, skill development, empowerment of women, and water, to name a few.

India is now set to become a US$ 5 trillion economy in the next five years and Indian industry will remain the principal growth engine for achieving this target. With the theme for 2019-20 as 'Competitiveness of India Inc - India@75: Forging Ahead', CII will focus on five priority areas which would enable the country to stay on a solid growth track. These are - employment generation, rural-urban connect, energy security, environmental sustainability and governance.

With 68 offices, including 9 Centres of Excellence, in India, and 11 overseas offices in Australia, China, Egypt, France, Germany, Indonesia, Singapore, South Africa, UAE, UK, and USA, as well as institutional partnerships with 394 counterpart organizations in 133 countries, CII serves as a reference point for Indian industry and the international business community.

CII-ITC Centre of Excellence for Sustainable Development

CII-ITC Centre of Excellence for Sustainable Development is a not-for-profit, industry-led institution that helps business become sustainable organisations. It is on a mission to catalyse innovative ideas and solutions, in India, and globally, to enable business, and its stakeholders, in sustainable value creation. It's knowledge, action and recognition activities enable companies to be future ready, improve footprints profiles, and advocate policymakers and legislators to improve standards of sustainable business through domestic and global policy interventions.

CESD leverages its role of all-inclusive ecosystem player, partnering industry, government, and civil society. It has been a pioneer of environment management systems, biodiversity mapping, sustainability reporting, integrated reporting, and social & natural capital valuation in India, thus upgrading business in India to sustainable competitiveness.

With three locations in India, CESD operates across the country and has also been active in parts of South and South East Asia, Middle East, and Africa. It has held institutional partnerships and memberships of the United Nations Global Compact, Global Reporting Initiative, International Integrated Reporting Council, Carbon Disclosure Project, development agencies of Canada, the USA, the UK, and Germany.

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ANNEXURE-A-5

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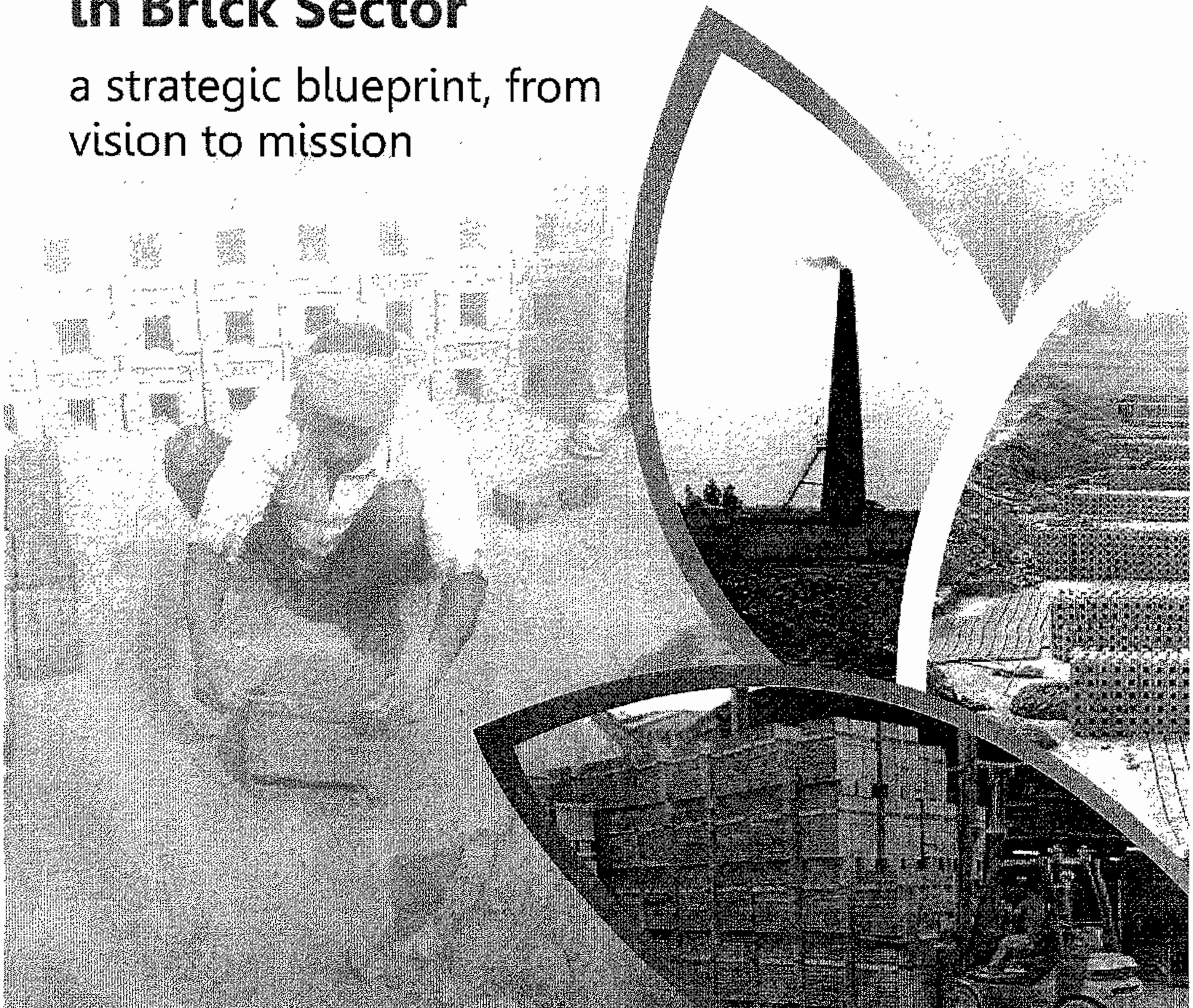
Market Transformation towards Energy Efficiency in Brick Sector

a strategic blueprint, from vision to mission



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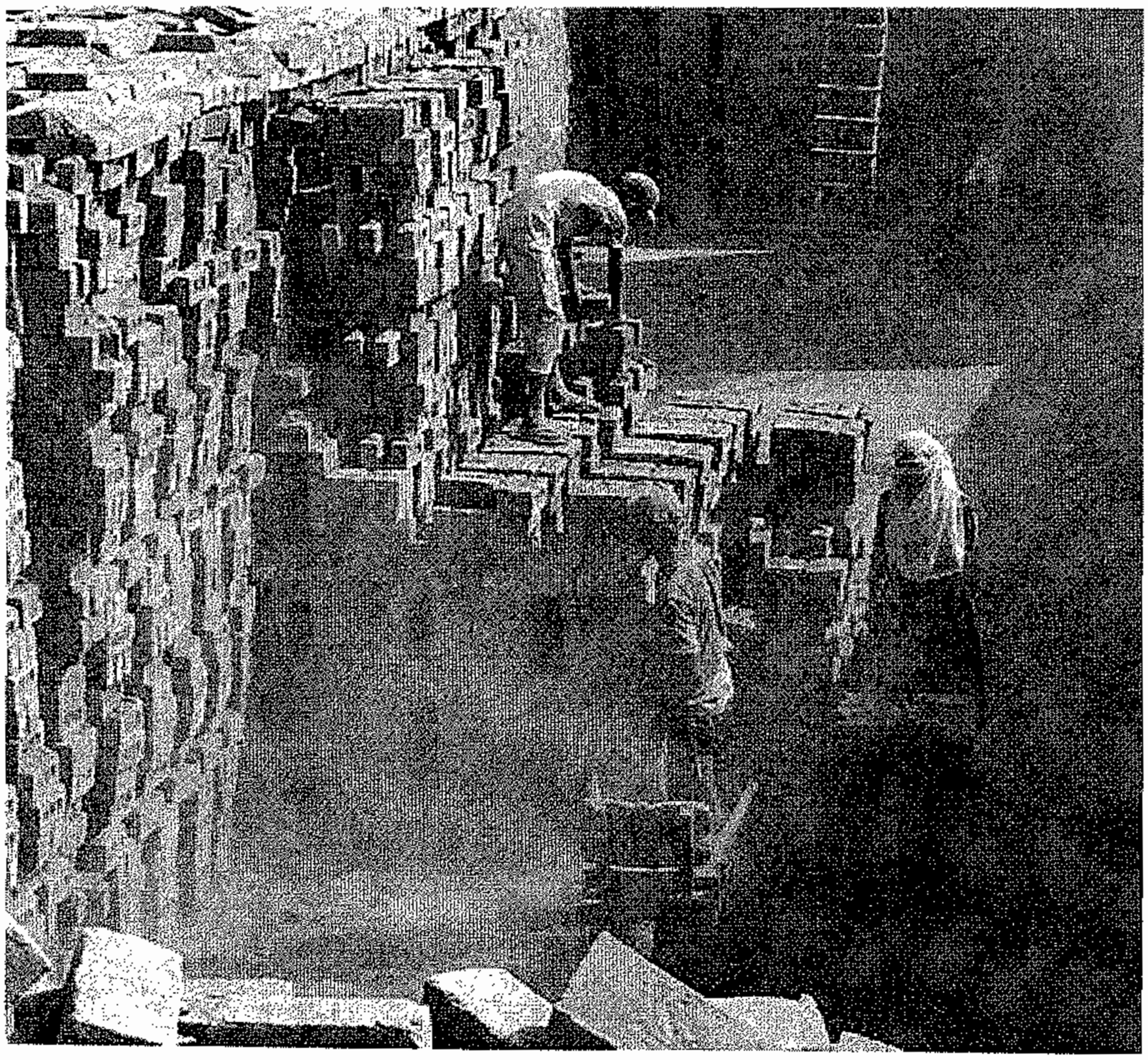

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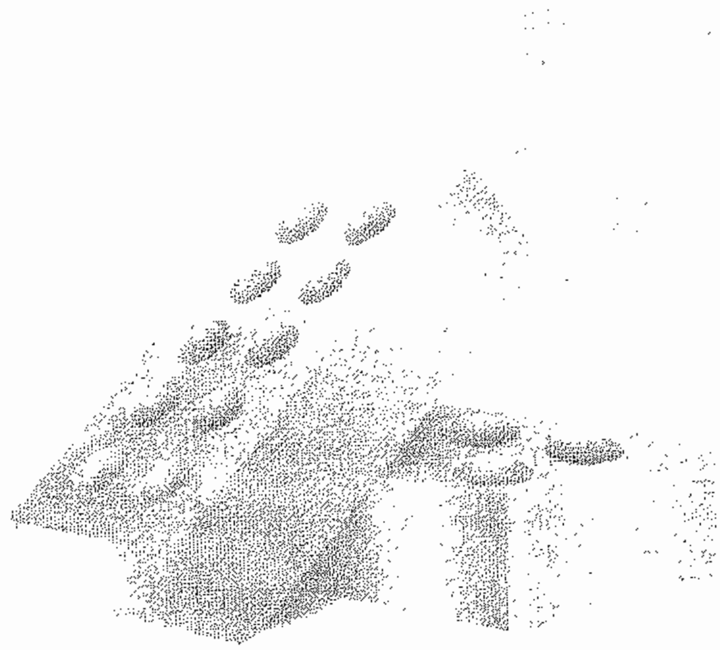


01 PROLOGUE

Earth provides enough to satisfy every man's needs, but not every man's greed.

M K Gandhi

01 PROLOGUE

Energy efficient modernization entails mechanization of brick manufacturing process AND shift in product from dense solid brick to lower density (e.g. perforated, hollow) bricks and/or diversified brick.

Under the BEE's strategy, brick manufacturers who adopt energy-efficient manufacturing shall be awarded a new BEE accredited mark called "Energy Efficient Enterprise (E3)" mark. The adoption of E3 mark shall be wholly voluntary by Industry.

Market awareness for the E3 mark shall be generated by BEE to encourage sourcing bricks from manufacturing units who have been awarded the E3 mark.

Overall the market transformation strategy is expected to reduce - energy, clay, water use and reduces wastes per unit production.

The traditional red clay brick is a time-tested walling material of choice and an important raw material for the construction industry. India is the world's second-largest producer of bricks and this demand is expected to multiply three to four times over the next 20 years. The sector contributes nearly 0.7% to the country's GDP, offers seasonal employment generation to over 10 million workers and has strong influence on other economic sectors such as transportation and construction.

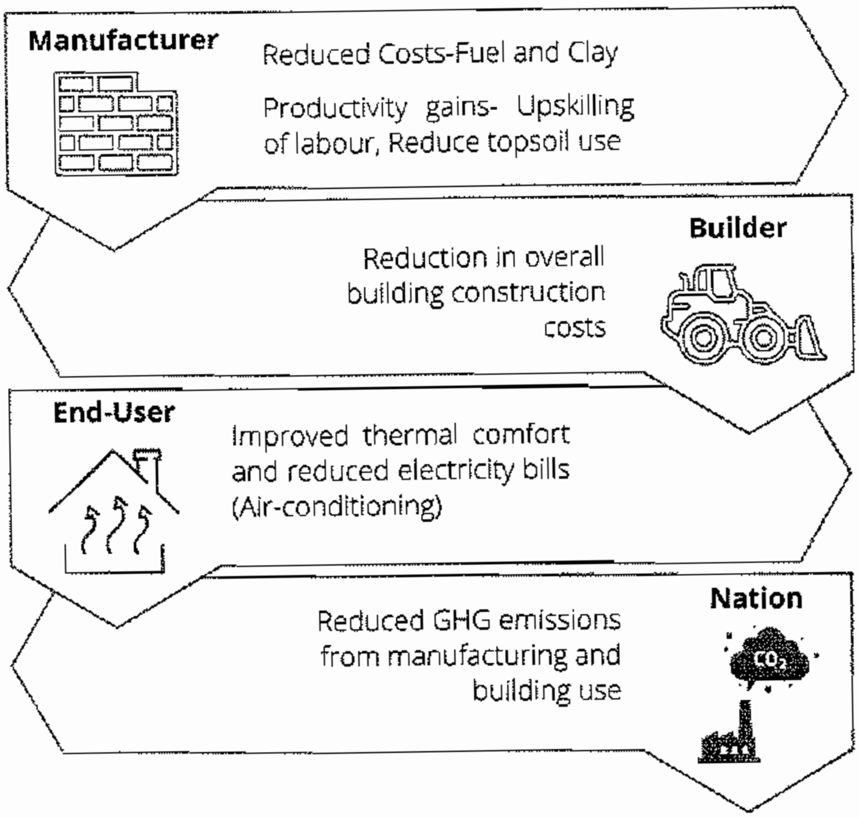
Bricks have been produced since ancient times (dating back to 6000 B.C) by mixing ground clay with water, forming bricks into desired shape and size, drying them and then firing them (at around 1100 ºC) to impart durability and weathering resistance.

The clay depending on its mineral content, geological occurrence yields bricks of varying density, strength, water absorption, and thermal conductivity.

This conventional method of brick manufacturing carries environmental consequences represented by the emissions of greenhouse gases (GHG), due to fuel firing in the brick kilns, which contributes to climate change and raises concerns on the extraction of clay and the removal of topsoil. Newer man-made materials have emerged which emphasize on either aesthetics, maintenance, time/effort of construction, etc. The focus on short run incentives e.g. cost savings; often overlook aspects like thermal comfort or the 'long-run sustainability like end-of-life issues' of the new technology.

Over the last decade, innovations in the use of clay bricks have been noted, leading to reduced resource use (energy and clay). The innovated clay product (typically perforated and hollow clay bricks and blocks) have lower densities, consume less clay/energy in manufacturing, have lower thermal conductivity values, and can also be produced in larger size format. These attributes bring-in several benefits along the construction value chain.

Figure 1: Market Transformation Benefits



Brick consumers are mainly government agencies, real estate developers, individuals constructing residential buildings, and contractors for road construction, etc. Given this spread in the user base, the sector is slow to change. For example, in India the share of new type of clay bricks is currently less than 0.5%[1] (of the market share); majority bricks being the solid clay brick. Even though, twenty to forty percent of the manufacturing cost of a brick is due to energy, a variety of barriers dis-incentivize modernization in this sector, (inter-alia):

Buildings already account for more than 30 percent of electricity use, with rapid urbanization expected in the coming decade has implications for national energy security (as electricity is largely generated in coal-fired power plants) and greenhouse gas emissions.

A technological makeover of the traditional solid bricks to porous and hollow products would offer both energy and raw material efficiency, with the potential to put India on a more sustainable pathway in infrastructure development. Perforated and hollow products allow for the use of clay other than topsoil, which can thus be preserved.

In India, the Bureau of Energy Efficiency is the nodal agency to assist Government in developing policies and strategies with a thrust on self-regulation and market principles, under the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing the energy intensity of the Indian economy.

[1]Policy Roadmap for Promoting Resource Efficient Bricks in India (GKSPL 2017), the annual production of perforated and hollow bricks was around 0.2 billion bricks/year. If enterprises producing perforated and hollow products, produce other products as well, the maximum total production from such units is not more than 1 billion bricks per year (~ 0.5 % of the total production).

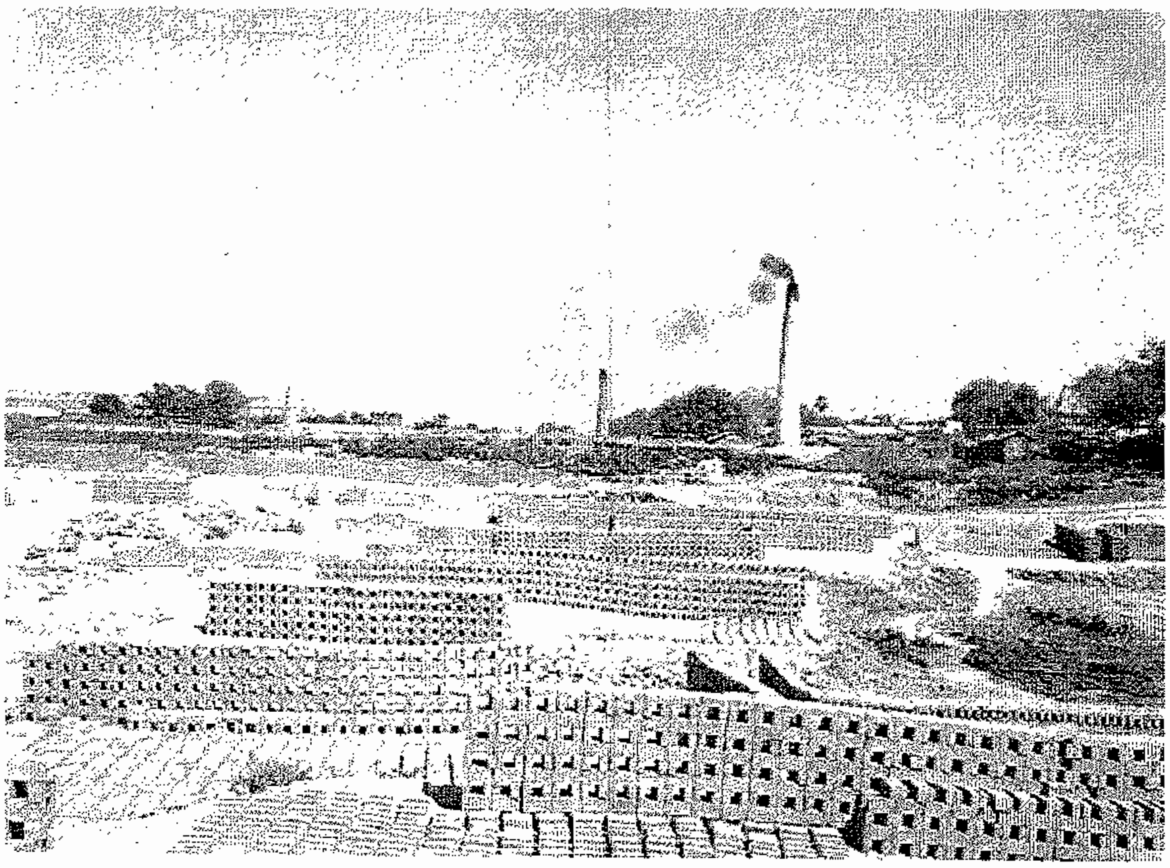
The adoption of E3 mark shall be wholly voluntary by Industry . Energy-efficient transformation in brick making through BEEs active steering is expected to enable the brick sector and indeed India to lock itself into an energy-efficient and sustainable infrastructure.

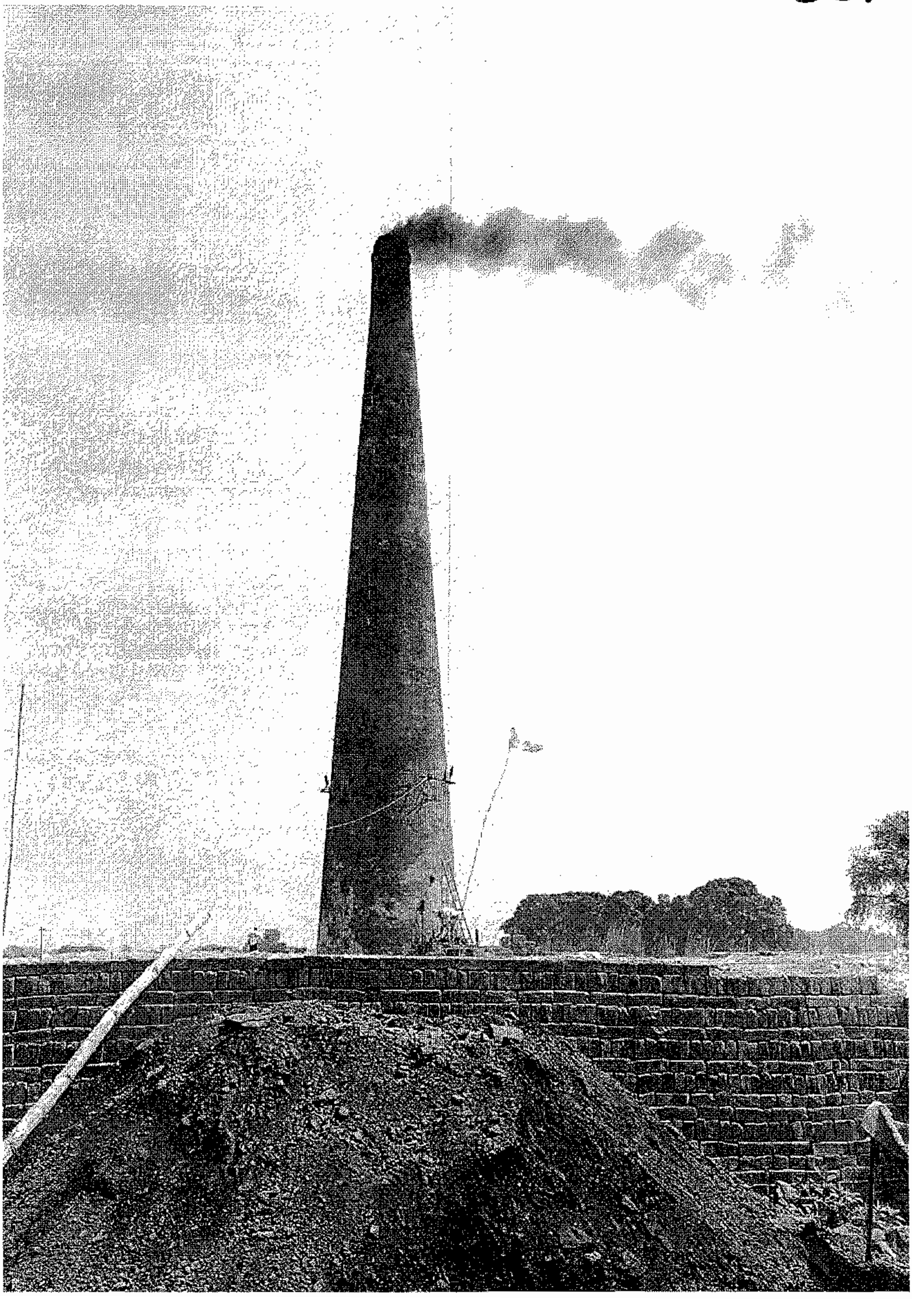
The Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is an International Cooperation enterprise for sustainable development which operates worldwide, on a public benefit basis. GIZ is fully owned by the German Federal Government and implements development programs in partner countries to achieve the German development policy objectives.

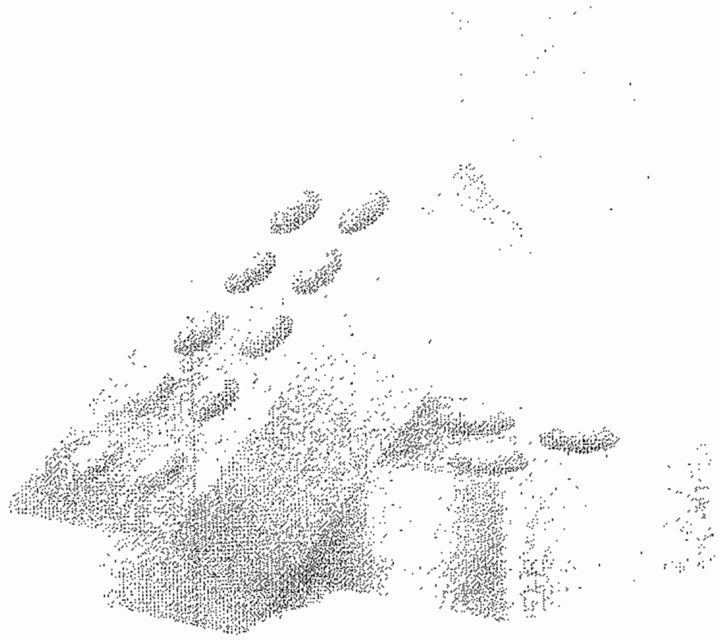
The Federal Republic of Germany and the Federal Republic of India have, under the Indo German Technical Cooperation, agreed to jointly promote the "Indo-German Energy Programme" (IGEN) with the aim to promote energy efficiency/conservation in energy consumption to use energy more efficiently and in turn improve the environment and aid climate protection.

The GIZ works closely with the Bureau of Energy Efficiency (BEE) to promote energy efficiency and the execution of policy backed national and state-level programs. The BEE with support from GIZ has developed the market transformation strategy to enhance the demand towards energy efficient brick manufacturing.

M/s Greentech Knowledge Solutions Pvt Ltd (GKSPL) had been retained by GIZ to support the strategy development and the development of this document. To accomplish the assignment, two methods were used: (i) desk review of relevant documents, reports, and data and other available information, and (ii) interaction with stakeholders (brick industry, government, and bank and non-bank financial institutions, etc). Feedback received through these stakeholder consultations was considered to shape the brick market transformation strategy.







02 BRICK SECTOR OVERVIEW

Connecting with nature means to connect with ourselves. If we do so we nurture a better planet

Narendra Modi

02 BRICK SECTOR OVERVIEW

Burnt clay brick is a time-tested walling material of choice in India. Newer man-made materials have emerged which emphasize on either aesthetics, maintenance, time/effort of construction, etc. The focus on short run perverse incentives e.g. cost savings, often overlook aspects like thermal comfort or the 'long-run sustainability like end-of-life issues' of the new technology.

Traditional solid brick manufacturers through a technological makeover can morph to 'Energy-efficient bricks' viz porous and hollow products, which offer energy and raw material efficiency both during production and use.

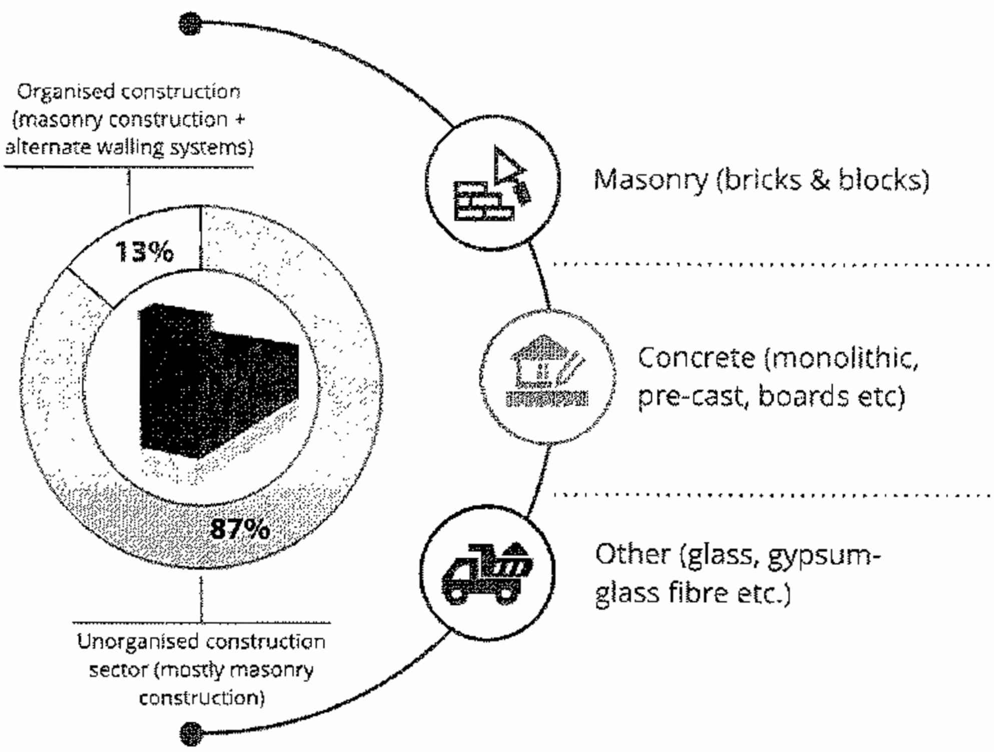
India has an opportunity to choose 'Energy-efficient bricks' as a more environmentally sustainable pathway in infrastructure development.

Active steering shall enable India to lock itself into an energy efficient and sustainable infrastructure.

A building brick or block, in the context of this document, is defined as a building material in the form of a rectangular unit which is primarily used to make walls of buildings using masonry construction techniques. The other applications of bricks and blocks are in the construction of pavements, boundary walls, canals, drains, and other elements.

The largest application of building bricks and blocks is for the construction of walls. Apart from brick masonry construction, a variety of other materials and construction techniques exist for the construction of walls (Figure 3).

Figure 3: Technologies for the construction of walls



In India, the organized real estate sector is estimated to construct around 0.1 billion m^2/ year, which is a small segment (~13%) of the total annual building construction[2] in India. The organized construction sector makes use of both brick masonry as well as alternate walling technologies.

Construction carried out by the unorganized sector which includes construction done by local masons, civil contractors, small builders as well as self-construction is estimated at around 0.65 billion m^2/year[3] (~ 87%) making it the main mode of construction in the country (Figure 3). Within the unorganized sector, brick masonry construction is the most popular method for the construction of walls.

In the coming decades, while the percentage shares of both the organized real estate sector as well as alternative technologies for wall construction are likely to increase, that of bricks and blocks-based masonry construction is also expected to increase to retain the Lions share in wall construction.

2.1 Types of bricks and Market demand

The brick manufacturing sector contributes 0.7% of India's GDP and employs one of the nation's largest workforce after agriculture. It is also one of the largest (coal) energy users and source of GHG emissions from India.

India is the world's second-largest producer of bricks, with an annual production of around 250 300 billion bricks[4] (440 530 million m^3) per annum[5,6]. Given the large projected increase in the building stock in India, the demand for bricks is expected to multiply by 3-4 times in next 20 years and reach 750-1000 billion brick/year.

There are various types of bricks being produced, the main being solid burnt clay bricks, fly ash bricks (with cement), fly ash bricks (with lime and gypsum), solid and hollow concrete blocks, and aerated autoclaved concrete (AAC) blocks. Around 85% of the bricks produced are burnt clay bricks and the remaining 15% are non-fired bricks (AAC blocks, flyash bricks, concrete blocks, etc.). Perforated and hollow clay brick products comprise less than 0.5%

Based on the experiences in Europe, and Asian countries like China[7] and Vietnam, despite introduction of non-fired bricks, the burnt-clay brick industry is likely to retain a market share of 60%-80% in the future. Projections suggest that raw material availability in the future for

[2]Bain & Company, Residential real estate in India http://www.naredco.in/notification/pdfs/FINAL_India_Real_Estate_Digest_ALL_pages.pdf accessed on 01 June 2017.

[3]The total built-up area in India is estimated to be around 15 billion m^2 by NITI Aayog (IESS, 2047). If we take an annual growth rate of a 5% increase in the building built-up area, the annual addition in the built-up area will be 0.75 billion m^2/year. The organized real estate constructs around 0 1 billion m^2/year, thus the remaining 0.65 billion m2/year is assumed to be constructed by the unorganized construction sector.

[4]Standard size of brick is taken as 230 mm x 110 mm x 70 mm, which is the most prevalent brick size in the country.

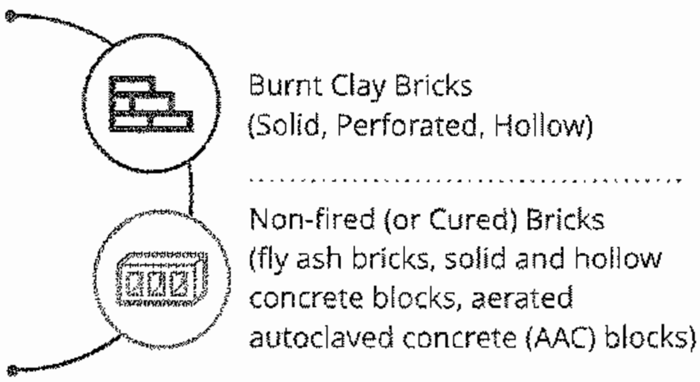
[5]Bricks are mainly used for the construction of different types of walls and it may be more useful if the annual production is expressed in terms of volume of walling material produced.

[6]It is to be noted that there is a lack of officially validated data on both the manufacturing side as well as on the consumption side i.e. on the building construction. The majority of the brick production takes place in small manufacturing units belonging to the unorganized sector. Thus, most of the numbers used in this paper are taken from estimates available in reports prepared by non-government organizations working in the brick sector such as The Energy and Resources Institute (TERI), Centre for Science and Environment & Greentech Knowledge Solutions.

[7]Data sourced from The Fired Brick Industry in China. Presentation made by Xiaolin Yu at Second Policy & Advocacy Network (PAN) Asia Workshop, 20-21 June 2019, Organized by ICIMOD, Climate & Clean Air Coalition & UNEP

alternate products like Autoclaved Aerated Concrete (AAC) blocks, flyash bricks, etc. would not be enough to meet the brick demand of the country. Given the global experience and raw material trends, it is thus prudent to assess that the burnt-clay brick will continue to command significant market share even in the future.

Figure 4: Types of bricks



Lessons from China

China started modernizing the fired clay brick industry since 1990. Even today, the fired clay brick continues to hold the largest market share and the current production is estimated at over 1000 billion bricks/ year.

Over 25 years, three clear transformation trends have emerged:

Consolidation of brick manufacturing — large scale (1200 tpd sizes) in about 4000 units. Earlier this was around 100-200 tpd in 150,000 plus kilns. The kilns are also located close to raw material supply chain in the hinterland.

Shift to modern technologies like Tunnel and Rotary Tunnel kiln working all around the year.

Clay remains the main raw material constituting 85% of the brick market. However, instead of depending on clay from agriculture fields, new sources of clay have been identified and instead of solid brick now the product mix has larger share of perforated and hollow bricks.

2.2 Opportunities for energy savings

Energy Use in Manufacturing

Burnt clay brick (the traditional red brick) making accounts for significant energy consumption, wherein nearly twenty to forty percent of a brick's cost of manufacture is due to energy.

Solid burnt clay bricks are manufactured in small manufacturing units belonging to the unorganized/ informal sector. The estimated number of such manufacturing units range from 1,50,000 to 2,80,000. Most of the brick production (around 75% of the total bricks produced) is accounted by 50,000 - 60,000 relatively bigger units based on arch-less moving-fire continuous kiln technologies (fixed chimney bull's trench kiln technology and zig-zag kiln technology), with a typical production capacity of 30-70 lakh bricks/year/enterprise. A few medium/large scale enterprises are also in operation, involved in the production of mostly perforated and hollow burnt clay bricks[8]. Coal and biomass fuels are used for firing bricks and the annual consumption is estimated at around 30-35 million tons of coal and 10 million tons of biomass fuels.

The average[9] specific energy of manufacturing burnt clay bricks ranges from 1300 – 3200 MJ/ m^3 based on factors such as:

- Type of brick kiln technology employed (viz. the Specific Energy Consumption (SEC) of the kiln technology) and

[8]The pictorial brick manufacturing process and solid brick alternate options are shown in Annexure-V.

[9]The "average specific energy" term encapsulates the range of average SEC of different "brick product-production process" combinations. For example, SEC of "solid brick-clamp kiln" combination varies between 2400 to 4000, and the average SEC would be 3200 (Refer row 1 of Table 1).

- Brick material density (mainly depends on the type of final product – solid/perforated/ hollow)

Table 1: Indicative Average Specific Manufacturing Energy (MJ/m3, by Product/Process)

Type of Brick Product	Indicative Average Specific Manufacturing Energy (MJ/m3)	Process & Assumption
Solid burnt clay brick – Clamp kiln	3200 MJ/m^3	Mostly manual clay preparation and moulding; sun drying; Fired in clamp/downdraught kiln; Specific Energy Consumption 1.5 2.5 MJ/kg, Average SEC – 2.0 MJ// kg; Average brick density of 1600 kg/m^3.
Solid burnt clay brick - FCBTK	2100 MJ/m^3	Mostly manual clay preparation and moulding; sun drying; Fired in FCBTK; Specific Energy Consumption of 1.1 1.5 MJ/kg of fired brick, Average SEC 1.3 MJ//kg; Average brick density of 1600 kg/m^3.
Solid burnt clay brick – Zigzag kiln	1800 MJ/m^3	Mostly manual clay preparation and moulding; sun drying; Fired in Zigzag kiln; Specific Energy Consumption of 0.95-1.3 MJ/kg, Average SEC : 1.125 MJ//kg; Average brick density of 1600 kg/m^3.
Burnt perforated clay brick – Zigzag kiln (around 25% perforation)	1600 MJ/m^3	Semi-mechanized clay preparation; extrusion; shed/ sun-drying; Fired in a Zigzag kiln; Specific Energy Consumption of 1.0-1.35 MJ/kg, Average SEC 1.175 MJ//kg; Average brick density of 1350 kg/m^3
Burnt hollow clay block – Tunnel kiln (around 60% perforation)	1300 MJ/m^3	Mechanized clay preparation, extrusion, followed by artificial drying; Fired in a Tunnel kiln; Specific Manufacturing Energy Consumption of around 1.6 MJ/kg of fired brick; Average brick density of 800 kg/m^3.

Source: GKSPL, 2017: Roadmap for Resource Efficient Bricks

In recent years, the burnt clay brick production has seen some improvements in energy efficiency due to the implementation of pollution control board directives to reduce air pollution from brick kilns through a shift to Zigzag kiln technology from FCBTK technology. It is to be noted that despite a change in the brick kiln technology, the type of brick product produced has not changed and remains the solid burnt clay brick.

There will a significant improvement in energy efficiency if the kiln technology is further upgraded to, say, tunnel kilns, as well as there is a shift from solid bricks to hollow/perforated bricks. Even Zigzag kilns with a change in product will yield substantial energy efficiency gains.

Thus, the key to energy efficiency in the Brick manufacturing sector is to encourage a comprehensive shift rather than incremental changes.

Although nearly twenty to forty percent of cost of brick manufacture is due to energy, comprehensive energy efficiency improvements[10] and technology modernization (apart from incremental improvements[11] due to tightening emissions standards[12]), have not found much traction in India due to a variety of factors apart from, (inter-alia):

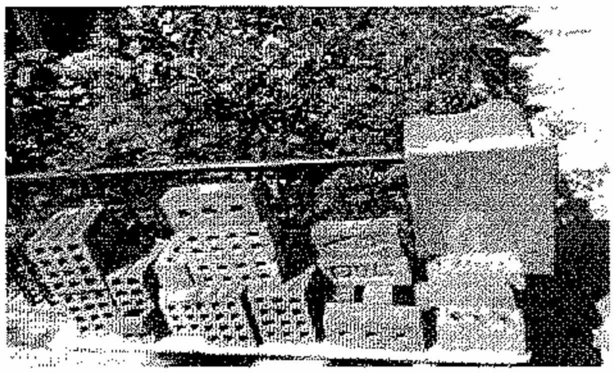
Historical: traditional Brick making has low entry barriers and large risks (weather, cyclic market); thus, entrepreneurs seek (quick) profitability by extracting savings from labour, machinery, customers and regulation compliance. The uncertainties in the sector are aptly captured in the Hindi proverb bhatta baith gaya!

Policy Stability: frequent revisions and lack of clarity in policy surrounding mining, use of alternative materials (e.g. fly-ash) discourage brick kiln owners to invest in new technology.

Perception overhang: Brick output quality mix from traditional kilns is ~ 50% (Good)/25% (under-fired)/25% (over-fired). This puts pressure on the pricing of good bricks and in the past encouraged dumping of the low-quality product through bulk public and private construction projects. The low-quality product coupled with non-compliance with regulations has dimmed the entire sector perception, especially amongst policymaking circles.

Brick price: Brick owner recover costs of technology risk, fuel choice, marketing, financing, etc through end-product price which ranges from Rs 1.5 to 3 per kg solid brick to Rs 2.5 to 5 per kg Hollow Blocks. Price of product varies across regions like North-West India is low whereas, in Bengal, North East states and parts of South India better pricing and profitability encourages brick makers to consider technology upgradation.

[10]Comprehensive energy efficiency improvements focus on modernization of all steps in brick manufacturing process AND shift in product from dense solid to lower density (e.g. perforated, hollow) bricks and/or diversified brick and tile production. It is characterized by the use of machinery for clay-mixing and brick forming (e.g. extrusion), use of artificial dryers and efficient/modern kilns (e.g. zigzag, tunnel kiln). The brick manufacturing enterprise transforms from "traditional informal enterprise" to "organized formal enterprise" and significant improvements in working conditions. Typically, 30-50% reductions in SEC (MJ/m3 of brick) are possible when perforated and hollow products are produced.



[11]Incremental energy efficiency improvements mean energy efficiency improvements due to incremental improvements in traditional brick kilns e.g. retrofitting fixed chimney BTK to zigzag kiln. There is no change in the final product (solid brick), and no significant change in the brick manufacturing process, nature of enterprise and working conditions. Typically, 15-20% reductions are possible in SEC through incremental improvements like retrofitting FCBTKs to Zigzag kilns.

[12]Two incremental energy efficiency improvements in the brick industry have happened due to the implementation of emissions standards to control air pollution emissions. This includes, shift from movable chimney to Fixed Chimney Bull's Trench Kiln (FCBTK) technology in the late 1990s and the ongoing shift from FCBTK to Zigzag kiln. In both cases (if done correctly), the shift results in 15-20% reduction in specific energy consumption.

Overall, end-product brick price to the consumer does not encourage investments to bring in comprehensive energy efficiency technology in the sector. The price arbitrage from bricks manufactured using traditional kilns and those using modern technology creates a perception of lack of affordability, which is reflected by the less than 0.5 market share of burnt clay brick units manufacturing perforated/ hollow bricks in India.

Energy Efficiency- The Opportunity

Introducing comprehensive energy efficiency in brick making will not only reduce energy use, but it would also result in reductions in raw material use.

Manufacturing of burnt clay bricks: The average specific energy of manufacturing burnt clay bricks ranges from 1300 – 3200 MJ/m^3. The energy consumption for the manufacturing of bricks can be reduced by following two broad paths:

1. Kiln Efficiency Improvements: Changeover from the traditional kilns like clamp and Fixed Chimney Bull Trench Kiln (FCBTK) to Zigzag and other efficient brick kilns (e.g. Tunnel kiln) for the firing of burnt clay bricks.
2. Shift to Alternative Clay Bricks: Changeover from solid burnt clay bricks to lighter[13] burnt clay products (porous, perforated or hollow bricks/blocks). At present, there are just a few enterprises involved in the production of perforated and hollow burnt clay bricks.

Operational Energy of Buildings: The Bureau of Energy Efficiency has come out with two building energy conservation codes – Energy Conservation Building Code, 2017 for commercial buildings and Eco-Niwas Samhita (Part 1), 2018 for residential buildings. Both codes aim at reducing heat transmission from the building envelope to reduce the operational energy required for cooling or heating of the building. The choice of brick impacts the thermal transmission value of the outer walls of a building. **Usually, the lighter clay brick products (porous or hollow bricks/blocks) also have lower thermal conductivity values**. The use of bricks having lower thermal conductivity for construction of the outer wall helps in energy savings in the operational life of the building and thus can support meeting the requirements of the energy conservation building codes.

As per a 2017 Indo German Energy Forum (IGEF) report conducted by TERI on behalf of BEE, burnt clay brick manufacturing has been identified with the second-largest potential for energy efficiency amongst the industrial sector in India with savings of around 2 mtoe by 2031 and 4 mtoe by 2041[14]. Therefore, a national initiative must be launched to transform clay brick production in the country and to realise the sectors energy-saving potential.

Market driven sectoral transformations have been successfully tried out in a diversity of sectors in India to scale up energy efficiency.

Modernization of brick manufacturing is a low hanging energy efficiency fruit, which has recently started through conversions to zig-zag / tunnel kilns albeit with low momentum. This momentum needs to be accelerated to enhance the supply and bring in affordability through economy of scale.

[13]Lighter products (porous and hollow products) have lower specific manufacturing energy (MJ/m^3). Usually, these bricks (because of porosity or presence of air gaps) also have lower thermal conductivity values which help in lowering the operational energy of the building.

[14]The largest is the iron and steel sub-sector (about 27 mtoe by 2031 itself and 45 mtoe by 2041)

2.3 Barriers to adoption of energy-efficiency in brick sector

Supply Side Barriers

a) Lack of appropriate technology package at an affordable price, and technical support:

The burnt clay brick production involves several processes, the main being clay preparation, shaping/ moulding, drying, firing, and material handling. Shift to zigzag kiln brings-in improvement only in the firing process and others remain the same.

Shift to the production of perforated and hollow brick products to achieve larger energy efficiency targets will require upgradation in all aspects of the brick-making processes including choice of raw material, degree of mechanization and production capacity.

Apart from a few, most of the technology vendors are based abroad. Investment required in procurement from turnkey suppliers (European / Chinese) abroad is very high. Moreover, the entrepreneur faces difficulties in deciding the best fit technology for his plant for a specific product-mix, and then integrating the procured machinery from different vendors, including any indigenous common machinery, for results.

Standardization of appropriate technology packages may bring in economy of scale and thus affordable technology pricing. Besides, with limited technical capabilities, the manufacturing enterprises may also require technical support in the selection of technologies and dissemination of operational best practices.

b) Lack of access to finance for technology upgradation

Brick manufacturing enterprises are mostly financed wholly by the entrepreneur or through informal arrangements as the majority of them are informal producers with no fixed assets. Thus, the business seldom has a credit history.

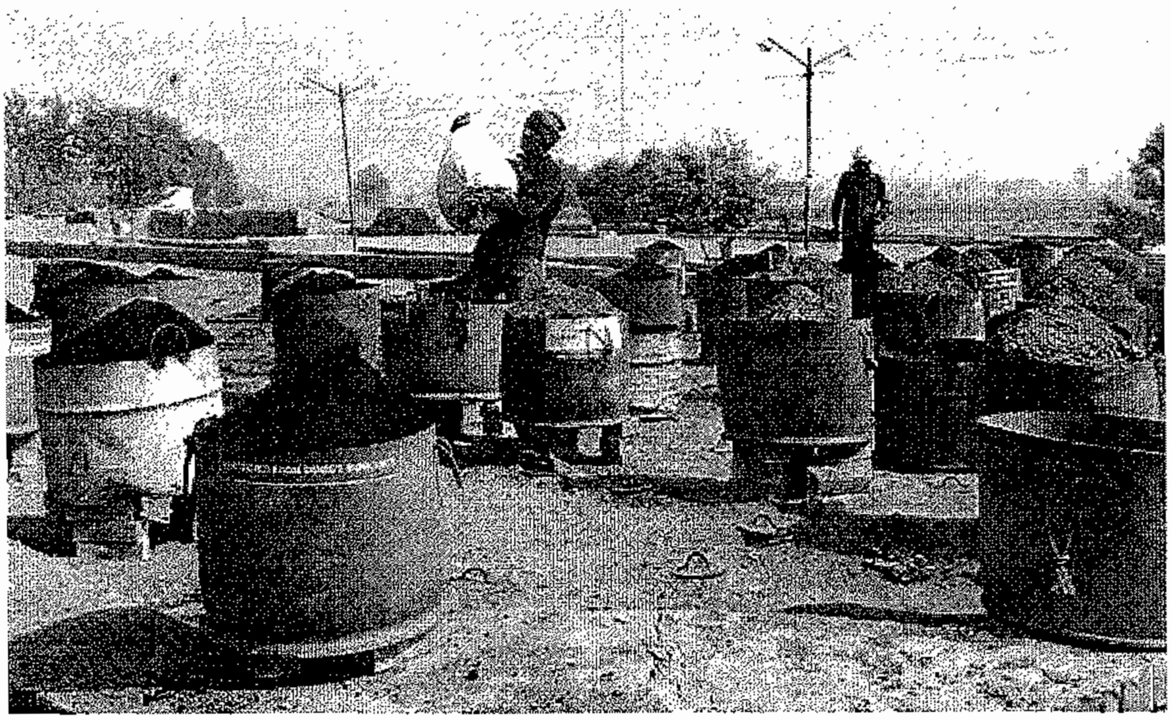
Technology modernization is also expensive. A traditional (manual labour intensive) brick kiln based on FCBTK would cost around INR 5 million to commission. A modern tunnel kiln would easily take around INR 70 million. Add to this investment required for mechanization of value chain activities and the investment stretches to around INR 120 million.

Table 2: Comparative cost of kiln technologies

Cost of establishing a new FCBTK kiln	INR 5 million
Cost of establishing a new Zigzag kiln	INR 5 million
Cost of upgrading an existing FCBTK to Zigzag kiln	INR 2 million
Cost of establishing a new Tunnel kiln	INR 70 -120 million

To finance heavy Capex, a financier would seek commensurate collateral in place of credit history which is difficult to obtain. Very few entrepreneurs venture to extend such collateral.

Further, there are no government incentives or financial products to attract energy efficient technology investments.



Given this context, viable project financing models do not exist. Thus, overall there is a lack of formal finance in upgradation of the enterprises.

c) Limited or lack of assured market demand for energy efficient bricks

The market demand is dominated by solid burnt clay bricks, especially in the unorganized construction sector. The perforated and hollow bricks are being used in very limited regions. This limited or lack of market demand hinders the manufacturing enterprises to invest. It is also seen as a risk by the financiers in financing the manufacturing enterprises.

A perceived sustained shift of customer preference towards such energy efficient products shall enable serious adoption of energy efficiency by brick manufacturers.

d) Uncertainty in the environment and mining policies / Creation of Perverse incentives

Lack of clarity and certainty in policy surrounding mining, use of alternative raw materials (e.g. fly-ash) pose uncertainty to the future of clay brick industry and discourages brick kiln owners to invest in new technology. For example, a draft amendment to the fly ash notification issued by MoEFCC vide notification dated 25 Feb 2019 proposed shift of all the clay brick manufacturing units to fly ash brick manufacturing, without analyzing the reasons for the slow progress in the implementation of previous fly ash regulation in the brick sector during last 20 years.

Demand Side Barriers

a) Higher product cost (Issue of Affordability):

Solid burnt clay bricks are priced significantly less than the perforated/ hollow bricks. The lower price is explained by the

- lower capital requirement and manual labour

- the informal nature of the burnt clay brick manufacturing
- intense competition among burnt clay brick manufacturing enterprises and
- negligible marketing expenses since the product is well entrenched in the market

On the other hand, the bricks manufactured through energy efficient processes (e.g. perforated and hollow burnt clay blocks) are mostly manufactured in

- the formal sector with a higher cost of compliance with regulations related to environment, labour, etc.
- capital intensive to bring in economy of scale
- marketing of product

A market assessment study on perforated and hollow burnt clay bricks[15], found that one of the reasons for the higher price of the product in North India was small production capacity (thus low economy of scale), low plant utilization factor coupled with the higher expenditure on the marketing of the product. Builders also perceive the product as being expensive to their projects or cite lack of masonry skills for use. However, this is not universally true as experience from Bengaluru market shows that the use of lighter and bigger hollow blocks for constructing apartments, results in lower cost of overall project construction due to savings in reinforcement (steel, cement) and faster construction[16].

b) Lack of awareness among end-users and limited availability:

While the solid burnt clay bricks are produced across the country, the production of other types of bricks is usually confined to a few regions. For example, the hollow burnt clay blocks are produced mainly in the area around Bengaluru and Kerala.

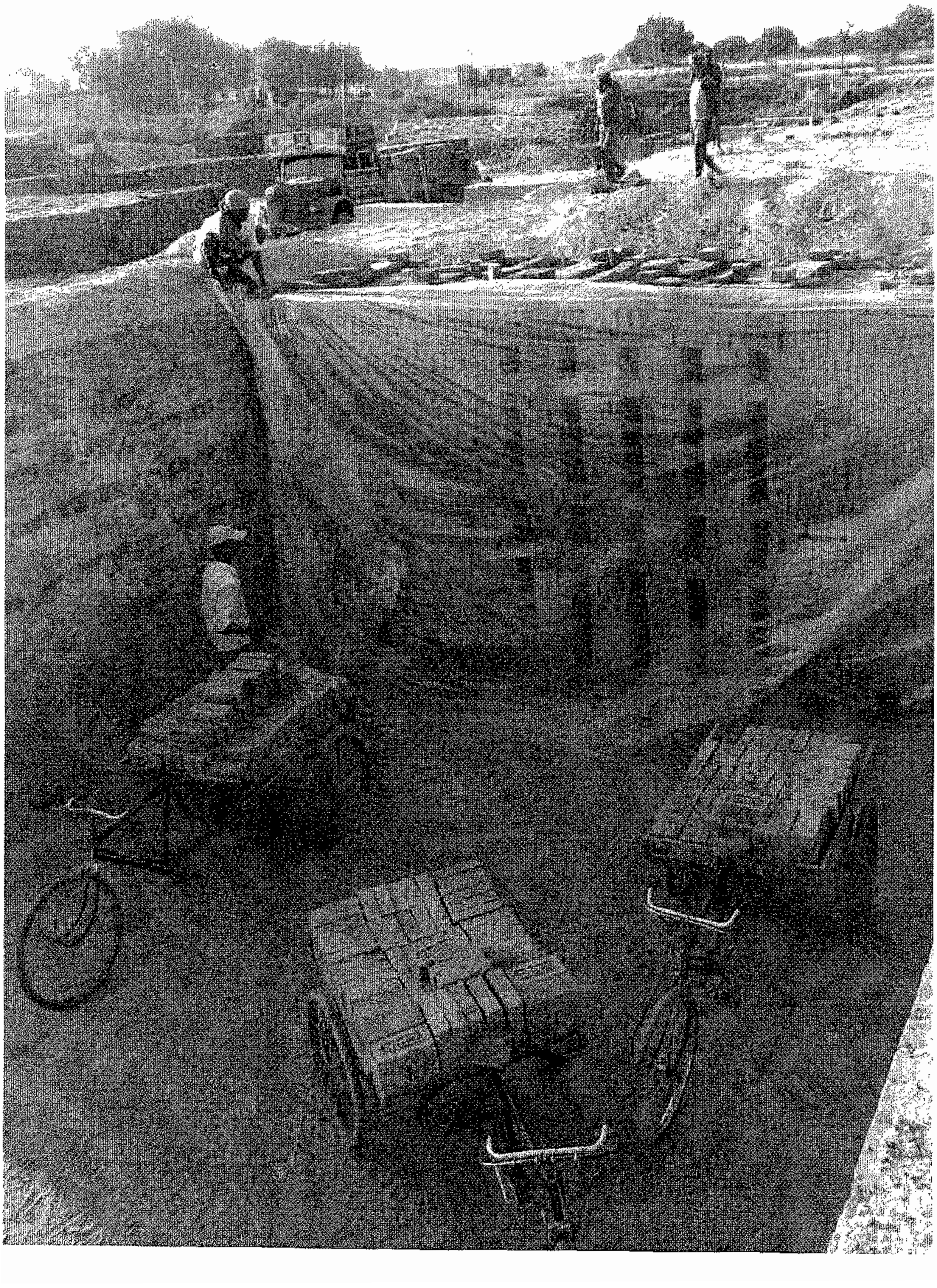
The awareness about the energy efficient manufacturing of bricks and its benefits especially to end-user is low. Moreover, products like hollow burnt clay blocks are yet to be included in the Schedule of Rate (SoR) with state PWDs which hinders their use in government construction.

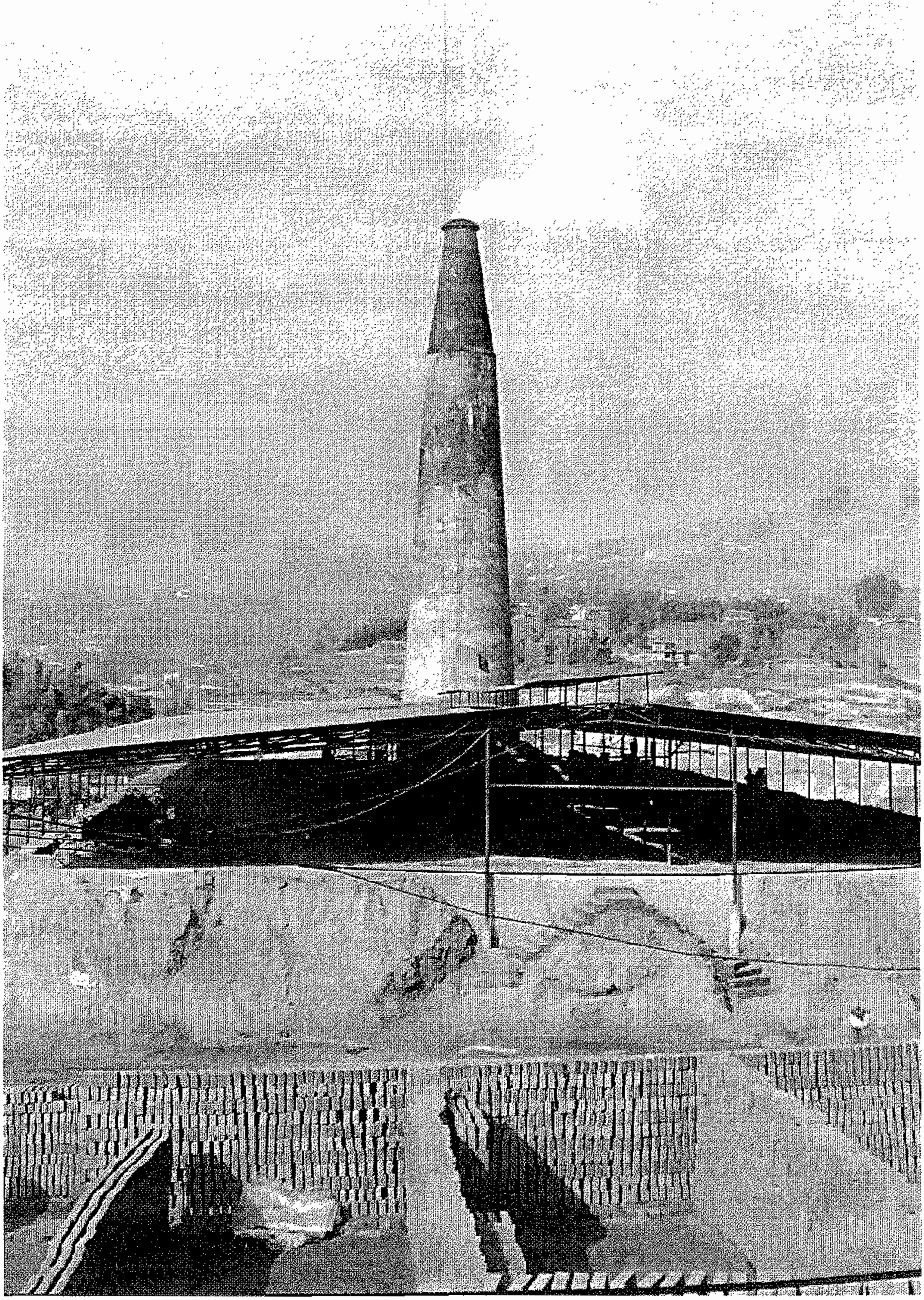
c) Perceived lack of standards/Assurance:

Construction is a traditional and risk-averse business. The builders, individual homeowners, contractors and masons are hesitant to adopt a new product or a construction technique. The process of adoption of any new brick product is slow. There are no widely used Marks/ labels or rating systems which inform the end-user about the energy-environment performance of the bricks used.

[15]GKSPL (2016). Market Assessment for Burnt Clay Resource Efficient Bricks (REBs). UNDP-GEF project on Energy Efficiency Improvements in Indian Brick Industry.

[16]Refer section of this document where the estimated savings are of the order of 1 to 1.5% of a project's capex outlay.





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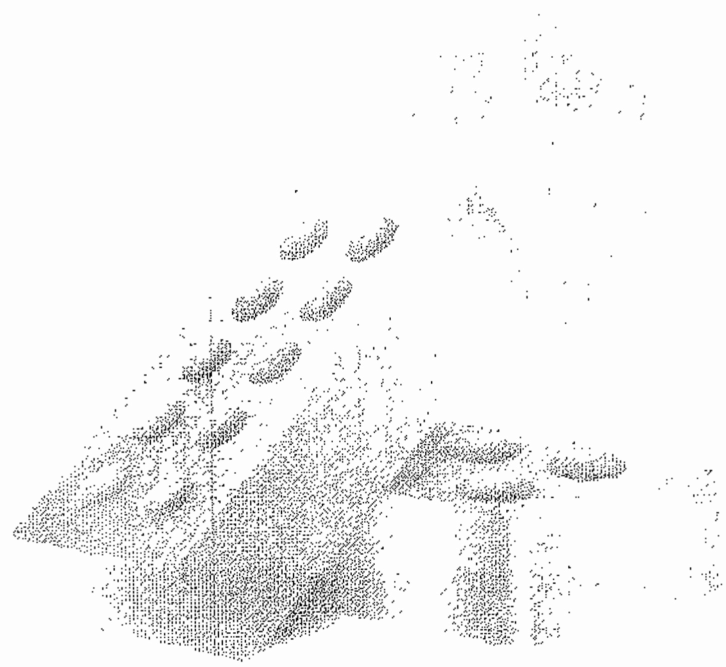

03 BRICK SECTOR MARKET TRANSFORMATION

It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change

Charles Darwin

03 BRICK SECTOR MARKET TRANSFORMATION

3.1 The Bureau for Energy Efficiency

The Government of India set up Bureau of Energy Efficiency (BEE) on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The mandate of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy.

As highlighted earlier the Indo German Energy Forum (IGEF) came out with a report on the study by TERI which identified burnt clay brick manufacturing as having the second-largest potential for energy efficiency amongst the industrial sector in India with savings of around 2 mtoe by 2031 and 4 mtoe by 2041[17]. This energy-saving would be enough for lighting up of around 23 million households by 2031 and around 47 million households by 2041[18].

Given the large potential for energy efficiency in clay brick manufacturing, the BEE is proposing a market transformation initiative for this sector, under which the end-customer market shift takes place towards bricks sourced from manufacturing units adopting lower specific energy for manufacturing and product innovation (viz. perforated and hollow bricks).

3.2 Brick Sector: Market Transformation Strategy

The BEE, under the Energy Conservation Act, 2001 has the function and powers to:

13-e: take all measures necessary to create awareness and disseminate information on efficient use of energy and its conservation.

13-j: Formulate and facilitate implementation of pilot projects and demonstration projects for promotion of efficient use of energy and its conservation.

13-k: Promote use of energy efficient processes, equipment, devices and systems.

In line with its powers the BEE proposes to launch a voluntary initiative for the brick sector.

The market transformation strategy, on one hand, focuses on lowering the specific manufacturing energy through improvements in production technologies and promoting the production of energy efficient bricks[19] (supply side measures), and on the other hand, creating market demand for such manufactured bricks (demand-side measures).

The proposed strategy is dual-pronged. Firstly, it is proposed to develop a voluntary BEE accredited symbol/mark to convey the adoption of energy efficient manufacturing and develop the award process for "Energy Efficient Enterprise (E3)" symbol/mark to such manufacturers. Secondly,

[17]The largest is the iron and steel sub-sector (about 27 mtoe by 2031 and 45 mtoe by 2041)

[18]Assumption: 7 LED lights per household (20 W each and each used for 5 hours/day) and 4 Fans per household (50 W each and each used for 10 hours/day) i.e. a minimum connected load of 340 W per household.

[19]Energy efficient bricks are those bricks that have lower specific manufacturing energy, i.e. those bricks which are manufactured using energy efficient technologies and processes. Additionally, these bricks, because of low density, have better insulation properties and saves energy for the home buyer or end user in air conditioning.

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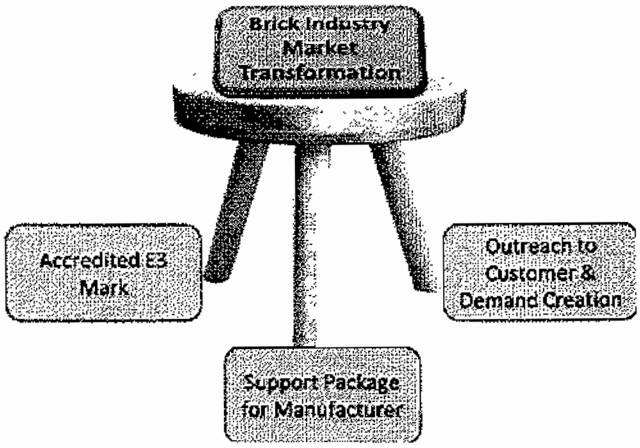
it is proposed to develop market demand (by E3 mark) in the eyes of the customer to source bricks from manufacturing units who manufacture energy efficiently.

The core of the strategy is depicted in Figure 5 below:

Figure 5: Proposed Strategy



The BEE accredited symbol shall be awarded to those brick manufacturers who meet the BEE proposed methodology to estimate the process SEC threshold[20]. The Manufacturer SEC is calculated based on deemed specific manufacturing energy for different production processes (MJ/kg) and the product density (kg/m^3). A manufacturer will be awarded "E3" mark if the weighted average specific manufacturing energy of the manufacturing plant is below a certain threshold value. To begin with, it is proposed that the threshold value should be kept at 25%[21] lower than the national baseline for specific manufacturing energy of clay bricks. This threshold shall be reviewed and revised every (say) two years.

The proposed supply side interventions are:

- Energy Efficient Enterprise (E3) Mark for manufacturers with energy efficient brick production
- Support package to manufacturers to facilitate a shift to E3 marked enterprises
  - Development of standard & affordable technology packages
  - Institutional capacity building and training
  - Catalysing green finance[22] (including for institutional customers as well)

[20]Refer Section 2.3 for the Deemed SEC approach and criteria.

[21]Threshold has been set to ensure that the E3 mark is aspirational for those undertaking upgradations to zigzag kilns; possibly with additional process / product modifications.

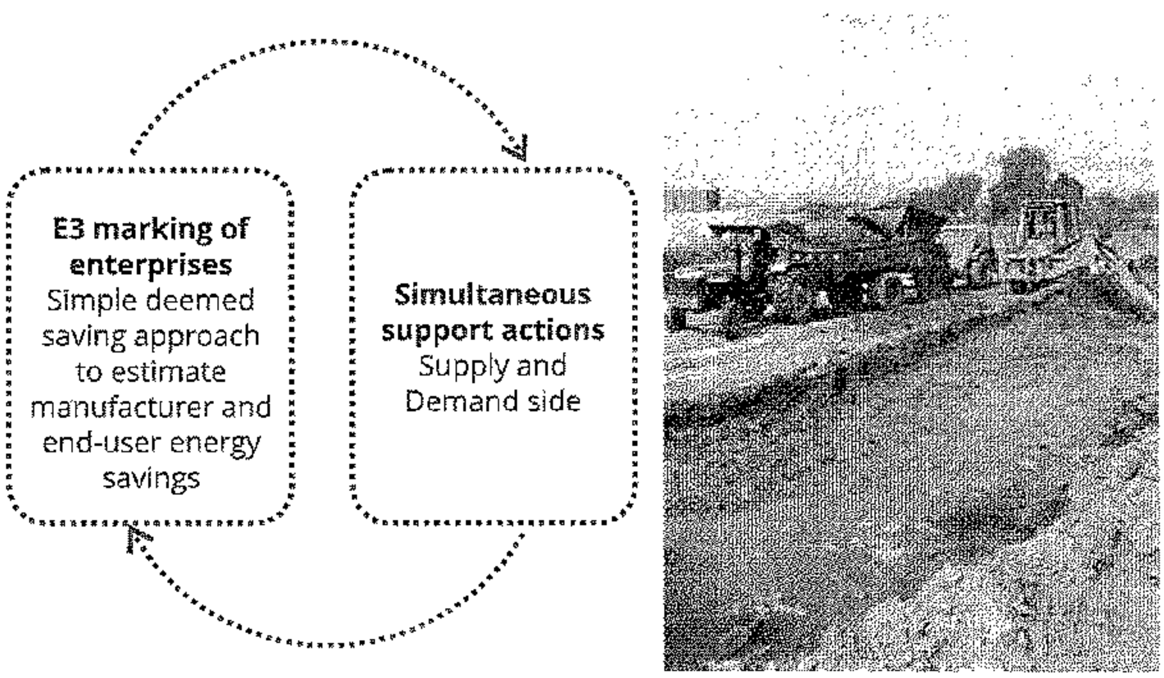
[22]Green finance refers to financial investments flowing into sustainable development projects and initiatives, environmental products, and policies that encourage the development of a more sustainable economy. Green finance includes climate finance but is not limited to it, as it could support a wider range of other environmental objectives, such as industrial pollution control, water sanitation or biodiversity protection. https://www.thegef.org/sites/default/files/events/Intro%20to%20Green%20Finance.pdf

The supply side interventions will be supplemented by simultaneous actions on the demand-side such as:

- Increasing demand of Energy Efficient bricks by large institutional players such as government or private builders.
- Launching a targeted outreach and communication campaign for builders, architects, and other demand influencers.

The deemed energy-saving approach proposed for estimating energy efficiency savings to manufacturer and end-user of the E3 bricks would be useful to mobilise green finance towards sector modernization and builders/ developers sourcing bricks from E3 marked manufacturers.

Figure 6: Proposed dual market strategy



The implementation of this proposed approach will require active involvement and concerted efforts of a wide range of stakeholders including various government ministries/departments. Therefore, to achieve the goal of this market transformation initiative, it is proposed to launch a "Brick Industry Mission" spearheaded by the Bureau of Energy Efficiency.

3.3 Concept of "Deemed Specific Manufacturing Energy"

Specific Manufacturing Energy

For this document, the Specific Manufacturing Energy of a brick product includes energy consumption in the manufacturing of bricks in the manufacturing plant i.e. within plant gates. The energy consumed in the mining of raw materials and transportation of raw materials and finished products is not included.

Figure 7 below shows the various stages and energy consumption involved in the entire production process of a brick product and the boundary considered for estimation of Specific Manufacturing Energy.

Figure 7: Specific Energy for Manufacturing boundary (Red dotted lines)

Energy Consumption in Mining of raw material → Energy Consumption Transportation of raw material → Energy Consumption in Manufacturing of Bricks → Energy Consumption in transportation of finished product

'Gate to Gate' manufacturer boundary: Includes energy used in brick forming, extrusion, drying, firing, plant & machinery but not the energy for mining of raw materials and transportation of finished product

Estimation of Deemed Specific Manufacturing Values (MJ/m³)

In the case of burnt clay products, the specific manufacturing energy includes fuel used in the kiln, fuel used in the drying of bricks, and electricity/diesel used in the operation of the brick manufacturing plant.

Specific manufacturing energy (MJ/m³) will depend upon two parameters:

(i) deemed specific manufacturing energy for different production processes (MJ/kg). It will depend upon the type of production process and the kiln technology being used for manufacturing of bricks. Deemed values for different production processes and kiln technology are provided in Table 3.

(ii) the product density (kg/m³). It will depend upon the type of brick product. The product density can be measured easily. There are standard processes for taking samples for measurement (IS 5454: 1976), and for measuring the density (ASTM C20 for bricks; and IS 2185 for blocks). The standards are common for both solid and perforated/ hollow bricks and blocks.

The deemed specific manufacturing energy (MJ/m3) for a brick product can be estimated by multiplication of the two parameters explained above.

It should be noted that for the estimation of specific manufacturing energy (MJ/m³), only the product density needs to be measured. For data on specific energy consumption in the manufacturing process, deemed values (as provided in Table 3) will be considered.

Indicative specific energy consumption in manufacturing[23] of burnt clay bricks for different production processes and kiln technologies are provided in Table 3.

[23] Indicative values based on data available through sample energy audits and plant data made available by individual manufacturers.

Table 3: Indicative specific energy consumption in manufacturing

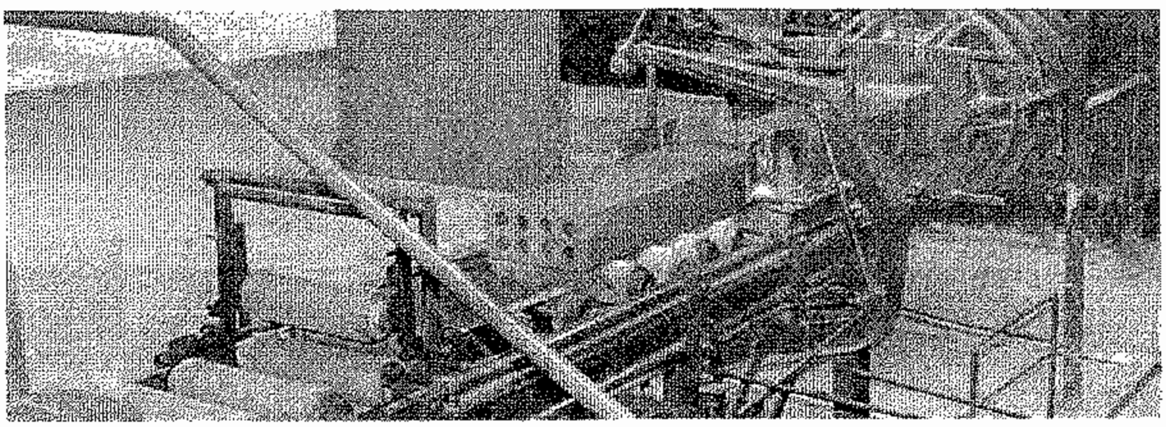
Production Process & Kiln Technology	Average Indicative Specific energy consumption in manufacturing (MJ/kg)
Mostly manual clay preparation and moulding; sun drying; Fired in clamp/downdraught kiln; Specific Energy Consumption 1.5 -2.5 MJ/kg	2.0
Mostly manual clay preparation and moulding; sun drying; Fired in FCBTK; Specific Energy Consumption of 1.1 -1.5 MJ/kg of fired brick	1.3
Mostly manual clay preparation and moulding; sun drying; Fired in Zigzag kiln; Specific Energy Consumption of 0.95 -1.30 MJ/kg;	1.125
Semi-mechanized clay preparation; extrusion/ soft mud moulding; shed/sun-drying; Fired in a Zigzag kiln. Specific Energy Consumption of 1.0-1.35 MJ/kg	1.175
Mechanized clay preparation, extrusion, followed by artificial drying; Fired in a Tunnel kiln. Specific Energy Consumption of around 1.6 MJ/kg of fired brick	1.6

Source: GKSPL, 2017: Roadmap for Resource Efficient Bricks. The data of specific manufacturing energy provided in the above table is based on monitoring of brick kilns done by various agencies like TERI, GKSPL, PSCST, etc. The data is available in the public domain in the form of reports, research papers and presentations.

The densities for some of the brick product samples are provided in Table 4[24].

Table 4: Indicative densities for some of the brick products

Type of brick product	Indicative density (kg/m³)
Solid burnt clay brick	1600
Perforated burnt clay brick (around 25% perforation)	1350
Hollow burnt clay block (around 60% perforation)	800



[24]These values are indicative and are provided for illustration purpose only. There can be variations in densities depending upon the type of clay and production process. The densities of brick products need to be measured while the estimation of specific manufacturing energy.

3.4 "Energy Efficient Enterprise (E3)" mark

International Experience - Energy based Industry Mark

Experience is available on energy-based mark certification for 15 industry sectors (brick industry is not one of them) from the Energy Star certification in USA and Canada.

The ENERGY STAR provides Energy Performance Indicators (EPIs) to benchmark industrial plant energy performance.

The EPIs are external, industry-specific benchmarking tools that score a plant's energy performance and compare it to that of similar plants in its industry within the U.S and Canada. EPIs are developed using annual plant energy (includes all fuels) and production data for a specific manufacturing industry.

Manufacturing plants with an EPI score of 75 or more can earn the ENERGY STAR certification and display the ENERGY STAR.

Source: https://www.energystar.gov/buildings/facility-owners-and-managers/industrial-plants/measure-track-and-benchmark/energy-star-energy

E3 mark shall be awarded to an enterprise based on specific manufacturing energy parameter.

The Specific Manufacturing Energy is calculated in MJ/m3, as the bricks are to be finally used for the construction of walls. Specific manufacturing energy will be computed based on deemed specific manufacturing energy for different production processes (MJ/kg) and the product density (kg/m^3).

A manufacturer will be awarded "E3" mark if the weighted average specific manufacturing energy of the manufacturing plant is below a certain threshold value.

It is proposed that this threshold value should be kept at 25% lower than the national baseline for the specific manufacturing energy of clay bricks.

This detailed explanation now follows.

Criteria for awarding "E3" Mark

Currently, the national baseline of specific manufacturing energy of burnt clay bricks and blocks is estimated to be around 2350 MJ/m^3. The threshold value for the award of "E3" mark is proposed to be kept at 1750 MJ/m^3 which is 25% lower than the current baseline[25].

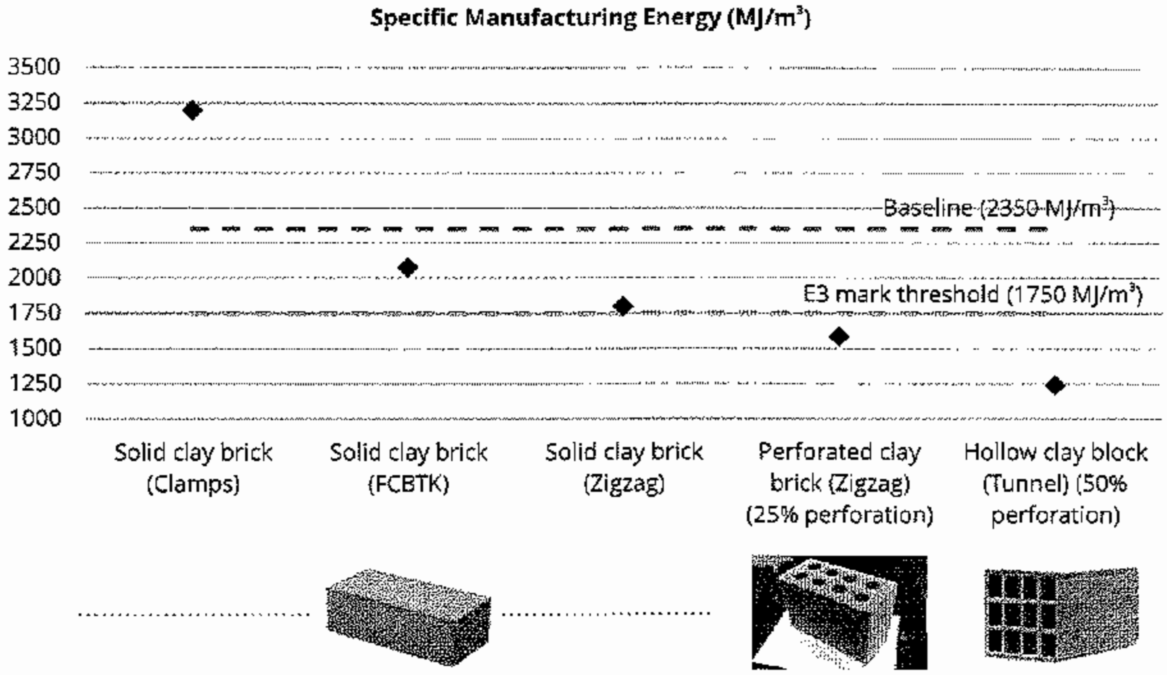
That means an enterprise will be awarded "E3" mark if the specific manufacturing energy of its manufacturing plant is lower than the threshold i.e. 1750 MJ/m^3. The methodology of estimation of baseline is provided in Annexure-II.

If an enterprise is manufacturing more than one product, then for the award of "E3" mark, the weighted average specific manufacturing energy of its entire product range should be less than the threshold.

The specific manufacturing energy for various products and the proposed threshold for E3 Mark is represented in Figure 8.

[25]It is proposed that the national baseline will be updated periodically every 2 years; thereby the threshold for the award of the E3 mark will also get updated regularly.

Figure 8: Specific Manufacturing Energy Baseline & E3 Mark Threshold for various products



MRV Methodology based on Deemed Specific Manufacturing Values

> It will not be required to do a complete energy audit of the manufacturing unit at the time of award of E3 mark or for estimation of energy savings.

The Measurement, Reporting and Verification (MRV) methodology for the award of "E3" mark will be based on deemed values of specific manufacturing energy of various manufacturing technologies and processes as specified in Table 3. The estimation of energy efficiency savings will also be based on the deemed values.

The detailed process for award of "E3" mark is explained in Annexure-I.

3.5 Thrust Areas

The objective of this initiative to promote Energy Efficiency in the manufacturing of Bricks, through comprehensive technology and product change.

The thrust areas under the initiative and their brief overview are discussed below. The detailed action plan for these thrust areas for the first year is provided in section 4.

Thrust Area-1: Development of Brick Industry Mission

Develop Brick Industry Mission in consultation with the key stakeholders, key government ministries and agencies and get their inputs and buy-in for the programme. The mission document will lay the guidelines for implementation of the initiative.

Thrust Area-2: Branding of manufacturers producing energy efficient bricks through "E3" mark

The E3 marking accreditation process is proposed to be established by a national agency viz. the BEE. This E3 marking will result in enhanced visibility of the brick manufacturing enterprise in the eyes of consumers looking for their products. A simple and robust process will be adopted for the award of E3 marking.

Thrust Area-3: Comprehensive support package to manufacturers to facilitate the shift to E3 enterprises

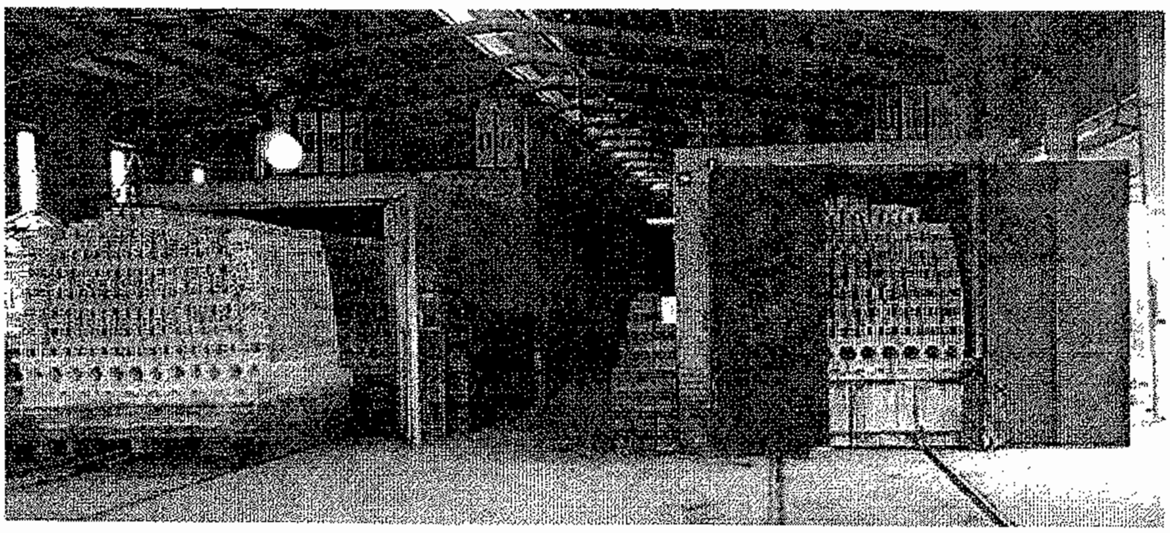
The key activities under this may include (inter-alia):

- Development of standard & affordable technology packages customised to Indian industry requirements
- Institutional capacity building and training
    - Deployment of simulation software to assist industry in plant design and operation
    - Knowledge exchange through exposure visit of Indian entrepreneurs to countries like China and Vietnam
    - Assistance in the creation of an ecosystem of technology providers, suppliers, test labs
- Catalysing green finance and incentive

Thrust Area-4: Creation of market demand for E3 mark sourced bricks

The key activities under this may include (inter-alia):

- Increasing demand for E3 mark sourced bricks by large institutional players through getting them included in the schedule of rates, developing standard procurement guidelines, and where possible through aggregated / bulk procurement
- Launching a communication and capacity building campaign targeted at builders, architects, contractors and home buyers for the uptake of E3 mark bricks.

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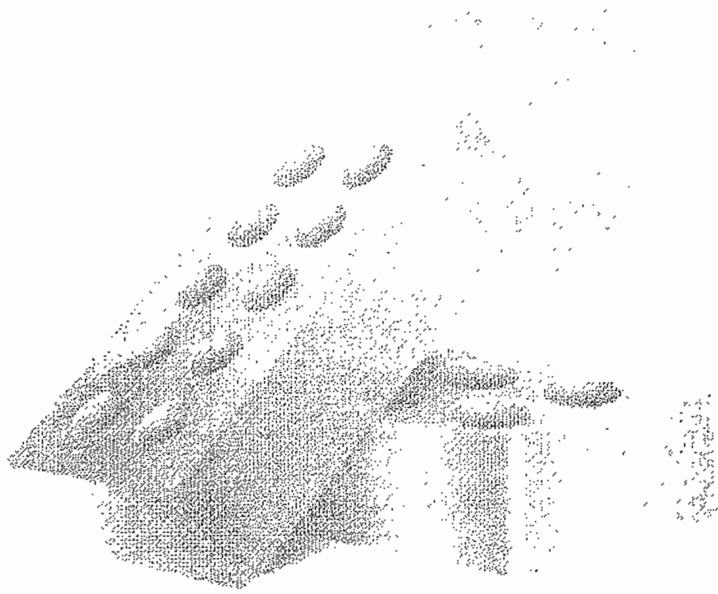


04 IMPLEMENTATION ARRANGEMENT

Openness brings progress while seclusion leads to backwardness

Xi Jinping

04 IMPLEMENTATION ARRANGEMENT

The initiative is proposed to be spearheaded by the BEE and implemented in two phases:

Phase-1: Initiation Phase

The initiation phase will be around 12-month duration. During this phase, the strategy will be implemented and tested in two selected regions. This phase will be focused upon establishing the mechanism for the award of E3 mark, developing the standard technology packages, developing communication and outreach materials targeted at various stakeholders such as manufacturers, consumers, financing agencies and relevant government stakeholders, and mobilization and exposure of the potential manufacturers, technology providers and key consumers. The institutional framework and the implementation procedures will also be established during this phase.

The potential regions for implementation during the initiation phase can be

1. Region-1: Bengaluru - Chennai - Coimbatore - Madurai (South India)
2. Region-2: Delhi NCR – Chandigarh - Varanasi (North India)

These locations are proposed for the pilot mainly because of the following reasons:

- Setting up a new E3 manufacturing plant would itself take around 2-3 years. At these proposed locations, the manufacturing capacity required to produce energy efficient bricks already exists. This will ensure the availability of energy efficient bricks in the market from the beginning and help in expediting the implementation and testing of the concept.
- There is also initial level awareness about the benefits of the use of energy efficient bricks among the users at these pilot locations.

The outcomes from this phase will be crucial to laying the foundation for scaling up implementation nationwide before undertaking the national launch of the Brick Industry Mission.

Phase-2: National Brick Industry Mission

The National Brick Industry Mission is proposed for the 4-year duration (say) 2020 till 2024. Under the mission, major clay brick manufacturing clusters in the country are expected to be covered. Detailed action plan for the National Brick Mission will be developed during the Initiation Phase.

4.1 Stakeholders, Roles and Responsibilities

Table 5: Stakeholders, Roles and Responsibilities

S. No.	Stakeholder	Role	Responsibilities
1	Bureau of Energy Efficiency	– Ownership of the programme and overall supervision of its implementation.	– Develop and own the National Brick Mission – Establishing mechanism for E3 enterprise marking, ensuring its credibility, and empanelment of relevant agencies for this purpose – Up-dation of baseline & threshold for E3 mark – Keep data on pilots/ dashboard updated – Advertisement, communication and outreach – Convening of Stakeholder Consultations
2	Government ministries/ departments/ agencies in the building sector & environment (MoHUA, MoEFCC, BMTPC, CPWD, PWD, NBCC, TCPO, BIS etc.)	– Promote EE bricks through adoption and regulation and help in market creation.	– Utilisation of E3 mark sourced bricks in construction projects supported/ implemented by them – Facilitate modifications in building and environment regulations/ incentives to incorporate E3 sourced bricks – Integration of E3 bricks in the Pradhan Mantri Awas Yojana
3	GIZ	– Assist BEE in the implementation of the programme.	– Coordinate implementation with the Technical Support Agency – Provide strategic advice and technical support to BEE – Any other in consultation with the BEE
4	Empanelled/ Accredited Agencies for awarding E3 mark	– E3 mark to manufacturers	– To analyse and validate information received from manufacturers and recommend the award of E3 mark following BEE laid down criteria and process
5	Green Financing Agencies (IFC, KfW, etc.) and MSME focussed banks (RBL, Yes Bank, Bandhan Bank, etc)	– Make green finance available for E3 manufacturers (and institutional builders)	– To recognise the E3 mark for gaining eligibility for green finance – To develop specific financing products

S. No.	Stakeholder	Role	Responsibilities
6	Brick producers and their associations	– Shift toward E3 enterprises	– Motivate members to adopt E3 mark
7	Builders and their associations (CREDAI, NAREDCO, etc)	– Help in creation of the market for energy efficient bricks	– To use energy efficient bricks in their projects and procure from E3 enterprises
8	Homebuyers	– Create demand	– To demand construction made from E3 marked bricks for better energy and environmental performance during ownership.
9	Local Facilitators (e.g.: Smart city, CREDAI and IIA local chapters, urban local bodies, etc.)	– Facilitate demand creation for energy efficient bricks	– As local demand influencers expected to aid in demand creation for energy efficient bricks

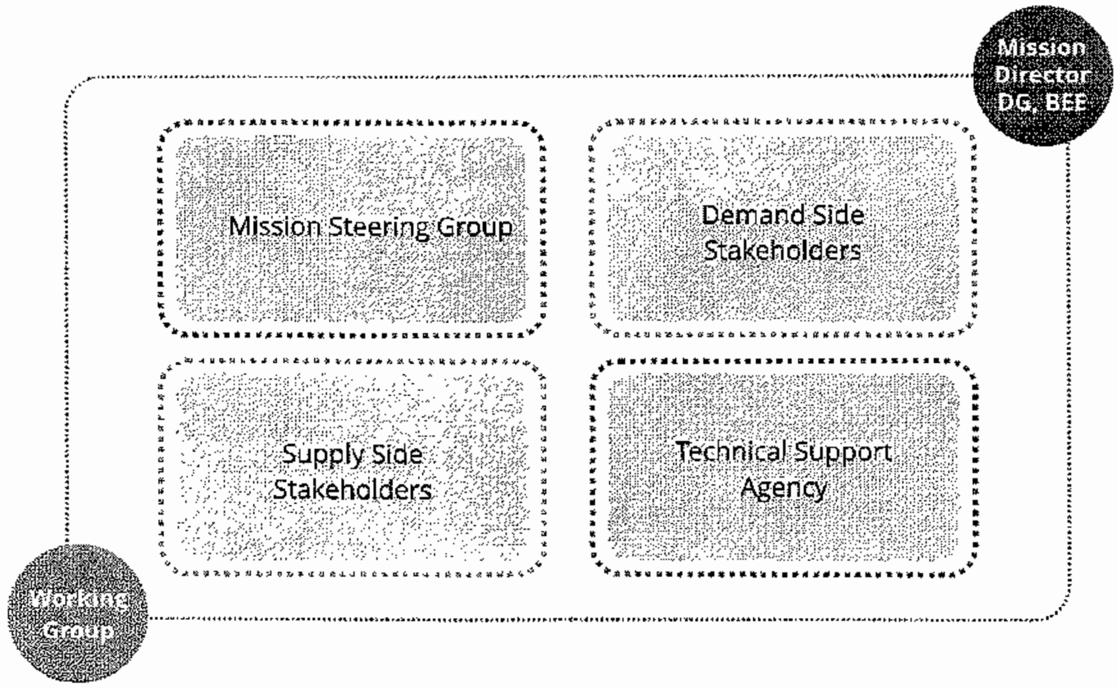
A Technical Support Agency (TSA) will be engaged to provide technical support to BEE during the implementation of the programme. Suggested scope of work for the TSA are provided in Annexure-IV.

4.2 Institutional framework for implementation

The initiation phase will be mainly implemented by the BEE. The relevant government ministries or agencies such as Ministry of Environment Forest and Climate Change (MoEFCC), Ministry of Housing and Urban Affairs (MoHUA), Building Materials and Technology Promotion Council (BMTPC) will be important partners in the proposed initiative. These stakeholders will be engaged during initiation phase and will be part of the Mission Steering Group for implementation of the National Brick Mission. To facilitate communication with these key stakeholders and get their buy-in for the programme, a policy maker's meet will be organised at the beginning of the Initiation phase.

The institutional arrangement for the implementation of the National Brick Mission is presented in Figure 9.

Figure 9: Institutional Map under the Mission

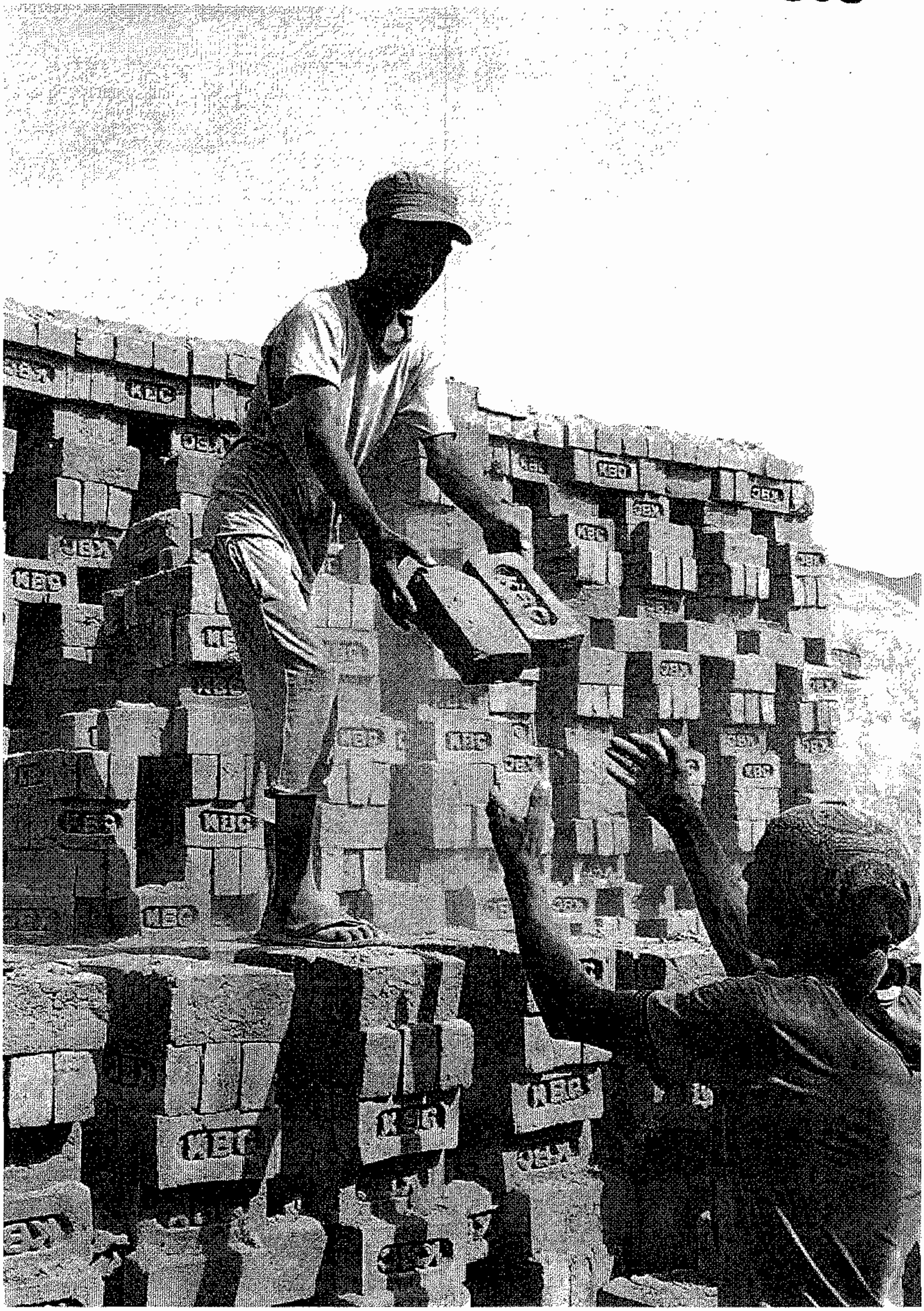


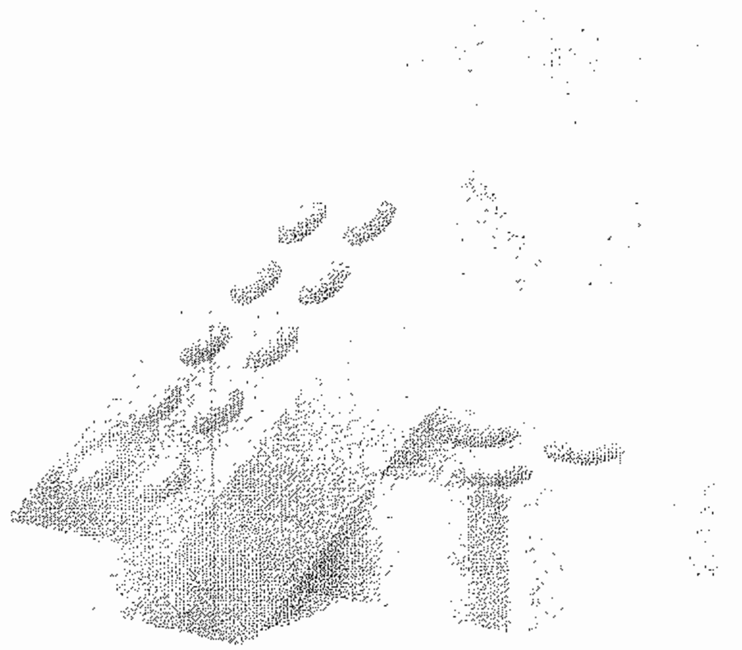
Mission Steering Group (MSG)

- Apex committee to review / guide all tasks
- ~10-15 member: MoP, BEE, GIZ, CPWD, EESL, Association (Brick, Builder), MoEF, MoUD, MSME, CPCB, BMPTC, SDAs, Smart Cities, CSE, Financiers etc

Mission Steering Group (MSG)

- Guide and Review tasks document development and Review Stakeholder inputs related toMission development
- Mission development
- Pilot thrust areas (SEC baseline data, Procurement guidelines, Technology modules, Accreditation Process, Symbol, Agreements etc)
- ~10 Multi-institutional membership: BEE,GIZ, Brick manufacturer, Builder, PWD, SDA, Technology, Financers, SPCB, ULB, CEPT etc.





05 ACTION PLAN FOR INITIATION PHASE

"Genius is in the idea. Impact, however, comes from action"

Simon Sinek

05 ACTION PLAN FOR INITIATION PHASE

The activities planned to be undertaken under different thrust areas under the initiation phase and the action plan are discussed below. As a first step, a Technical Support Agency (TSA) will be hired to support in the implementation of the initiation phase, and the two regions for the pilot will be finalised.

Activity-0: Hiring of Technical Support Agency & Finalization of the two regions for implementation of Initiation Phase (Month 0)

A Technical Support Agency (TSA) is proposed to provide technical and implementation support to BEE (refer Annexure-IV). The two regions will be finalized for implementation of the initiation phase and testing of the strategy.

Primary responsibility: GIZ & BEE

Indicator: TSA hired, and Two pilot locations finalized

Timeline: Month 0

5.1 Thrust Area-1: Development of Brick Industry Mission

Key Activities & Responsibilities:

1. Organization of Policy Maker's Meet (Month 1)

   To initiate communication with the key government ministries and agencies and get their inputs and buy-in for the programme, a policy maker's meet will be organized at the beginning of the Initiation phase. These along with other stakeholders shall be invited to be part of the mission steering group for implementation of the National Brick Industry Mission.

   Responsibility: TSA with support from GIZ & BEE

2. Preparation of draft National Brick Industry Mission Document (Month 1-3)

   The draft National Brick Mission document will be prepared. The inputs received from the policy makers meet and other stakeholder consultations organized under other thrust areas will also be incorporated in the mission document.

   Responsibility: TSA

3. Stakeholder consultation on the draft National Brick Industry Mission Document (Month 4)

   A consultation will be organized to gather inputs and suggestions from the stakeholders on the draft brick mission document.

   Responsibility: TSA with support from GIZ & BEE

4. Final National Brick Industry Mission Document (Month 4-6)

   Based on the inputs, the National Brick Industry Mission document will be finalized. The Brick Mission Operational Plan (maybe in the form of an annexure to the mission document or as a separate document) will also be prepared. The learnings and impacts gained from implementation of the initiation phase will also be incorporated in the brick mission document.

   Responsibility: TSA

Performance Indicators and Timeline:

Performance Indicator	Timeline						
	M1	M2	M3	M4	M5	M6	M 7-12
Draft national brick industry mission document							
Stakeholder consultation							
Final brick mission document and Operational plan							

5.2 Thrust Area-2: E3 Mark to energy-efficient brick manufacturers

Key Activities & Responsibilities:

1. Preparation of tender documents for empanelment of agencies who shall award the E3 mark (Month 1)

   BEE to empanel agencies via an Open Tender Process wherein two or more agencies are identified to offer the E3 mark in pilot regions. TSA shall prepare a tender document to empanel agencies who shall award the E3 mark.

   Responsibility: TSA in consultation with GIZ & BEE

2. Development of the process for award of E3 Mark (Month 1)

   TSA will prepare a document detailing the process to be followed for awarding E3 mark to manufacturing enterprises. This will include application formats, application review and data verification process, guidelines for the use of the E3 mark, design of E3 mark, etc. The document will be reviewed and approved by BEE.

   Responsibility: TSA in consultation with GIZ & BEE

3. Empanelment of agencies for the award of E3 mark to manufacturers (Month 1-3)

   BEE to empanel agencies via an Open Tender Process wherein two or more agencies are identified to offer the E3 mark in pilot regions. The potential labelling agencies include green building rating agencies (e.g. GRIHA, GBCI, IGBC, etc.), Industry facing bodies (NPC, CII, FICCI, PHDCCI, etc.) as well as inspection testing and certification bodies (e.g. TUV, UL, etc.). TSA would provide technical assistance in evaluating the applications for empanelment.

   Responsibility: BEE with support from TSA & GIZ

4. Finalization of the baseline deemed MRV protocol and the E3 marking scheme (Month 2)

   Specify (deemed) manufacturing energy values for different types of brick products and production processes, lay down national baseline of specific manufacturing energy (refer Annexure 1) and establish E3 mark award process. One review roundtable will be organized in each of the two regions, involving selected representatives of brick producers, brick buyers and local government. The baseline, E3 enterprise marking scheme and MRV protocol based on deemed values will be presented and finalized.

   Responsibility: TSA with support from GIZ & BEE

5. Launch Event/ Stakeholder Workshop – I (Month 3)

   A launch event or stakeholder workshop (proposed in Delhi) will be organised in which the initiation phase of the brick market transformation initiative will be launched. The event will bring together all concerned ministries, departments, national builders and brick industry associations, technology providers, labelling agencies, etc. TSA will assist BEE and GIZ in designing and organising the launch event.

   Responsibility: GIZ & BEE with support from TSA

6. Communication and Outreach with manufacturers (Month 3-6)

   The communication and outreach materials will be developed to enable outreach to the manufacturers and encourage them to upgrade towards E3 marked enterprise. The associations of manufacturers will also be engaged.

   Responsibility: TSA in consultation with GIZ & BEE

7. Process of E3 marking of manufacturers (Month 4-12)

   The TSA, empanelled labelling agency and local facilitators (e.g. SDA) will mobilise the brick manufacturers to shift to E3 enterprises and apply for E3 Mark. For a conventional brick manufacturing enterprise, it may take around 1-3 years to upgrade to E3 enterprise. Therefore, in the beginning, the enterprises already manufacturing energy efficient bricks will be mobilised for E3 marking. The gain the E3 mark, the E3 enterprises will sign an agreement or MoU with BEE ensuring production and supply of energy efficient bricks in certain minimum production quantity. This activity will start in month 4 and will be continued through the entire duration of the initiation phase. However, by the end of month 6, there should be at least one signed agreement (like Memorandum of Understanding (MoU)) with one E3 mark manufacturer and one User.

   Responsibility: TSA and Empanelled Agency with support from GIZ & BEE

8. Dashboard (Month 3-6)

   A dashboard linked to the BEE website will be created. It will give key data on the programme (energy efficient brick sales, deemed energy savings, CO2 reductions, etc). It will provide information on energy efficient bricks, host digital formats for brick manufacturers to apply for E3 marking, and will have a map showing updated geotagged locations of the E3 manufacturing locations.

   Responsibility: TSA with support from GIZ & BEE

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Performance Indicators and Timeline:

Performance Indicator	Timeline						
	M1	M2	M3	M4	M5	M6	M 7-12
Tender document for empanelment of labelling agencies	■						
Documents on E3 mark award process, application formats, application review and data verification process, and guidelines for the use of mark	■						
Design of E3 mark/logo			■				
Empanelment of at least one agency for the award of E3 mark			■				
Roundtable in two pilot locations to finalize the baseline, deemed MRV protocol and the E3 marking scheme		■					
E3 marking scheme launch event/ Stakeholder workshop-I		■					
Communication and outreach materials targeted at manufacturers developed			■			■	
At least one manufacturer with E3 Mark and MoU with BEE			■			■	
Dashboard linked to BEE website						■	

5.3 Thrust Area-3: Comprehensive support package to manufacturers to facilitate the shift to E3 enterprises

Key Activities & Responsibilities:

1. Development of standard & affordable technology packages customized to Indian industry requirements (Month 6-12)

   TSA with support of BEE shall consult select manufacturers (India) and technology providers (India & abroad) to develop affordable technology package(s) as per Indian requirements. There may be 2-3 technology packages depending upon the desired product mix and production capacities (e.g. 100 ton per day, 200 ton per day, etc.).

   Responsibility: TSA with support from GIZ & BEE

2. Institutional capacity building and training (Month 6-12)

   A supportive ecosystem involving technology providers, test labs, technical services and other professional bodies to assist the manufacturing industry in this transformation. TSA with support of BEE shall mobilize potential test labs, technology providers and other professional bodies to create this support ecosystem. TSA will identify training and capacity building needs of these bodies and will develop training modules and arrange for their training. Expert agencies from other countries (e.g. TCKI, Netherlands) will be engaged to impart training to the Indian professionals. TSA may also identify appropriate simulation software for plant design and operation and assist the industry in its use.

Responsibility: TSA with support from GIZ & BEE

3. Exposure visit of brick manufacturers, builders and policymakers to China (Month 5-6)

   The clay brick industry of China has progressed substantially towards production and use of resource-efficient bricks over past the 30 years. An exposure visit to China will help in gaining understanding and learnings from their initiatives and it will also motivate the manufacturers for the transition. An exposure visit, of a delegation of key E3 manufacturers and E3 user builders along with BEE and GIZ, over a week time would serve to showcase learnings of manufacturing best practice, technology R&D institution, diversity of building application types etc.

   Responsibility: TSA with support from GIZ & BEE

4. Engaging Green Financing Institutions (Month 6-12)

   A pro-active engagement will be carried out with the International green financing institutions (kFW, IFC, etc), national financing institutions (SIDBI, etc.) and MSME focussed banks and NBFCs (RBL bank, Bandhan bank, Yes bank, etc.) to get them interested in the programme and offer financing to brick manufacturer who are upgrading to E3 enterprises.

   Responsibility: TSA with support from GIZ & BEE

Performance Indicators and Timeline:

Performance Indicator	Timeline						
	M1	M2	M3	M4	M5	M6	M 7-12
Standard technology packages developed							
Training program for potential test labs, technology providers and other professional bodies on plant design, operation, maintenance, and raw material and product testing such as making use of simulation software, International expertise							
Exposure visit of brick manufacturers, builders and policy makers to China							
Financing of at least one manufacturer for upgradation to E3 enterprise							

5.4 Thrust Area-4: Creation of market demand for E3 mark sourced bricks

Key Activities & Responsibilities:

1. Launching a communication and outreach campaign targeted at builders, architects, contractors and home buyers for uptake of E3 mark bricks (Month 4-12)

   Communication and outreach materials will be developed for consumers focusing on the benefits of using energy efficient bricks. The energy efficient bricks from the E3 enterprises are likely to become available in the market by the 5th month. It is proposed that one roundtable in each pilot location will be organized, to mobilize the targeted consumers to source bricks from E3 enterprises. Apart from key builders, market for E3 brick manufacturers will also be developed among individuals constructing their own houses and small builders. The potential consumers will be encouraged to sign an agreement or MoU with the E3 brick manufacturing enterprises or BEE for sourcing bricks for use in their projects. This activity will start in month 4 and will be continued through the entire duration of initiation phase. However, by the end of month 6, there should be at least one signed agreement/ MoU. Promotional activities may include, organisation of events for consumers, participation in exhibitions and multimedia advertisements will also be supported under this initiative.

   Responsibility: TSA in consultation with GIZ & BEE

2. Increasing demand for Energy Efficient bricks by large institutional players through getting them included in the schedule of rates, developing standard procurement guidelines, and where possible through aggregated / bulk procurement (Month 4-12)

   Model procurement guidelines will be prepared to aid builders/aggregators in the procurement of energy efficient bricks. TSA will also provide technical support for the inclusion of energy efficient bricks in the schedule of rates of the local government/PWD.

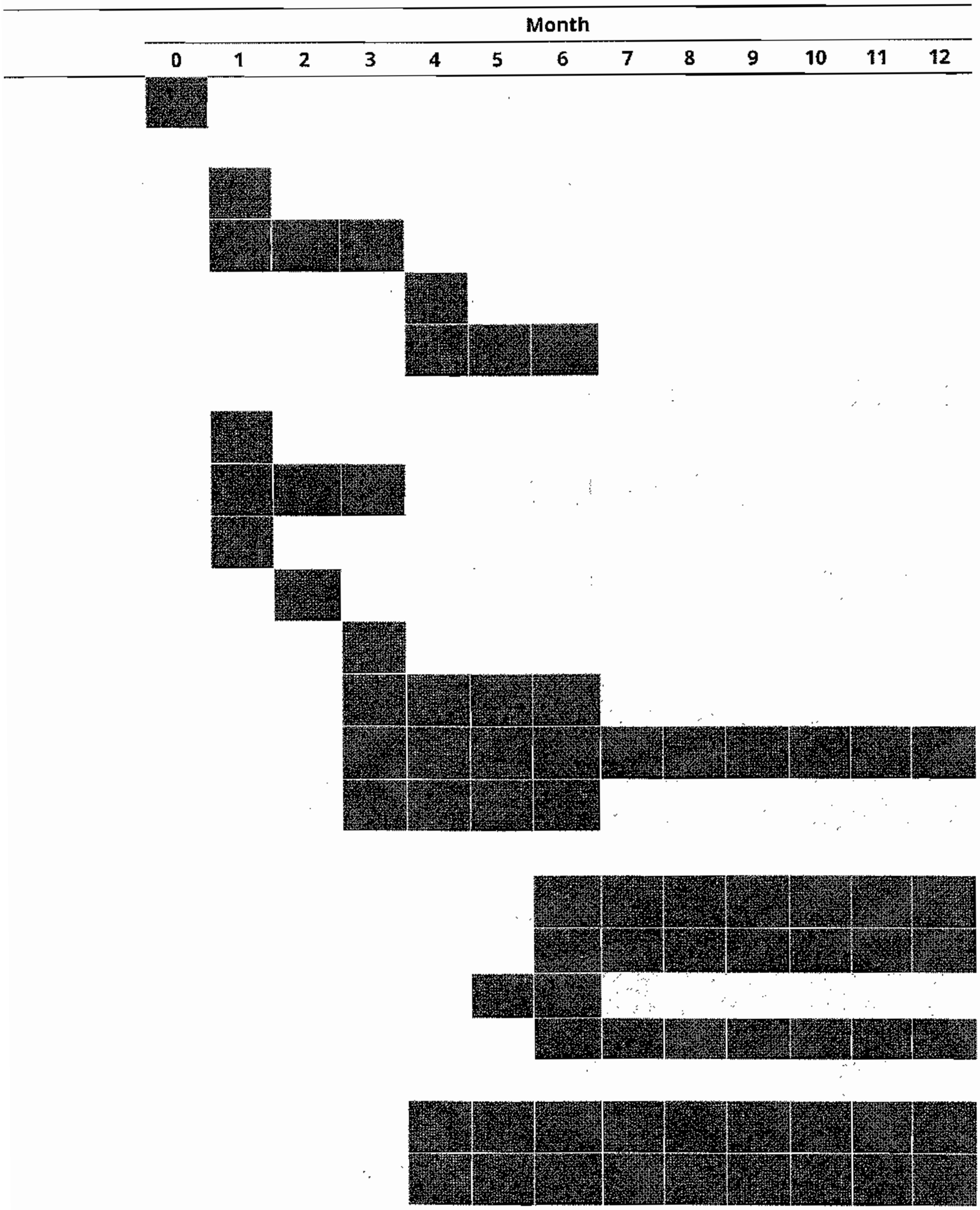
   Responsibility: TSA in consultation with GIZ & BEE

Performance Indicators and Timeline:

Performance Indicator	Timeline						
	M1	M2	M3	M4	M5	M6	M 7-12
Communication and outreach materials targeted at consumers developed							
At least MoU/agreement with one consumer for use of E3 Mark bricks							
Procurement guidelines for E3 bricks developed							
Inclusion of E3 bricks in SoR in pilot regions							

Table 6: Work-Plan for the Initiation Phase

Activities	Primary Responsibility
Hiring of Technical Support Agency	BEE, GIZ
Thrust Area-1:	
Policy Maker's Meet	BEE, GIZ, TSA
Draft national brick mission document	TSA
Stakeholder consultation of draft brick mission	TSA
Finalization of national brick mission and operational plan	TSA
Thrust Area-2:	
Tender document for empanelment of E3 marking agency	TSA, GIZ, BEE
Empanelment of E3 marking Agencies	BEE, GIZ
Development of process of award of label	TSA, GIZ, BEE
Finalisation of baseline, deemed MRV, E3 marking scheme	TSA, GIZ, BEE
Launch event E3 marking scheme (Stakeholder Workshop -I)	BEE, GIZ, TSA
Communication and Outreach with manufacturers	TSA, BEE, GIZ
E3 marking of manufacturers	Empaneled Agencies
Dashboard	TSA
Thrust Area-3:	
Development of standard technology packages	TSA
Institutional capacity building and training	TSA
Exposure visit to China	TSA, BEE, GIZ
Engaging Green Financing Institutions	BEE, GIZ, TSA
Thrust Area-4:	
Communication and outreach campaign with builders and demand influencers	TSA, BEE, GIZ
Procurement guidelines, Inclusion in SoR and other demand creation activities	TSA, BEE, GIZ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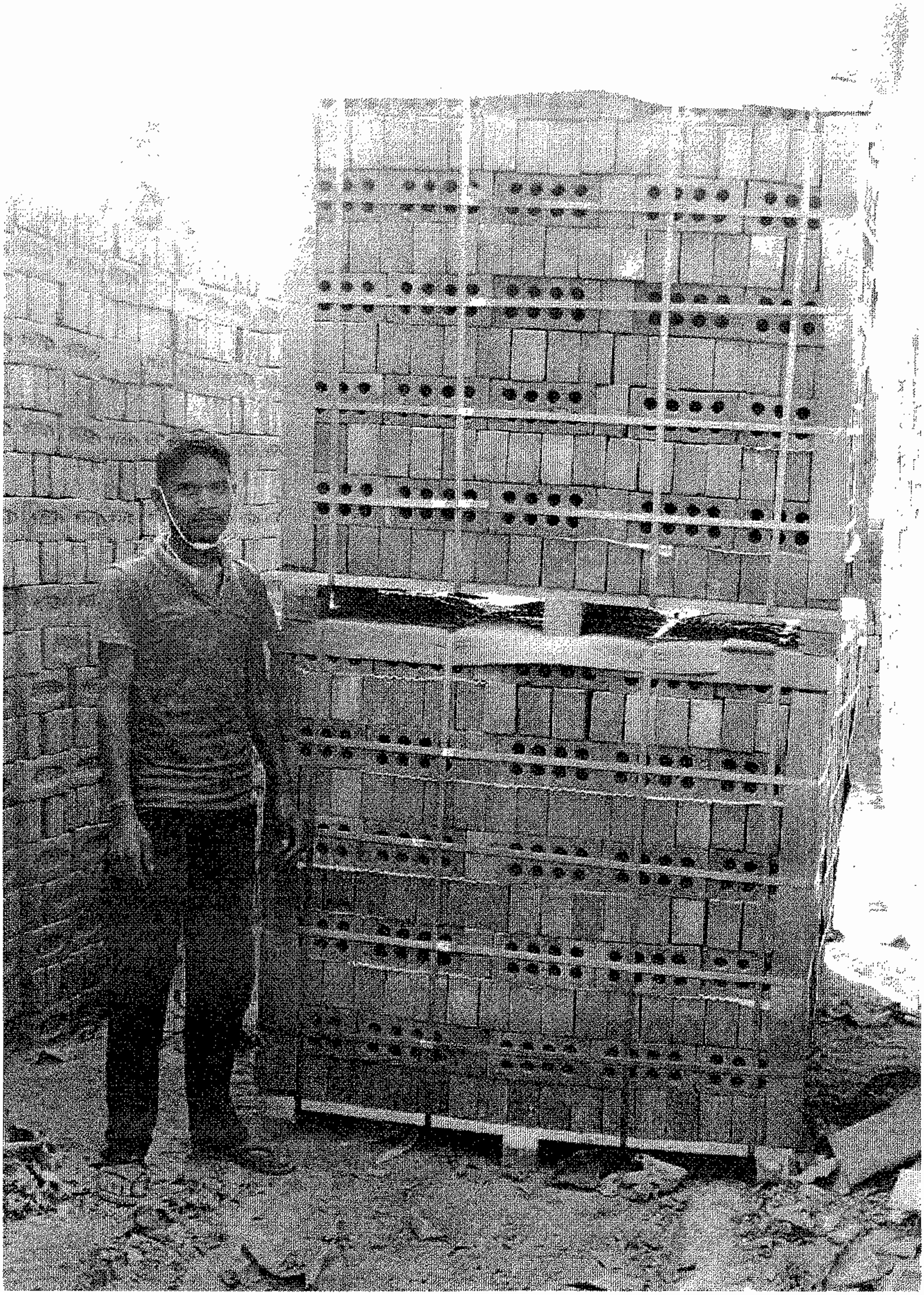
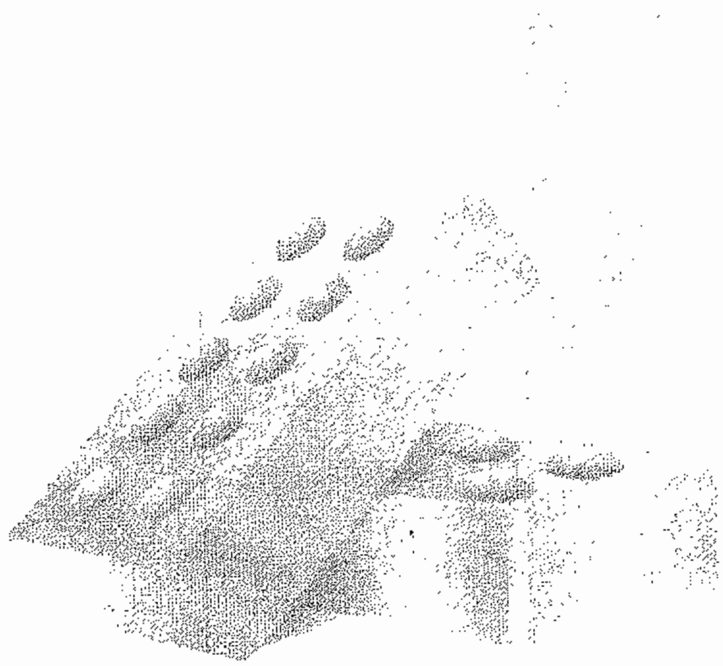




06 IMPACTS

Small gestures can have a big impact. Create where it matters.

Anonymous

06 IMPACTS

6.1 Energy savings and GHG avoided as compared to BAU

The savings in energy consumption and reduction in GHG emission as compared to the BAU scenario are plotted below:

Figure 10: Energy savings as compared to BAU[26]

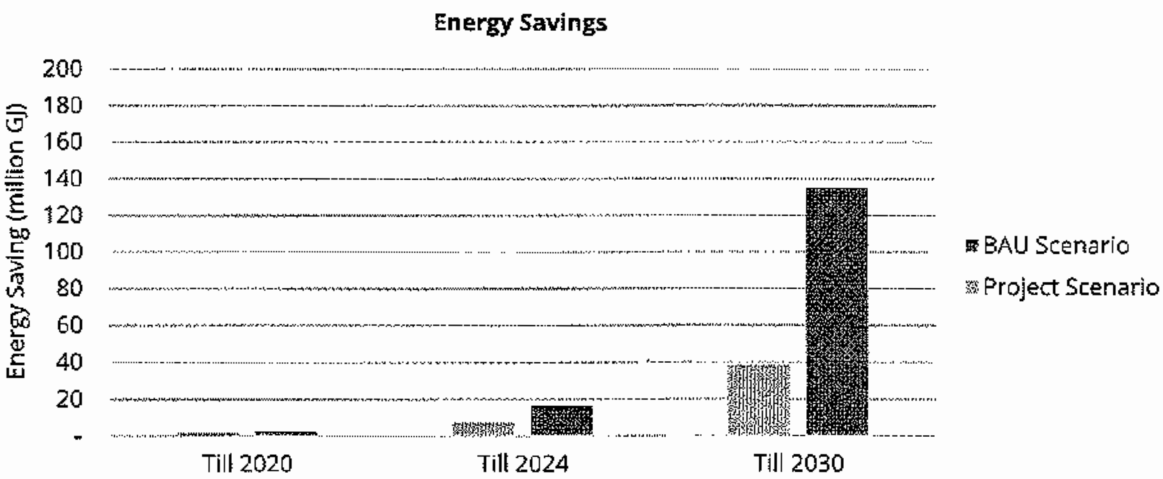
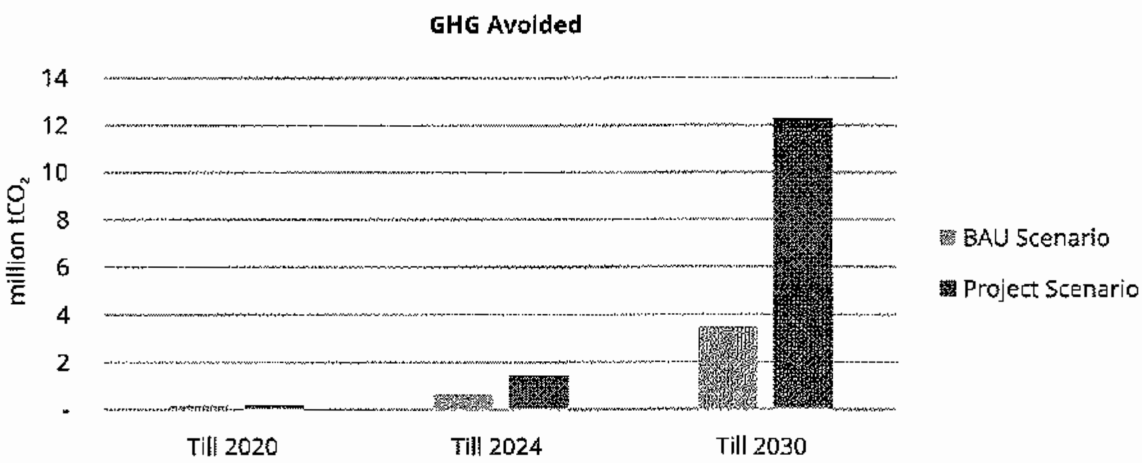


Figure 11: GHG avoided as compared to BAU



6.2 Benefits along the value chain

The savings in energy consumption and reduction in GHG emission as compared to the BAU scenario are plotted below:

Table 7: Estimated built-up area constructed using E3 bricks in BAU and Project scenario

Time line	Total built-up area constructed using E3 mark sourced bricks (million m²)	
	BAU	Project Scenario
2019-20 (1 year)	1	1
2020-24 (4 years)	13	35
2024-30 (6 years)	50	205

Brick manufacturing is the second highest coal consumer after steel industry in India. Around 2% coal is imported, the rest being sourced domestically.

Official statistics club coal consumption in brick sector under 'Others', as brick units largely purchase through local intermediaries or spot markets.

The sector accounts for nearly 5% of raw coal consumption in India (30-35 million tonnes per annum). Of this around 10-15% is imported coal (e.g. USA, Indonesia). This consumption is more than Cement, Paper, Textile, Sponge Iron, fertilizer & Chemicals put together!

The choice of coal depends on landed coal price and local availability, for example kilns in Punjab, South India (with no local mines) may choose imported coal over domestic coals, whereas those in Bihar will not

Despite price sensitivity, brick units pay nearly 3 to 4 times (Rs 6000 – 11000 per tonne coal) when compared to power plants. The Calorific value of coal used ranges from 4000-6000 kcal per kg

Fuels with high Sulphur content (2-4%), and lower costs per calorie, may also be used (Pet Coke) etc.

Source http://www.mospi.gov.in/sites/default/files/publication_reports/Energy%20Statistics%202019-finall.pdf

In addition to saving energy during brick production, the BEE initiative of transitioning towards E3 marked enterprises will carry benefits for all stakeholders along the value chain. The E3 sourced clay products (perforated and hollow clay blocks) would have lower densities, consume less clay in manufacturing, have lower thermal conductivity values, and would enable production of larger sized bricks. These attributes bring-in several benefits as highlighted below:

Brick Manufacturer:

- Reduction in fuel consumption and clay consumption, and hence in production cost
- Reduction in transaction costs associated with technology selection due to standardized technology packages and know-how

Builders/Consumers:

- Reduction in building construction cost
  - o Lower structural cost because of lighter products
  - o Reduction in cost of labour and mortar because of larger size format

Homeowner:

- Reduction in electricity bills (where building is air-conditioned) or improvement in thermal comfort because of lower thermal conductivities.

Country-level:

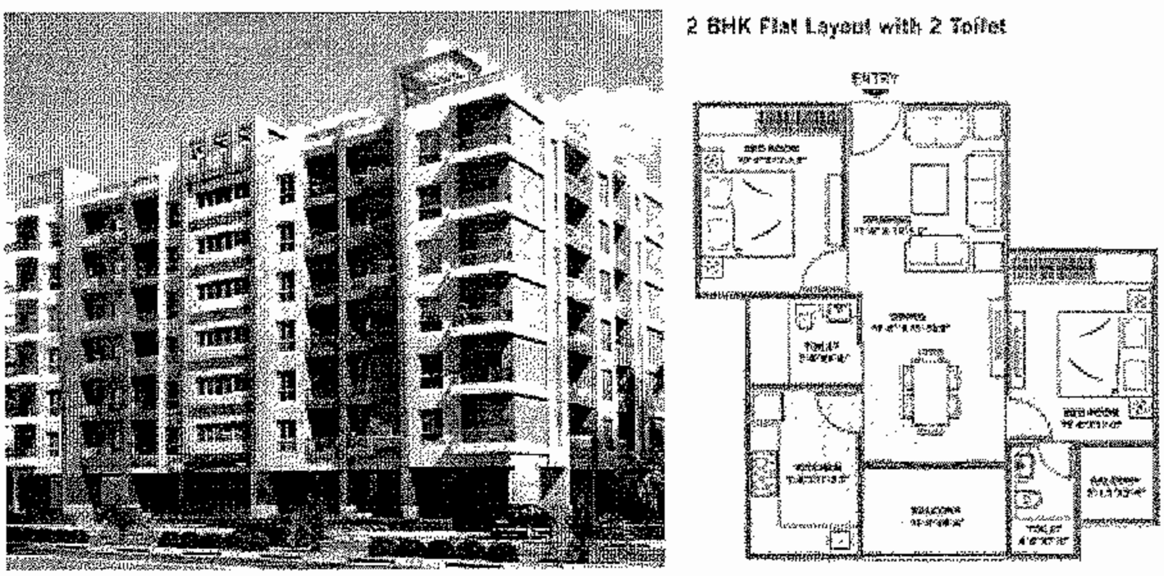
- Creation/ preservation of jobs
- Reduction in resource use (fuel and clay) in brick manufacturing. Perforated and hollow products allow for the use of clays other than topsoil, which can be preserved.
- Reduction in operational energy of buildings and electricity consumption
- Reduction in GHG emission associated with brick manufacturing as well as building operation.

6.2.1 Case Example: Estimated benefits for a sample residential building

To estimate the benefits, an example of a residential building tower as below is considered:

No. of storey	= 7
No. of flats per storey	= 8
Type of flats	= 2 BHK (100 m² size each, ~ 1080 sq ft)
Total no. of flats in the tower	= 56
Baseline	Construction of walls using solid burnt clay bricks
Project case	Construction of walls using hollow burnt clay blocks

Figure 12: A sample residential tower and flat layout (for representation purpose only)



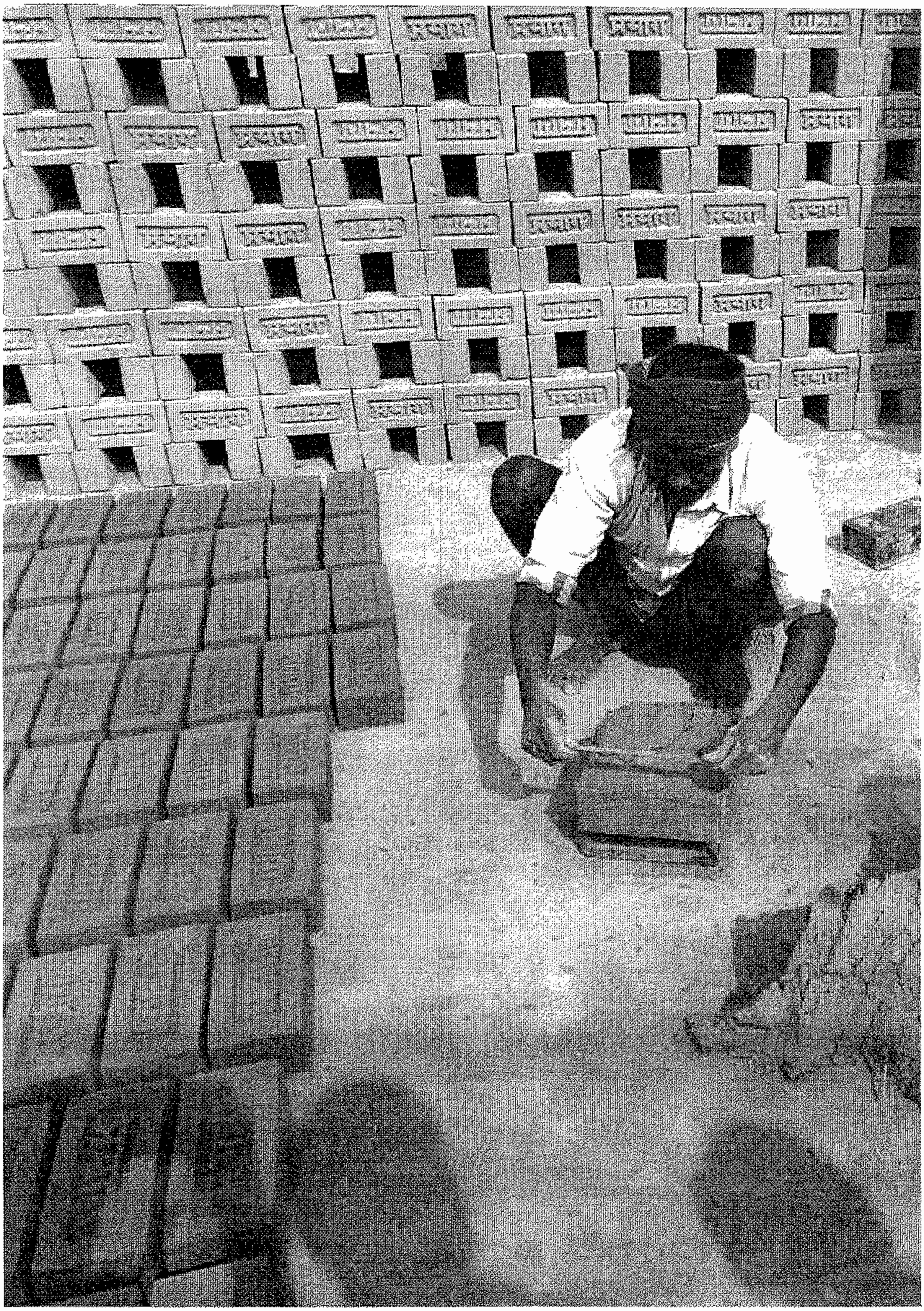
The estimated benefits for various stakeholders along the value chain is provided in Table 8 below:

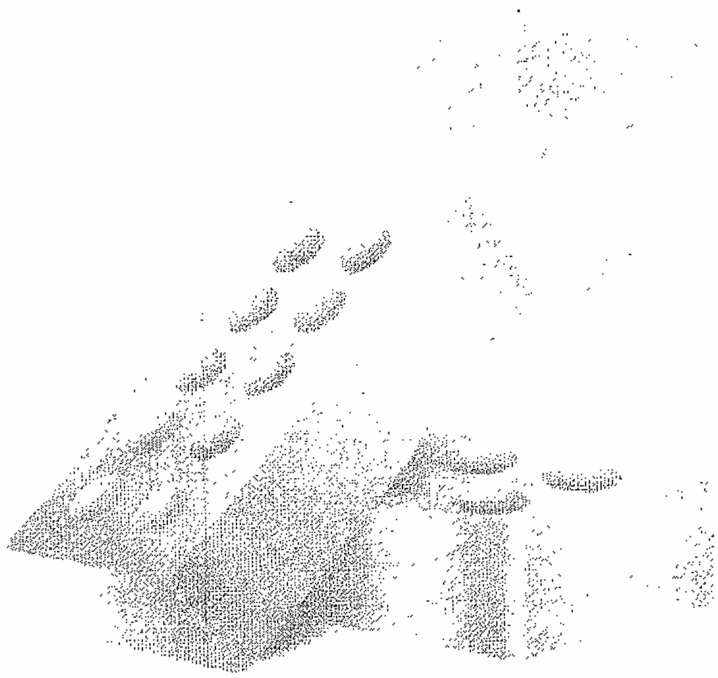
Table 8: Estimated benefits along the value chain

Parameter	Apartment level (100 m²)	Tower level (8x7=56 flats)	Primary Beneficiary
Savings in manufacturing energy (MJ)	43,050	24,10,800	Manufacturer
Savings in electricity consumption (kWh/ year)	1,246	69,776	Homeowner
Reduction in weight of building walls (ton)	37	2,100	Builder
Reduction in overall construction cost (% of total construction cost of building)[27]		1% - 1.5%	Builder
Net savings in energy (ton of Coal eq.)	29	1,614	Country
GHG avoided (tCO^2)	55	3,056	Country
Additional Benefits			
40%-70% reduction in raw material (clay and fuel) consumption. Reduction / elimination in use of topsoil in brick making.			Country
Significant reduction in air pollution during manufacturing of bricks			Country

The deemed savings methodology for estimation of (deemed) energy savings based for this case example is provided in Annexure-III.

[27]With use of hollow clay blocks instead of solid clay bricks, there is an estimated saving of Rs 15-25 per square feet in the construction cost of the building mainly because of (i) reduction in load of building and hence reduced steel consumption, (ii) reduction in mortar consumption and (iii) faster construction reducing the labour cost. Reference: Excerpts of the talk given by Mr Siddhant Sivaraman of Living Walls, in the awareness workshop for architects on resource-efficient bricks organised at Bengaluru on 04 December 2015 under UNDP-GEF-MoEFCC project on" Energy Efficiency Improvements in Indian Brick Industry".





07 BUDGET

too much attention is paid to the cost of doing something. One should worry more about the cost of not doing it.

Philip Kotler

07 BUDGET

The proposed market transformation strategy advocating the design and dissemination of the E3 mark would require consistent collaborative work on the part of the BEE and its affiliates to ensure the on-going integrity of the E3 mark with brick manufacturers and brick customers.

Apart from investing to support the technical development and maintenance of the E3 mark, significant support would be required to generate customer awareness for E3 mark.

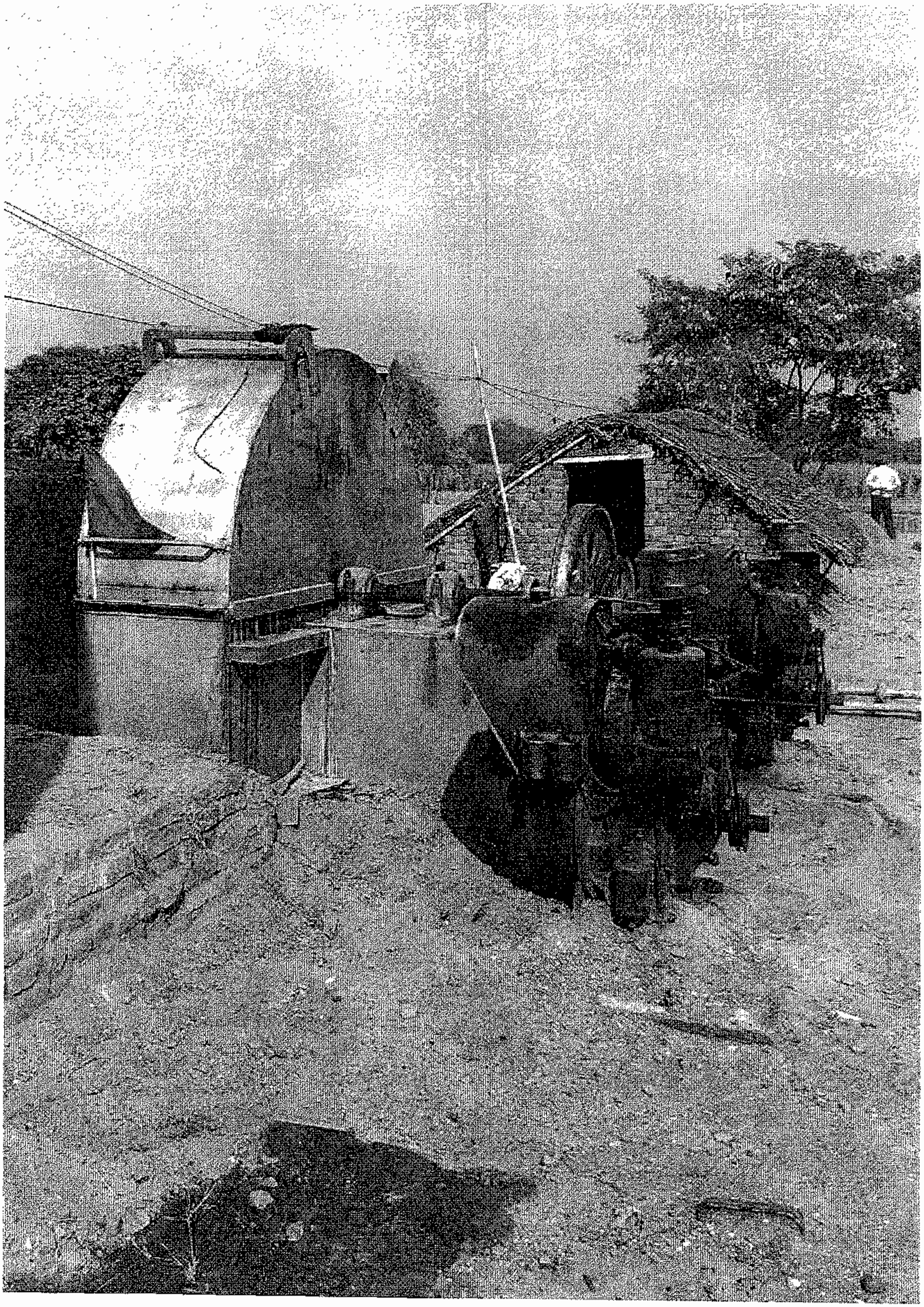
A better understanding of the necessary budget heads is expected during the initiation phase planned in two key brick markets. An initial rough estimate is however provided in Table below:

Table 9: Rough budget estimates for rolling out the Market Transformation approach

		Amount (INR)		
S. No.	Head of Expenditure	Initiation Phase (12 months, till 2020)	National Brick Mission (4 year, till 2024)	Saturation Phase[28] (6 year, till 2030)
1	Technical Support Agency (Professional Fee and Travel)	100 lakhs	600 lakhs	300 lakhs
2	Dashboard (development and maintenance)	10 lakhs	30 lakhs	30 lakhs
3	Events & Outreach (Stakeholder workshops, Exposure visits, Local events, Advertisements, Participation in exhibitions, Social media outreach etc.)	150 lakhs	200 lakhs	300 lakhs
4	Development of Capacity building initiatives (Technology, Finance, Skill, financial Incentives etc.)	--	To be estimated post Pilot	To be estimated post Pilot
	Total	260 lakhs	830 lakhs	630 lakhs

Note: The above are estimates. The actual costs would depend on the scope of the works put up for public bidding by BEE or its affiliates.

[28]In this document the duration of proposed Brick Industry Mission is till 2024. However, the estimates of impacts and budget has been made for the period 2024-2030 on a pro-rata basis. This will help in making decision on extending the mission beyond 2024 till 2030..



08 ANNEXURE

> *A letter to the future*
> *Ok is the first Icelandic glacier to lose its status as a glacier. In the next 200 years all our glaciers are expected to follow the same path. This monument is to acknowledge that we know what is happening and what needs to be done. Only you know if we did it.*"
>
> Memorial plaque Okjökull glacier Iceland

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ANNEXURE-I: THE AWARD OF "E3" BRAND MARK TO MANUFACTURERS

1. Empanelment of labelling agencies (E3 mark agencies) for awarding E3 mark

To be Established

- BEE empanelment procedure for brand award agency
- Tender for empanelment brand award agency

Through public procurement the BEE will invite applications to empanel agencies (two or more for initiation phase) which will collect information from the manufacturers, verify data and award E3 mark based on the criteria laid down by BEE. The E3 mark will be awarded for two years.

A standard cost/fee for the labelling agencies will also be fixed, through the tender, by the BEE which the manufacturer will directly pay to the empanelled agency.

To be Established

- Manufacturer Branding Form and Online Process
- Dashboard of Pilot phase outcomes

The interested manufacturers will submit the E3 marking application form along with the required data in the prescribed format to the empanelled agency. A digitized application process shall be explored.

3. Due diligence by E3 mark agency

The empanelled agency will verify the data provided by the manufacturers and assign deemed specific manufacturing energy values to the manufacturers.

To be Established

- E3 Mark design and guidelines for its use

4. Award of E3 Mark

Post evaluating the application made in previous step, the empanelled E3 marking agency shall consider awarding E3 mark to the manufacturer. This mark will be awarded for two years. The list of E3 manufacturers will be displayed on the web-portal/dashboard and will be updated quarterly.

To be Established

- Surveillance Agency Procedures
- Tender document to appoint Surveillance Agency

5. Surveillance: Audit of E3 Mark Agencies

A certification body will be hired by the BEE which will do random sample audits of the E3 manufacturers to verify their eligibility for the mark and the due diligence process followed by the E3 mark agencies. A penalty will be levied on the E3 mark agencies in case of any discrepancy. The defaulting E3 manufacturer shall be black-listed from the E3 programme.

ANNEXURE-II: METHODOLOGY FOR SPECIFIC MANUFACTURING ENERGY BASELINE

The baseline of specific manufacturing energy will depend upon two parameters:

i. The average specific manufacturing energy of each brick product - production technology combination and

ii. Market share of each brick product - production technology combination

The methodology for estimation of baseline of specific manufacturing energy is provided in Table 10 below:

Table 10: Estimation of baseline of specific manufacturing energy

S. No.	Type of Brick Product & Production Technology	Average SEC of production Technology (MJ/kg)	Initiation Phase (12 months, till 2020)	Average Specific Manufacturing Energy (MJ/m³) [A]	Estimated Market Share (%) [B]
1	Solid burnt clay brick – Clamp Kiln	2.0	1600	3200	25.0 %
2	Solid burnt clay brick - FCBTK	1.3	1600	2100	64.9 %
3	Solid burnt clay brick – Zigzag Kiln	1.125	1600	1800	10.0 %
4	Burnt perforated clay brick (around 25% perforation) – Zigzag Kiln	1.175	1350	1600	0.02 %
5	Burnt hollow clay block (around 60% perforation) – Tunnel Kiln	1.6	800	1300	0.08 %
	National Baseline = ∑ (Ai x Bi) = 2344 = 2350 MJ/m³ (approx.)				

Source: GKSPL, 2017: Roadmap for Resource Efficient Bricks

ANNEXURE-III: METHODOLOGY FOR ESTIMATION OF ENERGY SAVINGS BASED ON DEEMED VALUES

Conceptually the energy saving due to sourcing from E3 marked brick manufacturers of a building wall has two components:

- Energy savings because of saving in manufacturing energy of the total volume of bricks consumed in the construction of the building walls
- Savings in operational energy of the building during depending upon the thermal conductivity of the walling material.

Defining Baseline

- For estimating energy savings, the national baseline for specific manufacturing energy and U-value will be defined. Over time the baseline would be updated using secondary data sources or especially commissioned surveys. The methodology of estimation of baseline is provided in Annexure-II.

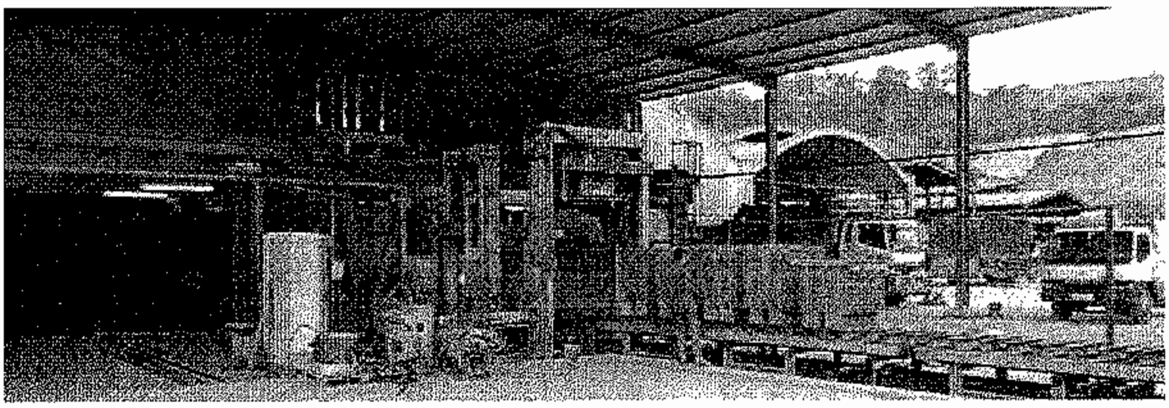
The methodology is now demonstrated for a sample residential flat of 100 m^2 floor area. The estimation of energy savings has been done for use of hollow clay blocks as against the current baseline.

Manufacturing Energy of Bricks consumed in construction of the Building:

This will depend upon the total volume of the bricks consumed in building construction and the specific manufacturing of the brick used.

For residential houses/flats, on an average, 0.41 cubic meter of brick material per square meter of the floor area is generally consumed in the construction of the walls of the flat[29].

Thus, knowing the specific manufacturing energy of the brick/block to be used in the construction of the building, the baseline specific manufacturing energy, and the floor area of the building, the savings in manufacturing energy can be estimated.



[29]GKSPL, 2017, Roadmap for Promoting Resource Efficient Bricks in India: A 2032 Strategy. (Assumption: Outer wall thickness ~ 200 mm and Inner wall thickness ~ 100 mm)

An illustration of the estimation of the manufacturing energy is provided in the table below:

Table 11: Illustration to estimate savings in manufacturing energy of a sample flat (100 m²)

Parameter	Unit	Current National Baseline	Hollow Clay Block
Specific Manufacturing Energy [A]	MJ/m³	2,350	1,300
Volume of brick material per square meter floor area [B]	m³/m² floor area	0.41	0.41
Manufacturing Energy of brick material consumed in the building per square meter floor area [C = A x B]	MJ/m² floor area	963.50	533.00
Floor area of the building (assumed) [D]	m²	100	100
Total Manufacturing Energy of brick material consumed in the building [E = C x D]	MJ	96,350.0	53,300.0
Savings in manufacturing energy as compared to baseline	MJ		43,050.0

Operational Energy of the Building:

The choice of wall construction brick material will have impact on the cooling energy requirement (or heating energy requirement in case of cold climates) and thus on the overall operational energy consumption of the building.

The Bureau of Energy Efficiency has recently launched "Eco Niwas Samhita 2018 (Part-1: Building Envelope)", which is the energy conservation building code for residential buildings[30]. As per this code, the energy simulations of buildings establish a correlation between the RETV and the cooling energy requirement of building.

With the help of the correlations in the code, the Residential Envelope Transmittance Value (RETV) for a wall assembly can be calculated. Higher the RETV value, higher will be the cooling/ heating energy requirement of the building.

For a typical wall assembly, constructed using different brick types, RETV values have been calculated. Following assumptions were taken while calculating the RETV:

- Wall assembly: 15 mm outside plaster + 200 mm thick wall made up of brick/block + 10 mm inside plaster
- Window to Wall Ratio (WWR): 15%
- Window overhang: 300 mm
- Glazing type: Single glazing

[30]https://www.beeindia.gov.in/latest-news/eco-niwas-samhita-2018-part-i-building-envelope-book-film-tool

Thus, knowing the RETV and the climatic zone in which the building is located, the cooling energy requirement can be calculated.

The results of the calculation for some of the brick types are provided below:

Table 12: Results of calculation for cooling energy requirement of buildings

Climatic Zone	Brick Type	RETV	Annual Cooling Energy Performance Index (EPI) in kWh/m².year	
			Air conditioned	Non-air conditioned
'Hot & Dry' or 'Composite' Climate	Current National Baseline (k=0.8 W/m-K)	19.42	58.03	0
	Hollow Clay Block	14.70	45.57	0
'Warm & Humid' Climate	Current National Baseline (k=0.8 W/m-K)	16.96	61.77	0
	Hollow Clay Block	12.96	49.37	0

Table 11 provides an annual cooling energy requirement of the building per square meter of the floor area for different brick types. For an assumed lifetime of the building, total energy saving in operational energy during the lifetime of the building can be calculated.

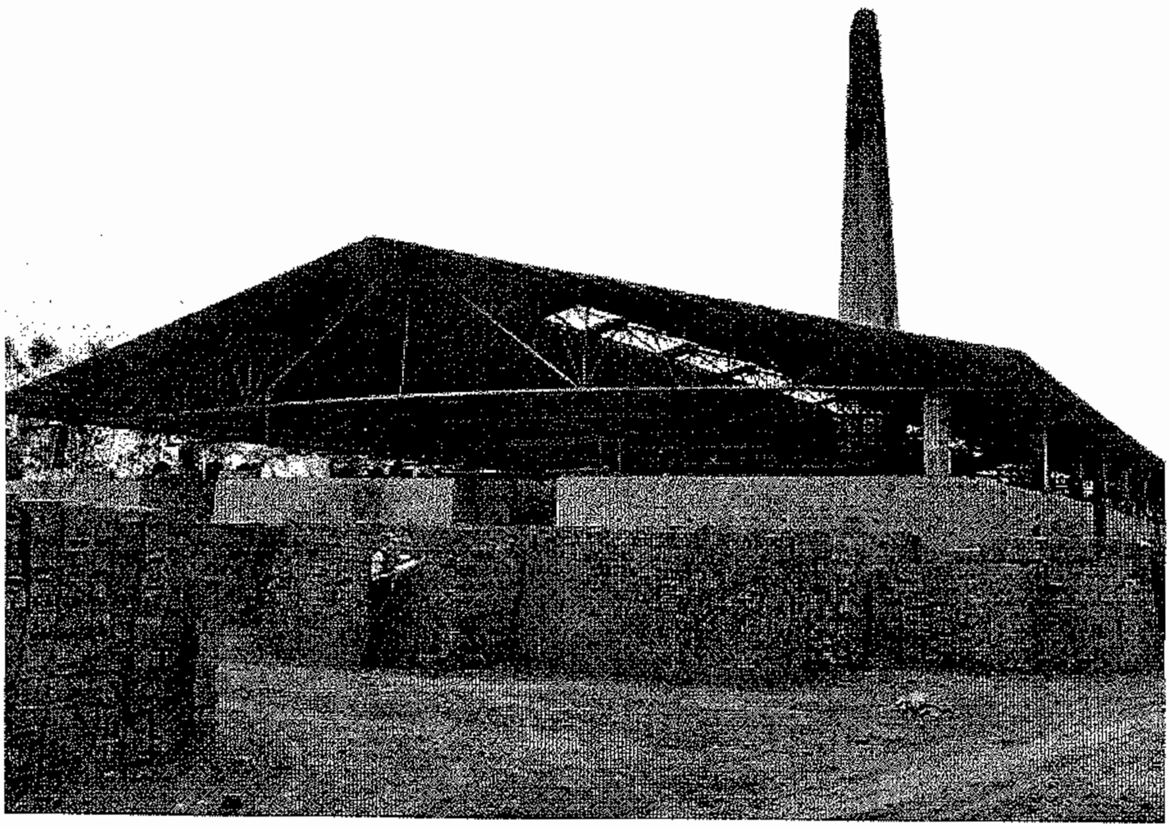
An important point to note under the proposed deemed MRV is that the savings in operational energy of building take place when the construction of outer walls is carried out using the chosen brick type and the building is air-conditioned.

If the building is not air conditioned, then there will not be any saving in operational energy. Nevertheless, the choice of brick type for the construction of outer wall will have an impact on the thermal comfort of building occupants.

The estimation of savings in the operational energy of a sample air-conditioned flat of 100 m2 floor area located in composite climate is now tabulated.

Table 13: Estimation of saving in cooling energy requirement of a sample flat located in composite climate

Parameter	Unit	Current National Baseline	Hollow Clay Block
Annual cooling electricity requirement per square meter floor area [A]	kWh/m².year	58.03	45.57
Savings in cooling electricity requirement per square meter floor area [B]	kWh/m².year	---	12.46
Floor area of the flat (assumed) [C]	m²	100	100
Total cooling electricity requirement of the flat [D = A x C]	kWh/year	5,803	4,557
Savings in cooling energy as compared to the national baseline	kWh/year	--	1246
Monetary saving in electricity bills (assuming electricity cost = Rs 5/Kwh)	Rs/year		6230



ANNEXURE-IV: SUGGESTED SCOPE OF THE TECHNICAL SUPPORT AGENCY (TSA) DURING THE PILOT PHASE

To provide technical support as well as implementation support during the initiation phase, a technical support agency will be hired with the scope of work as:

1. Thrust Area-1: Development of Brick Industry Mission
   - Assist in organizing the Policy Maker's Meet
   - Preparation of draft National Brick Mission document
   - Organization of stakeholder consultation to gather inputs on the draft national brick mission
   - Finalization of the National Brick Industry Mission and its Operational Plan
2. Thrust Area-2: E3 marking of manufacturers producing energy efficient bricks through E3 mark
   - Preparation of tender document for empanelment of agencies who will award E3 mark to manufacturers
   - Finalization of the process to be followed for awarding E3 mark to manufacturing enterprises. This will include application formats, application review and data verification process, guidelines for the use of mark, design of mark, etc.
   - Assist in evaluation of applications and empanelment of labelling agencies
   - Finalization of baseline, deemed MRV and the E3 marking scheme
   - Assist in organizing the launch event of the E3 marking scheme
   - Development of communication and outreach materials targeted at bricks manufacturers
   - Assistance in outreach and mobilization of manufacturers for E3 marking
   - Co-ordinate with the empanelled labelling agencies in the E3 marking process
   - Development of a dashboard linked to the BEE website
3. Thrust Area-3: Comprehensive support package to manufacturers to facilitate the shift to E3 enterprises
   - Development of standard technology packages as per Indian requirements
   - Mobilization of technology providers, test labs, technical service providers and other professionals in India to facilitate their involvement in the brick sector transformation
   - Identifying training needs and organizing training program for the above-mentioned professions by expert international agencies

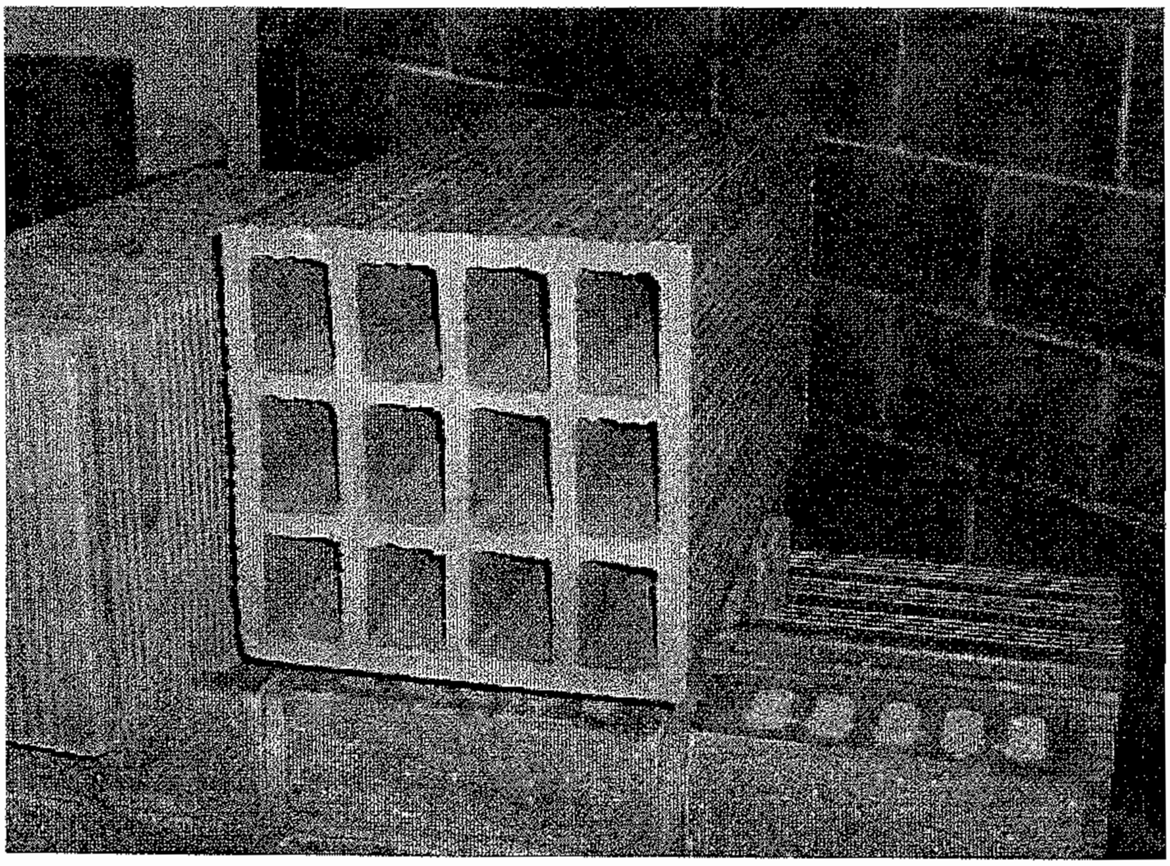
- Assist in organizing an exposure visit of Indian delegation (selected manufacturers, builders, policy makers, etc.) to China
- Assist in engaging green finance institutions

4. Thrust Area-4: Creation of market demand for energy efficient bricks

- Development of communication and outreach materials targeted at builders and demand influencers
- Assistance to in outreach and Mobilisation of builders and other demand influencers, and awareness campaigns
- Preparation of procurement guidelines for large institutional consumers
- Providing technical support for inclusion of E3 bricks in SoR of various government agencies.

5. Additional responsibilities of the TSA

- Keep track of implementation and impacts, and up-dation of the dashboard
- Estimation of energy and CO^2 savings through pilot initiatives
- Assistance in organising various events and workshops planned under this initiative
- Any other set of activities in line with the overall mandate.



ANNEXURE-V: BRICK MANUFACTURING PROCESS AND POTENTIAL E3 MARK SOURCED BRICKS

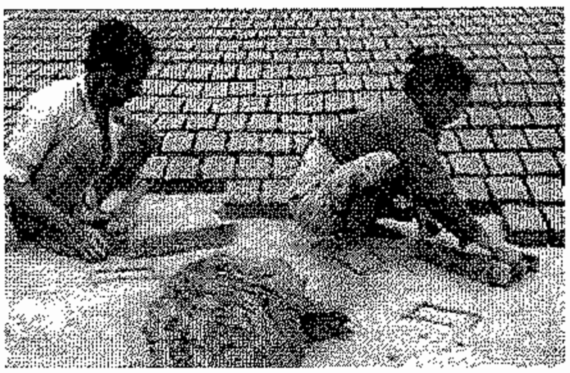
Brick manufacturing process:

The typical brick manufacturing process involves following key stages. Conventionally all the processes are done manually, however, use of various machines, particularly for clay preparation and material handling, are increasingly being used.

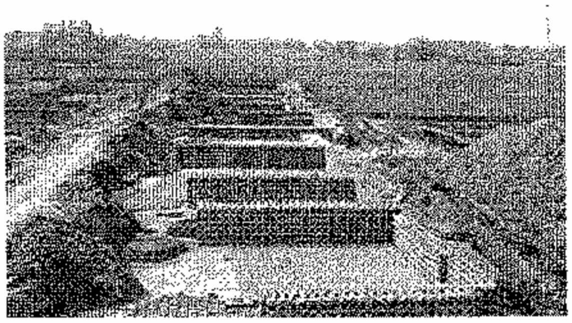
Table 13: Brick manufacturing process

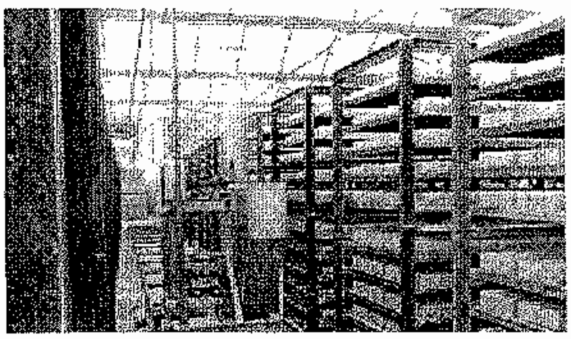
Step-1: Clay Preparation

Step-2: Shaping or Moulding

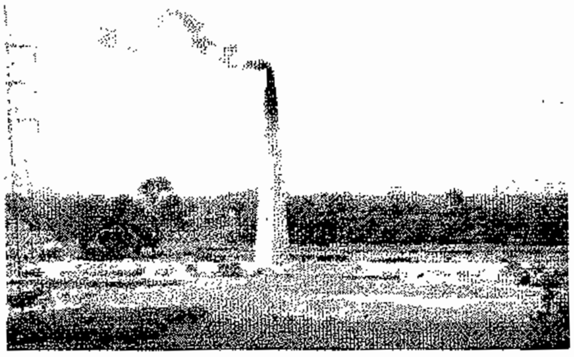


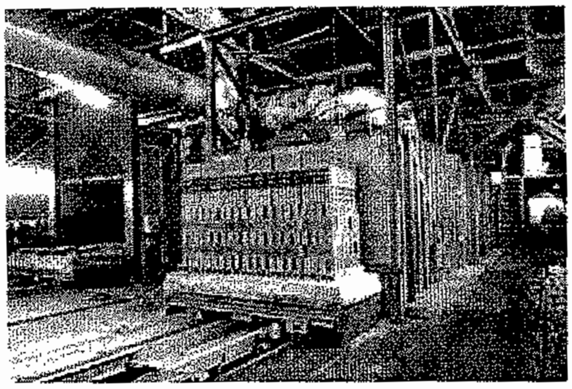
Step-3: Drying



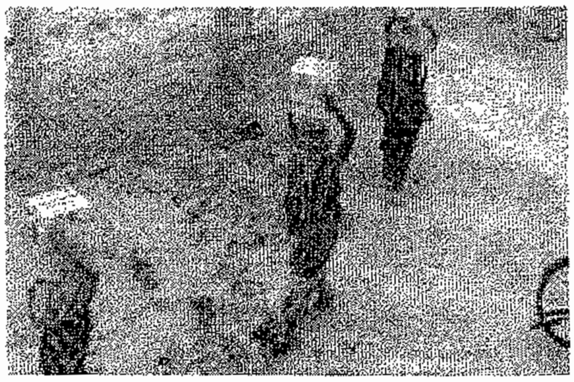


Step-4: Firing of bricks



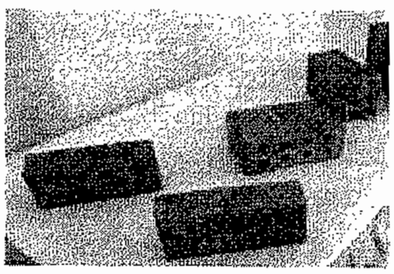


Material Handling

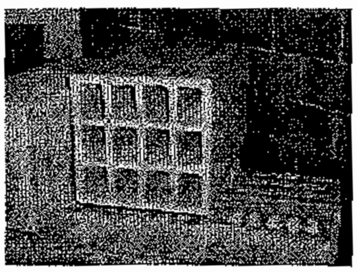


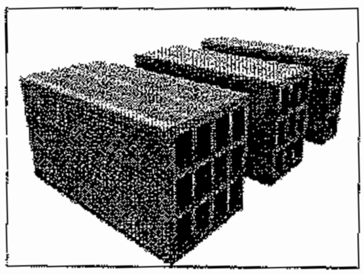
Potential E3 mark sourced bricks and blocks:

Perforated Bricks



Perforated Bricks





9. LIST OF ABBREVIATIONS

AAC	Aerated Autoclaved Concrete
B2B	Business to Business
BEE	Bureau of Energy Efficiency
BIS	Bureau of Indian Standards
BMTPC	Building Material and Technology Promotion Council
CPWD	Central Public Works Department
CREDAI	Confederation of Real Estate Developers Association of India
CSE	Centre for Science and Environment
EC Act	Energy Conservation Act, 2001
EE	Energy Efficiency
E3	Energy Efficient Enterprise
ESCO	Energy Service Company
FAQ	Frequently Asked Questions
FCBTK	Fixed Chimney Bull Trench Kiln
GDP	Gross Domestic Product
GHG	Green House Gases
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GKSPL	Greentech Knowledge Solutions Pvt Ltd
IFC	International Finance Corporation
IGEF	Indo German Energy Forum
IGEN	Indo German Energy Programme
MoEFCC	Ministry of Environment Forest and Climate change
MoHUA	Ministry of Housing and Urban Affairs
MoP	Ministry of Power, Govt. of India
MRV	Monitoring Reporting and Verification
MSC	Mission Steering Committee
MSME	Micro Small and Medium Enterprises
NAREDCO	National Real Estate Development Council
NBCC	National Buildings Construction Corporation
PWD	Public Works Department
SEC	Specific Manufacturing Energy of Consumption
SFC	Standing Finance Committee
SoR	Schedule of Rates
TCPO	Town & Country Planning Organisation
TERI	The Energy and Resources Institute
ToR	Terms of Reference
TSA	Technical Support Agency (viz. consultant)
WG	Mission Working Group

FEEDBACK FORMAT

Reference:

Document: Market Transformation towards Energy Efficiency in Brick Sector

Version: December 2019

Feedback may be provided as per format or emailed to
manu.maudgal@giz.de /mdeore@beenet.in

Feedback

1. How could we improve this document?

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2. Suggestions for consideration during roll out of the strategy for market transformation?

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3. A new initiative takes off through support received from passionate pioneers in respective domains. Your suggested name / organization to share E3 mark details?

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About Yourself

Name:	Email:
Organization name:	Phone:

Where would you place your organizational Interest vis-à-vis the Brick Sector

Supply Side	Customer Side	Policy / Regulator
• Brick Manufacturer • Brick Technology Vendor • Financier • Raw material vendor • Brick service provider (like Laboratories, Consultants) • Other (specify)	• Brick Distributor • Brick Customer-Institutional • Brick Customer-Retail • Financier • Builder Service Provider (like Architect)	• Central Ministry / Institution • State Department / Institution • Think tank

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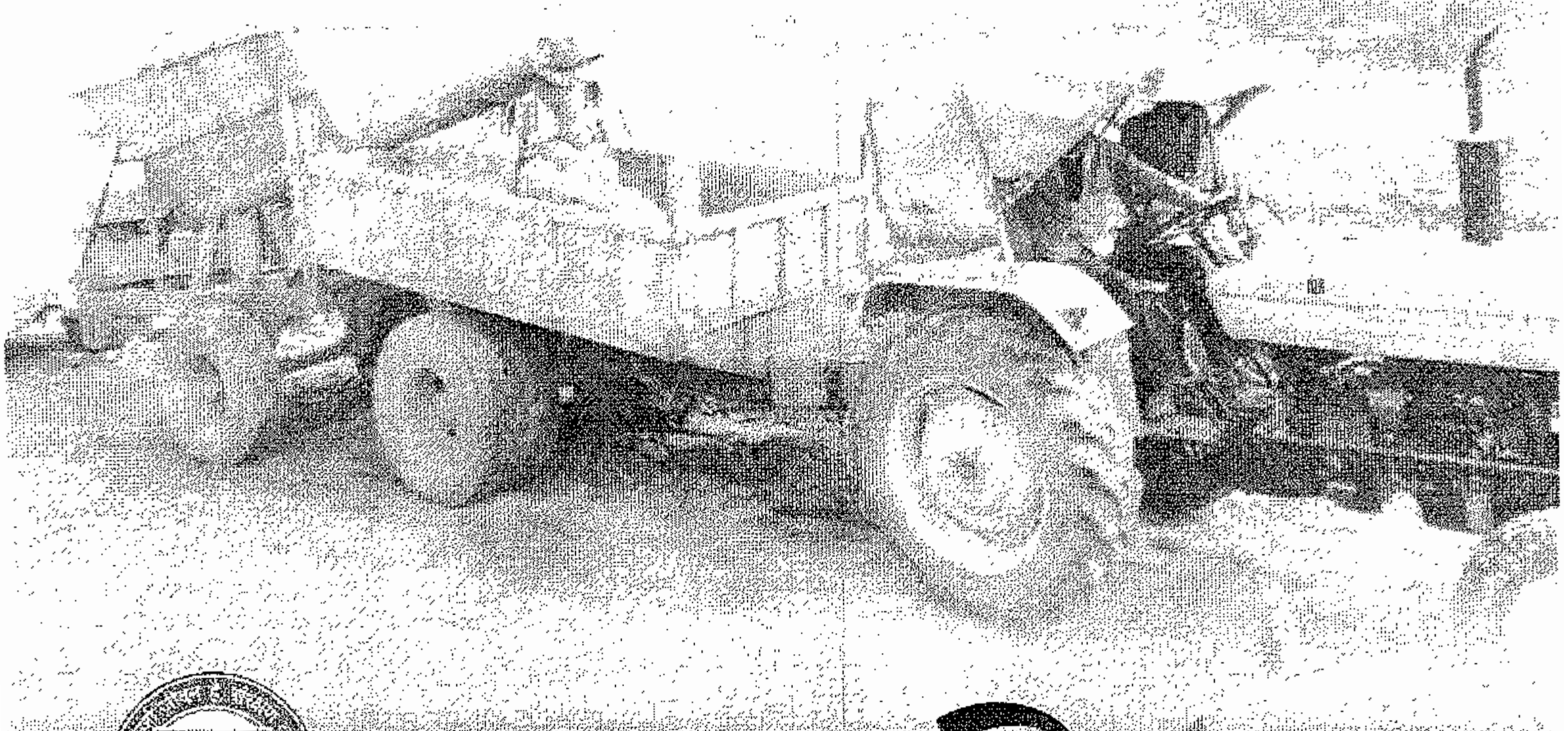
The Bureau of Energy Efficiency (BEE) is the nodal agency to support Government of India in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing the energy intensity of the Indian economy.

The fired (red) clay Brick manufacturing sector, which supplies 85% of all bricks used in construction, consumes annually nearly 5% of all coal used in India. With scant technological innovation, the sector has a large un-tapped energy efficiency potential.

The BEE is proposing a market transformation strategy under which brick manufacturers who adopt energy-efficient manufacturing shall be awarded a "Energy Efficient Enterprise (E3)" mark. The adoption of E3 mark shall be wholly voluntary by Industry.

The market transformation strategy further seeks to encourage customers to source bricks from manufacturing units who have been awarded the E3 mark.

The BEEs active steering is expected to accelerate the adoption of improved production technologies and encourage product innovation (like porous/hollow clay products) in the brick sector, locking India into an energy- efficient and thermally comfortable infrastructure.



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ANNEXURE-A-6

Atmospheric Pollution Research 5 (2014) 438-446
Short Communication

Atmospheric Pollution Research

www.atmospolres.com

Assessment of traffic–generated gaseous and particulate matter emissions and trends over Delhi (2000–2010)

Rati Sindhwani, Pramila Goyal

Centre for Atmospheric Sciences, Indian Institute of Technology Delhi, Hauz Khas, Delhi–110016, India

ABSTRACT

Development and urbanization over the past decade has led to rapid increase in the population of Delhi, the metropolitan city of India. Consequently, there has been a tremendous increase in the number of vehicles, which are causing very high levels of air pollution. Vehicular emissions are becoming most predominant source of air pollution in Delhi. An annual emission inventory of road transport emissions of pollutants including carbon monoxide (CO), methane (CH_4), nitrogen oxides (NO_X), sulfur dioxide (SO_2), volatile organic compounds (VOCs), particulate matter (PM_{10}), lead (Pb) and hydrocarbon (HC), organic carbon (OC) and black carbon (BC) has been developed (for the period 2000–2010), for the Delhi region. Emissions have been estimated using emission factor and activity–based approach recommended by IPCC. The emissions of CO and NO_X have increased nearly 77% and 29% respectively over 2000 to 2010, whereas contribution of SO_2 has greatly reduced (~21%) due to phasing out of diesel driven buses and implementation of Bharat Stage–III norms to commercial vehicles. An appreciable increase in NO_X emissions has been observed after 2005, which might be due to the use of CNG fuel. Emissions of PM_{10}, OC and BC have decreased in 2001 and 2002, however these are continuously increasing after 2002 due to rapid rise in the annual rate of growth of registered vehicles in Delhi. Two wheelers (2Ws), which constitute 60% of total registered vehicles, have been found to be major contributors towards emissions of the pollutants considered in the present study.

Keywords: *Air pollution, emission inventory, emission factors, transport sector, two wheelers*

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1. Introduction

Transport heralds the economic development of a region and plays a very crucial role in its urbanization. Delhi, one of the fastest growing economic centers of South Asia, has seen a rapid increase in vehicular population in the past decade. Delhi itself accounts for about 8% of the total registered vehicles in India. The city has more number of registered vehicles compared to that of combined number of vehicles in three metropolitan cities namely Chennai, Mumbai, Kolkata (CPCB, 2010a). The number of vehicles registered in Delhi has already reached 6 million in 2010 (DSH, 2012) and another 2.2 million vehicles mostly from the surrounding areas namely– Gurgaon, Faridabad, Ghaziabad, Noida, Greater Noida, Bahadurgarh and Sonipat contribute to total vehicular population (Sahu et al., 2011), which are responsible for degrading the air quality. Vehicular pollution, contributed about 72% towards total air pollution load in Delhi (Goyal et al., 2006), which was only 23% in 1970–71 (CPCB, 2008). A study on vehicular traffic by Hindustan Times (2011) (a leading daily newspaper) also stated that around 1 317 vehicles were added to Delhi's vehicle population every day out of which more than 60% were two wheelers (2Ws) and rest were cars. This increase was also attributed to the buying capacity and fascination for new bikes and cars in Delhiites. Moreover, the TRIPP (2001) projected that the implementation of CNG in Delhi would lead to an increase in bus fares. Therefore, a good percentage of bus users would use personal 2Ws, as their running cost was marginal (Rs 0.75 per km).

Air quality measurements undertaken by the regulatory authority, Central Pollution Control Board (CPCB) in the last decade show that ambient concentrations of coarse particles PM_{10} (particles with aerodynamic diameter less than or equal to 10 μm) have consistently exceeded National Ambient Air Quality standards (NAAQS). As a consequence, incidence of respiratory diseases in Delhi has greatly increased and about 30% of Delhi's population suffers from respiratory disorders (Kandlikar and Ramachandran, 2000).

Several previous studies have made an attempt to examine and estimate emissions of air pollutants in Delhi. Gurjar et al. (2004) presented a comprehensive emission inventory for the period 1990–2000 and concluded that transport sector contributed >80% of NO_X, CO and VOCs (volatile organic compounds) towards total emissions. Recently, Ramachandra and Shwetmala (2009) developed a decentralized emission inventory for vehicular transport sector of India for different metropolitan cities for the years 2003–2006. It was estimated that metropolitan city Delhi (area 431 km^2) emitted 284.43x10^6, 87.74x10^6, 129.99x10^6, 9.13x10^6 and 42.38x10^6 g km^{-2} of CO, HC, NO_X, PM and SO_2 respectively. Kansal et al. (2011) concluded that vehicular emissions are major sources of NO_X, TSP (total suspended particulate matter) and SO_2 emissions contributing about 90%, 54% and 33% towards Delhi emissions respectively. Mohan et al. (2012) estimated emissions for the period of 2000–2008 based on emission factors (EFs) from previous studies and stated that transport sector contributed about 60% to NO_X emissions.

Goyal et al. (2013) developed a gridded vehicular emission inventory of criteria pollutants namely CO, NO_X and PM which covered the metropolitan area of 26 km x 30 km (780 km^2) of Delhi for the base year 2008. CO and NO_X emissions due to passenger cars (PCs) were found to be about 34% and 50% respectively.

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However, the emissions of CO due to 2Ws were found to be about 61% and PM due to heavy commercial vehicles (HCVs) was about ~92%. Nagpure et al. (2013) quantified traffic–induced emissions for megacity Delhi for the years 2000–2005 and concluded that the levels of NO_X and TSP did not show appreciable increase, which might be due to CNG effectiveness as an alternative fuel. However, 2Ws dominated Pb emissions followed by cars while the contribution from different types of vehicles was negligible.

The present study aims to estimate emissions of various pollutants (e.g., CO, NO_X, SO_2, PM_{10}, CH_4, HC, Pb, VOC, OC and BC) from transport sector in Delhi over the period of 2000–2010. Bottom–up approach was adopted, which is based on annual average utilization for different vehicle category, number of registered vehicles and the corresponding emission factors (Gurjar et al., 2004). The emission trends of criteria pollutants have also been compared with previous studies available in the literature as well as with the observed annual average concentrations.

2. Study Area

Delhi (Latitude 28°35′ N, Longitude 77°12′ E) (Figure 1), with an area of 1 483 km^2 (ESD, 2004), home of ~16 million people is situated in the northern part of India. Geographically, Delhi is 160 km south of Himalayas, at an elevation of 216 m above mean sea level (Kansal et al., 2011). The river Yamuna forms the eastern boundary of the city. It is situated between the Great Indian Desert (Thar Desert) of Rajasthan to the west, the central hot plains to the south and the cooler hilly region to the north and east (ESD, 2009). Delhi has a semi–arid climate with an extremely hot summer, average rainfall and very cold winter. The summer (March, April, May) is governed by high temperature, the monsoon (June, July and August) is dominated by rain where as the post–monsoon (September, October, November) has moderate temperature (Kumar and Goyal, 2011). The most important season in Delhi is winter, which starts in December and ends in February. This period is dominated by cold, dry air and ground–based inversion with low wind conditions ($u \leq 1$ m s^{-1}), which occur frequently and increases the concentration of pollutants (Anfossi et al., 1990; CPCB, 2000). Normally, north–westerly winds prevail during the year while in the months of June and July, south–easterly winds predominate.

3. Methodology

Emissions from the transport sector depend mainly on type of transport and fuel used. The major pollutants emitted from transport sector are CO, NO_X, HC, VOC, SO_2, CH_4, PM_{10}, Pb, OC and BC.

Figure 1. Map of the study area.

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Emission load of road transport during the period of 2000–2010 have been calculated using the following equation (IPCC, 2006; Sahu et al., 2011):

$$E_i = \sum (Veh_j \times D_j) \times EF_{i,j\,km} \quad (1)$$

where, E_i is the emission of pollutant (i) (Gg), Veh_j is the number of vehicles per type (j), D_j is the distance travelled per vehicle in per year (j) (km), and $EF_{i,j\,km}$ is the emissions of pollutant (i) vehicle type (j) per driven kilometer(g km^{-1}).

3.1. Vehicle population

The urban population in Delhi is predominantly dependent on road transport. Delhi has the largest number of vehicles compared to any other Indian city. The vehicle population growth in Delhi has sharply increased by an average annual rate of 7.40% for private vehicles and 9.15% for commercial vehicles (GNCTD, 2010). The number of vehicles per kilometer of road in Delhi has gone up from 128 to 191 between 2003 and 2009 (Goyal et al., 2013). Population data of different types of vehicle (e.g., Bus, LCV, HCV, Taxi Car, etc.) for Delhi has been derived from the Statistical Abstract of Delhi (2012) (Figure 2). Annual average vehicle–kilometer travelled were assumed to be 10 000 for passenger cars; 36 000 for taxis and auto–rickshaws; 50 000 for buses and 30 000 for HCV and LCV (Guttikunda and Calori, 2013) and 27 000 for 2Ws (Sahu et al., 2011). Auto–rickshaws (or 3W) and buses have been assumed to use only CNG, as fuel post 2005. The population data of CNG vehicles has been taken from Ravindra et al. (2006) and the number of diesel vehicles is obtained from previous studies (Goyal, 2007). Diesel is mostly used in public passenger and cargo vehicles. 2Ws, light motor vehicles (passenger), cars and jeeps use gasoline. However, most of the buses and omni–buses and 5% of total cars and jeeps use compressed natural gas (Das and Parikh, 2004). Amongst the total 2W, 72% are motorbikes, and remaining 28% are scooters. Since 4S–2W emits less pollution compared to that of 2S–2W, thus a ratio of 72:28 has been considered for 4S–2W and 2S–2W. The age–wise distribution of vehicular population of Delhi has been taken from CPCB (2010b).

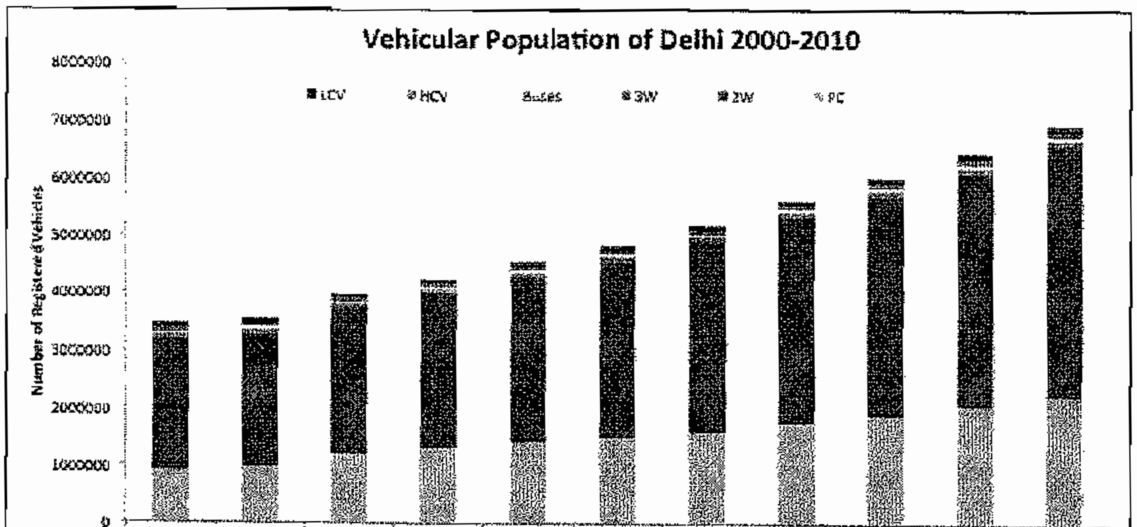
3.2. Emission factors

An emissions factor is a representative value that attempts to relate the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (U.S. EPA, 2009). Vehicular emissions vary with the age of the vehicle, its type, efficiency and type of fuel used. Emission Factors ($E_{i,j\,km}$) of different types of vehicles are compiled from previous studies and regulatory agencies (UNEP, 1999; Kandlikar and Ramachandran, 2000; EEA, 2001; Mittal and Sharma, 2003; ARAI, 2007; CPCB, 2010b) (refer to Table S1 in Supporting Material, SM).

4. Results and Discussion

Emissions of CO (Figure 3) increased by 77% from 193 Gg in 2000 to 342 Gg in 2010. This increase has been attributed to an increase of 40% in the total number of vehicles from 2000 to 2005 out of which, two wheelers and passenger cars are contributing an increase of 37% and 58% respectively. This figure clearly indicates that major contributors towards CO emissions are 2Ws, which are followed by passenger cars (>12%). A continuous increase was seen in the emissions from 2006–2010, which might be due to a continuous increase in the number of vehicles.

Emissions of HC showed a sharp increase of 87% from 148 Gg in 2000 to 277 Gg in 2010. A major increment in HC emissions was also observed during 2000–2002, from 140 Gg to 162 Gg respectively. Post 2002, HC emissions showed an increasing trend. Rise in the emissions can be correlated with the growth in vehicle population. More than 85% of HC emissions were contributed by 2Ws whereas contribution of other types of vehicle was relatively very less (Figure S1 in the SM).



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
LCV	82893	84543	67865	70056	73734	74264	78435	84060	91656	102046	109606
HCV	74991	75976	60970	63765	66252	66738	70487	75541	82638	90806	100305
Buses	41483	47578	47102	48813	54419	55747	46583	52765	55148	58047	61471
3W	86985	86985	49538	52905	53656	73644	74289	75297	83948	86482	88181
2W	2230534	2265955	2517788	2665750	2844004	3062536	3299838	3578199	3797943	4055229	4342403
PC	939085	989522	1224629	1326167	1445149	1487334	1614830	1760390	1899402	2058920	2231281

Year

Figure 2. Vehicular population of Delhi 2000–2010.

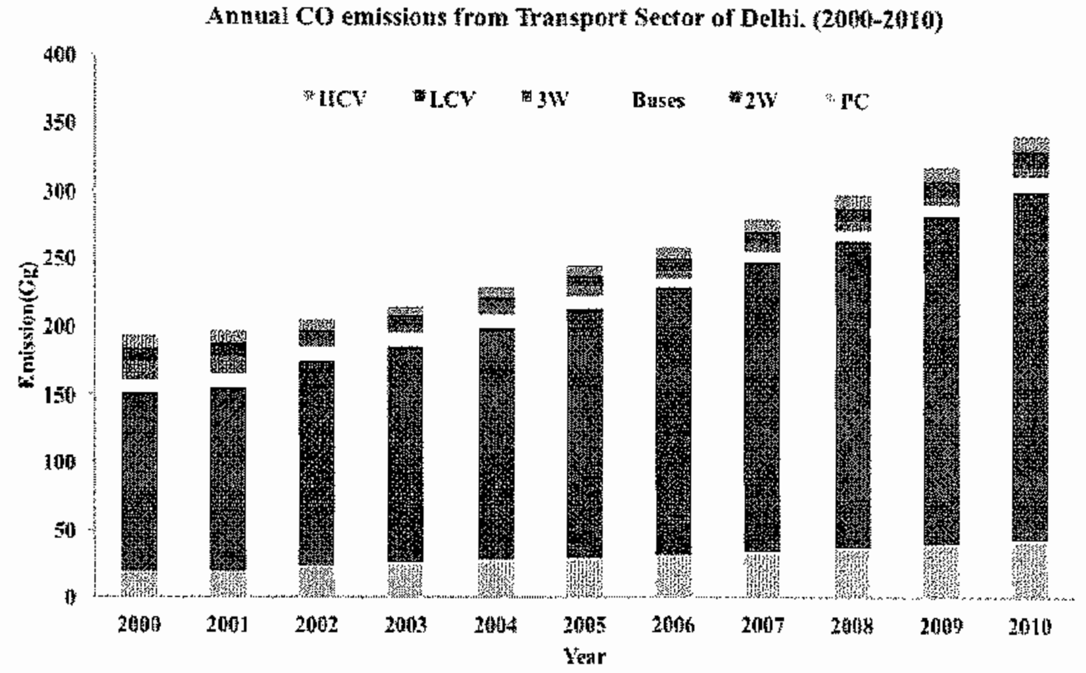


Figure 3. Annual CO emissions from transport sector of Delhi, 2000–2010.

A decreasing trend in the number of LCV and HCV vehicles was observed for the years 2001–2003. Since these vehicles dominated NO_X emissions during 2001–2003 so a decrease was seen during 2001–2003. However, NO_X emission trend reversed in 2004 and 2005 due to increase in the number of LCV and HCV vehicles as well as increased use of CNG as fuel in buses and 3Ws (Figure 4). After 2005, a steep decrease has been observed in 2006 followed by steadily increasing trend up to 2010. After 2005, 3Ws and buses are assumed to be using CNG fuel only. This may be one of the reasons, as its flash point is 540 °C, which is much higher as compared to that of diesel (232 °C–282 °C). At such a high temperature, more nitrogen from the air compresses and reacts with oxygen in the combustion chamber of CNG driven vehicles and thus produces more NO_X (Ravindra et al., 2006). Other reason may be due to fall in the number of total buses plying on Delhi roads, which decreased by 16% from 55 747 in 2005 to 46 581 in 2006.

In general, a significant decrease in the total emissions of SO_2 (7.8 Gg in 2000 to 6.1 Gg in 2010) was seen during the decade 2000–2010 (Figure 5). Buses contributed nearly 52% of SO_2 during 2000–2005. The major fall in SO_2 emissions was seen after 2005, which might be due to the control measures implemented by the policy–making agencies, as shown through yearly trend in Figure 5.

- In 2000, sulfur content in diesel and gasoline was reduced to 0.05%.
- In 2001, Bharat Stage II (EURO–II equivalent) emission norms were introduced for all commercial vehicles.
- In 2002, all diesel buses are either phased out or converted to CNG.
- In 2005, Bharat Stage III (EURO–III equivalent) emission norms were introduced for all private vehicles, city public service vehicles and city commercial vehicles. Also, the Bharat Stage II emission norms for sulfur content in gasoline were reduced to 0.035 % and 0.015% in two and three wheelers respectively.

It is noticeable that VOC emissions have an increment of more than 95% i.e., 139 Gg in 2000 to 275 Gg in 2010 (Figure S2 in the SM). The VOC emissions have increased with an average rate of 7% annually after the year 2003. Nearly 70% of VOC emissions were contributed by 2Ws, followed by passenger cars (20%).

Methane (CH_4) emissions (Figure S3 in the SM) have increased more than three times from 13 Gg in 2000 to 49 Gg in 2010. A steep increase was observed in 2006 from 26 Gg in 2005 to 37 Gg in 2006. The main reason can be attributed to implementation of CNG fuel in 3Ws and buses in 2002. Buses (40%) and 3Ws (10%) together are contributing nearly 50% towards methane emissions from 2006 to 2010.

PM_{10} emissions increased from 8.5 Gg in 2000 to 10.6 Gg in 2010, thereby registering an increment of 25% during the decade (Figure 6). A major decrease in PM_{10} emissions was observed during 2001–2002 due to implementation of control measures by Delhi government for reducing emissions from the transport sector in Delhi. However, a gradual increase was seen in PM_{10} emissions after 2002. Maximum decrease in PM_{10} emissions was observed in 2006 as 7.9 Gg from 9.8 Gg in 2005. This could be due to phasing out of diesel vehicles from public fleet and implementation of Bharat Stage III norms in 2005 and use of cleaner fuel CNG in buses and auto–rickshaws. After 2006, a rise was again seen in PM_{10} emissions, which might be due to continuous increase in the vehicle population in all types of vehicles. Emissions of BC and OC (Figure S4 and S5 in the SM) show a similar trend as PM_{10} emissions.

Lead (Pb) emissions have become double from 0.18 Gg in 2000 to 0.37 Gg in 2010 (Figure S6 in the SM). 2Ws are found to be major contributors towards Pb emissions, followed by passenger cars. After 2002, Pb emissions increased at an average rate of 6.5% annually. The increase in Pb emissions is of great concern and similar results of domination of Pb emissions have been found to be supported by several studies such as Puzas et al. (1992), Popescu, (2011), Nagpure et al. (2013), Kalra et al. (2013), Tiwari et al. (2013).

4.1. Comparison of transport emission estimates of present study with previous studies

Table 1 presents the differences between the present study and the studies made by others for estimates of transport emissions of Delhi. The main reason of difference is found to be the choice of different *EFs*. Some studies such as Bose (1999), UNEP (1999) and Das and Parikh (2004) have taken projections of vehicles for the emission estimation. Other studies like Auto Fuel Policy (2002), Nagpure et al. (2013) and the present study, have used actual number of vehicles obtained from government reports such as yearly economic survey and statistical abstracts. This may lead to a difference in the number of vehicles used in the calculations for emission estimation. Another reason may be the consideration of different proportion of different types of vehicles. For example, in the present study the proportion is 72:28 for 2W–2S: 2W–4S, which is based on report of CPCB (2010b). However, Nagpure et al. (2013) has taken a figure of 2 407 799 for 2W in 2001 and a proportion of 8:1 for 2W–2S and 2W–4S vehicles.

Emissions calculated in the present study for CO, NO_X and PM_{10} for the years 2008–2009 have been compared with Goyal et al. (2013) (Table S2 in the SM), which reflects that the estimated emissions of both studies are in well agreement. However, the above emissions are not matching to the emissions of same pollutants made by Gurjar et al. (2004), since the latter has used 2000 as the base year. It is also noticeable that emission estimates of the present study for 2000–2010 have lower values compared to that of the emissions estimated by Nagpure et al. (2013) for the years 2000–2005, but both are following the same trend.

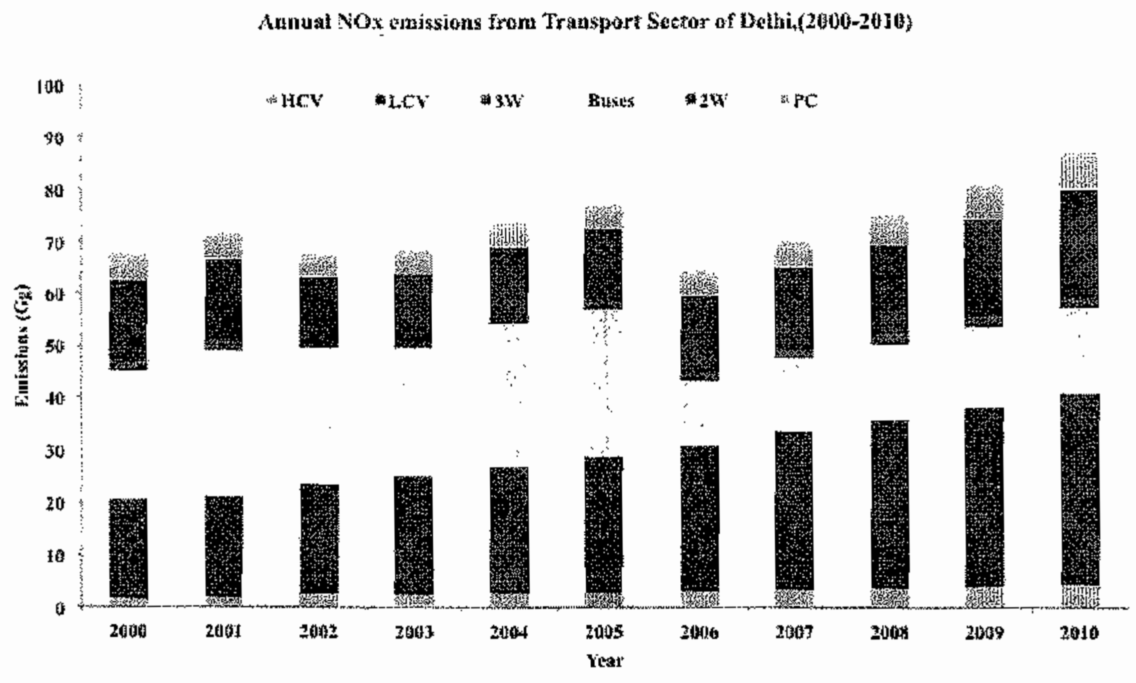


Figure 4. Annual NO_X emissions from transport sector of Delhi, 2000–2010.

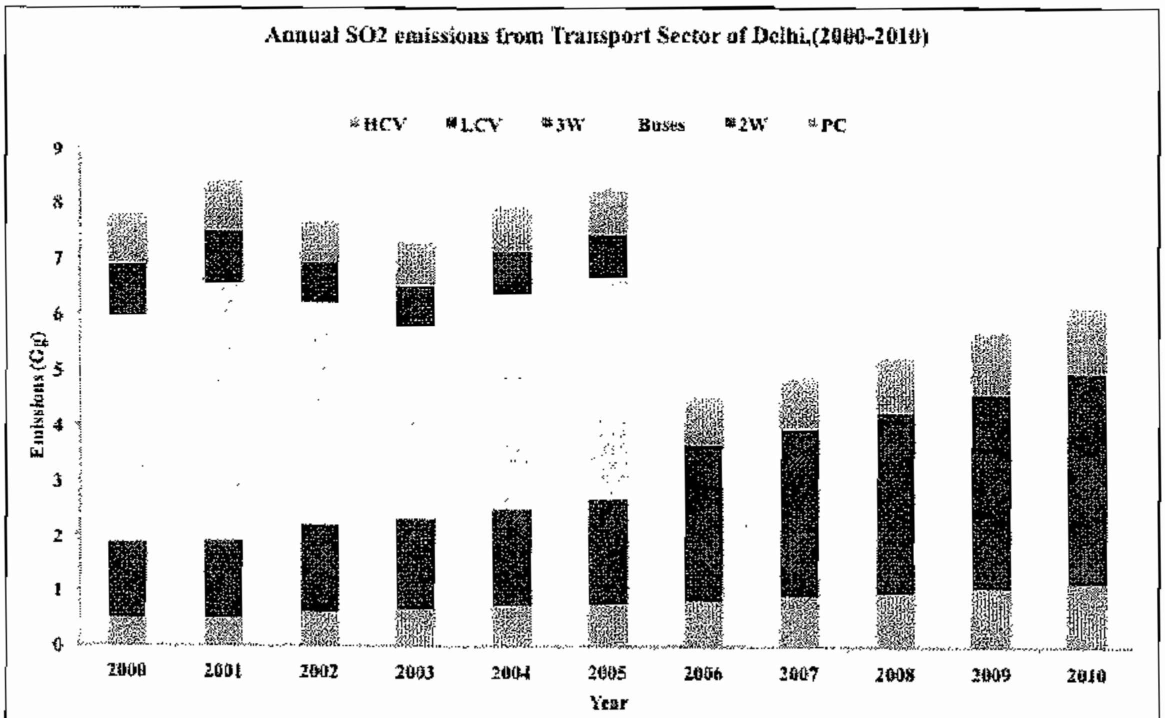


Figure 5. Annual SO_2 emissions from transport sector of Delhi, 2000–2010.

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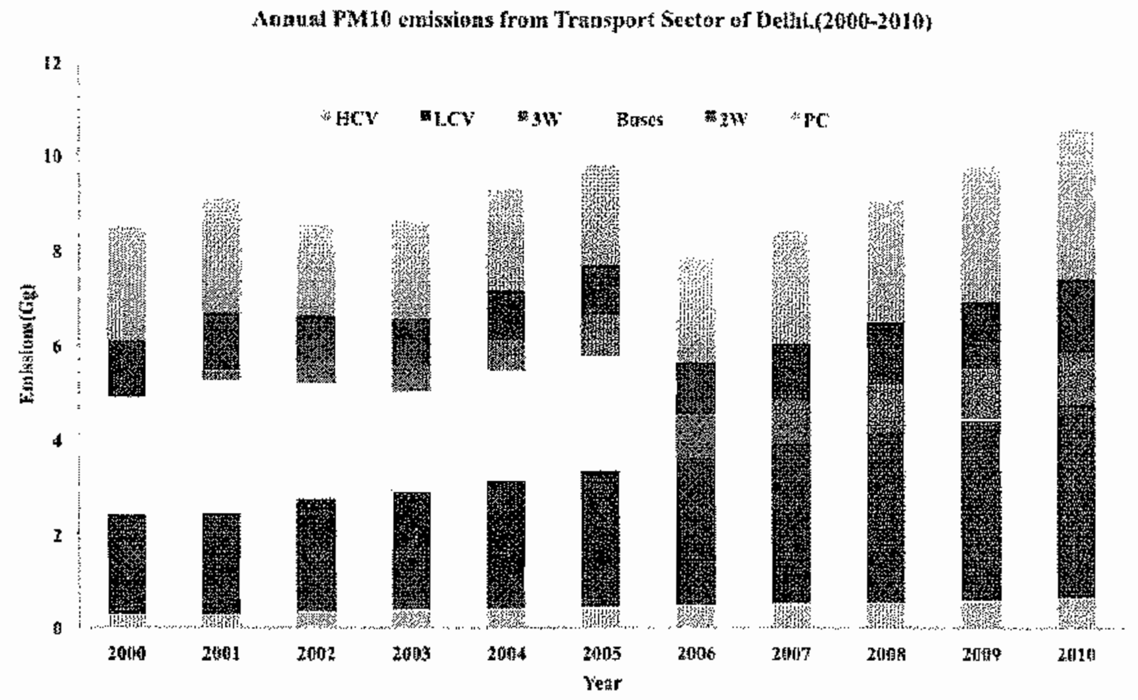

Figure 6. Annual PM_{10} emissions from transport sector of Delhi, 2000–2010.

In the present study, emission trends for the years 2005–2010 have been presented for the first time. Emission estimates from present study during 2000–2005 are less than Nagpure et al. (2013) but they show more or less a similar trend.

Since the phasing out of diesel vehicles in public transport was completed by 2005 and also due to implementation of Bharat Stage III norms, a sudden dip in the NO_X, SO_2 and PM_{10} emissions has been seen but again an increase is seen from 2006–2010. This rise can be attributed to continuous increase in the number of vehicles in Delhi, which has offset the impact of CNG implementation and phasing out of diesel vehicles. Therefore, a continuous increase in emissions has been found after 2006.

Nonetheless, one can say that emission estimates of the present study are comparable with the previous studies.

4.2. Comparison with air quality measurements

The most important part of emission inventory is its validation with the ambient air quality data. Practically, it may not be possible to estimate the accurate emissions from all the sources in an area especially when the sources are temporally and spatially changing since, the emission inventories are constructed based on several assumptions as well as projections for the missing data. The primary data is often available at annual basis. Therefore, it is for these inventories to represent the dynamics of time as well as space. Numerically emissions can be validated through concentrations obtained by modeling. However, it must be noted that formulating air quality models are themselves based on assumptions in atmospheric processes. The best qualitative method to assess the emissions is to compare its trend with the observed concentrations in a decadal study such as the present study. Xia and Shao (2005) have tried to validate emissions from traffic at three intersections using air quality monitoring data of three sampling stations in Hong Kong. In the present study, emission estimates and concentrations of NO_X, SO_2 and PM_{10} are compared on yearly basis with same pollutants at monitoring station ITO (traffic intersection), in Delhi for the period of 2000–2010. The trends of concentration and emissions of NO_X and SO_2 have been captured well with correlations of 0.51 and 0.40 (Figure S7 and S8 in the SM), whereas PM_{10} shows a correlation of 0.47 (Figure 7), respectively.

4.3. Implications of the study

In the present study, emissions from 2Ws have come up as a matter of great concern. A trend analysis (*t*–test) has been carried out for the decadal contribution of different types of vehicles towards total pollution in Delhi. The results have been found statistically significant within 99% confidence interval for 2W and PCs. Moreover the same has to be realized by the policy makers, and should come up with stricter Bharat Stage IV norms for 2W in the near future. New improvements in engine technology, better fuel quality with lesser sulfur content and a mandatory evaporative emission control units should also be introduced which would further help in reducing the emissions. Three scenarios have been taken up to assess emissions from 2W in the future year of 2020.

- Scenario 1: Continuation of present emission standard as well as growth rate of 2W vehicle in 2020.
- Scenario 2: Introduction of new Bharat Stage IV emission standards (say–in 2015) leading to change in emissions in 2020.
- Scenario 3: Modification of emission factors accompanied with the reduction of growth rate of 2W on the assumption grounds of increase in the price of 2W vehicles and improvement in public transport. A case of 30% reduction has been taken up.

This assessment will further result in decrease in emissions of CO, HC and NO_X by about 88%, 67% and 40% in 2020 on application of scenario 3 (Table S3 in the SM).

Uncertainty in the emission inventory, which arises due to lack of local vehicle emission measurements and fleet characteristics, also from the discrepancy in vehicle classifications between annual statistical reports has been estimated. The vehicle kilometer travelled (VKT) numbers are estimated through surveys, since they are not available through official reports. This leads to a systematic bias in estimating emissions from mobile sources. In the present study, the daily VKT of various types of vehicles was estimated by combining the vehicles annual travel distance and number of vehicles registered. The populations of the PC, 3W, 2W, LCV, bus

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and HCV in the present study have been acquired from the Statistical Abstract of Delhi (2012) and annual kilometers travelled from Guttikunda and Calori (2013). These have been compared with the report of CPCB (2001), according to which the average distance traveled by bus, HCV and LCV was 164 km day^{-1}, 82 km day^{-1} and 109 km day^{-1} respectively, and distance travelled by 2W was around 27 km day^{-1} in Delhi. Table S4 (see the SM) shows the VKT distribution of different types of vehicles in Delhi. The total VKT used in this study seems to be consistent with the CPCB (2001) with a difference of about 9%.

Table 1. Transport emission estimates taken from previous studies and present study (2000–2005)

	Auto Fuel Policy (2002) (Gg)	Bose (1999) (Gg)	Das and Parikh (2004) (Gg)	UNEP (1999) (Gg)	Gurjar et al. (2004) (Gg)	Nagpure et al. (2013) (Gg)	Present Study (Gg)
		194 (2000)			442 (2000)	197 (2000)	192 (2000)
				339 (2001)		214 (2001)	195 (2001)
CO	154 (2002)			341 (2002)		265 (2002)	203 (2002)
				341 (2003)		300 (2003)	214(2003)
				340 (2004)		328 (2004)	228 (2004)
		192 (2005)	203 (2005)	341 (2005)		350 (2005)	244 (2005)
		40 (2000)			133 (2000)	105 (2000)	67 (2000)
				210 (2001)		114 (2001)	71 (2001)
NO_x	40 (2002)			217 (2002)		74 (2002)	67 (2002)
				217 (2003)		91 (2003)	68 (2003)
				216 (2004)		98 (2004)	73 (2004)
		192 (2005)	39 (2005)	218 (2005)		104 (2005)	76 (2005)
		60 (2000)			27 (2000)	12 (2000)	7.8 (2000)
						13 (2001)	8.4 (2001)
SO_2	(2002)					8.9 (2002)	7.6 (2002)
						9.6 (2003)	7.2 (2003)
						10 (2004)	7.9 (2004)
		(2005)	3.5 (2005)			11 (2005)	8.2 (2005)
						8^a (2000)	8.5 (2000)
				12^a (2001)		8.4^a (2001)	9.1 (2001)
PM_{10}	4.7^a (2002)			13^a (2002)		7.7^a (2002)	8.5 (2002)
				13^a (2003)		8.8^a (2003)	8.6 (2003)
				13^a (2004)		9.6^a (2004)	9.3 (2004)
		8 (2005)	5.4^a (2005)	13^a (2005)		10^a (2005)	9.8(2005)

^{a} *Denotes TSP emissions*

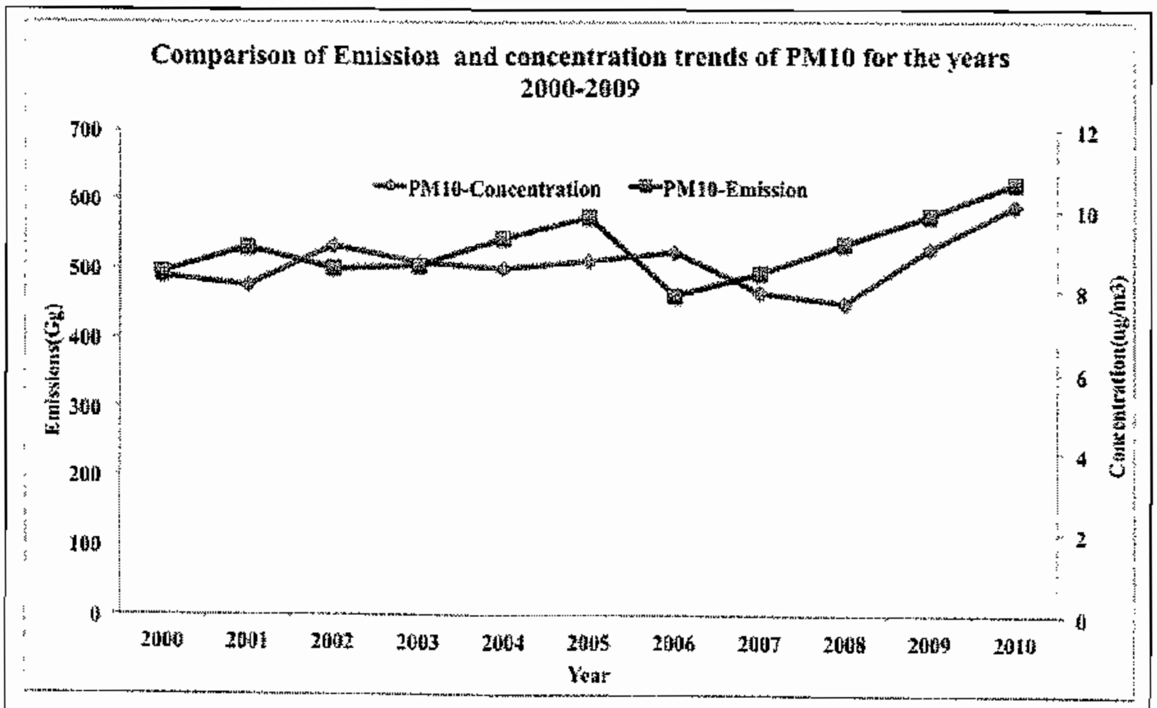

Figure 7. Comparison of emission and concentration trends of PM_{10} for 2000–2009.

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5. Conclusions

An attempt has been made to compile a decadal (2000–2010) emission inventory of the CO, NO_X, SO_2, PM_{10}, CH_4, VOC, BC, OC and Pb for the transport sector of Delhi. The emissions of all the pollutants except for SO_2 have shown an increasing trend during the decade. The main findings of this study are as follows:

- Emissions of CO, HC, VOC, CH_4 and Pb show an increasing trend during 2000–2010 in which 2Ws are contributing maximum emissions followed by passenger cars.
- Emissions of NO_X, SO_2, PM_{10}, EC and OC are found to show a decrease between 2001–2003, which is probably due to implementation of CNG and phasing out of old vehicles. Again, after 2003, an increasing trend in emissions is supported by the rise in the vehicular population of Delhi.
- A steep fall in emissions of NO_X, SO_2, PM_{10}, BC and OC is observed in 2006 as compared to 2005. The reason can be attributed to the implementation of stricter emission Bharat Stage III norms on all private and city vehicles in 2005. Diesel buses mainly contributed towards SO_2 emissions during 2000–2005, which were either completely phased out or replaced with CNG. Also, number of total buses plying on Delhi roads decreased by 16% from 55 747 in 2005 to 46 581 in 2006.
- Diesel vehicles are found to be the major contributors towards PM_{10}, BC and OC emissions, which reduced considerably in 2006 due to implementation of CNG and Bharat Stage III norms.
- Finally, one can conclude that implementation of CNG in the public transport and introduction of Bharat stage III norms has resulted in reduction in emissions of air pollutants but its effect was largely nullified by the tremendous increase in private gasoline vehicles.

Acknowledgments

The authors would like to thank Central Pollution Control Board (CPCB), Delhi for the data of the observed average ambient concentrations of criteria pollutants. The authors also acknowledge the financial and infrastructural support provided by Indian Institute of Technology Delhi for the study.

Supporting Material Available

Emission factors for road vehicles (g km^{-1}) (Table S1), Comparison of transport emission estimates taken from Goyal et al. (2013) and present study for the year 2008–2009 (Table S2), Reduction in emissions on application of three different scenarios (Table S3), Uncertainty estimates w.r.t Vehicle Kilometer Travelled (Table S4), Annual HC emissions from transport sector of Delhi, 2000–2010 (Figure S1), Annual VOC emissions from transport sector of Delhi, 2000–2010 (Figure S2), Annual CH4 emissions from transport sector of Delhi, 2000–2010 (Figure S3), Annual BC emissions from transport sector of Delhi, 2000–2010 (Figure S4), Annual OC emissions from transport sector of Delhi, 2000–2010 (Figure S5), Annual Pb emissions from transport sector of Delhi, 2000–2010 (Figure S6), Comparison of emission and concentration trends of NO_x for 2000–2009 (Figure S7), Comparison of emission and concentration trends of SO_2 for 2000–2009 (Figure S8). This information is available free of charge via the Internet at http://www.atmospolres.com.

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SUPPORTING MATERIAL

Assessment of traffic-generated gaseous and particulate matter emissions and trends over Delhi (2000-2010)

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Figure S6. Annual Pb emissions from transport sector of Delhi, 2000-2010.

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Table S1. Emission factors ($E_{i,j\,g\,km^{-1}}$) for road vehicles (g/km)

	Bus-CNG	Bus-Diesel	PCs	PCs- CNG	3W-Gasoline	3W-CNG	2W-2S	2W-4S	LCV	HCV
CO	3.18[a]	4.5[b]	1.98[b]	0.78[b]	4.47[e]	2.09[c]	1.37[e]	4.47[e]	3.66[e]	3.97[e]
HC	1.95[c]	1.21[b]	0.25[b]	1.55[b]	1.57[e]	0.16[e]	2.53[e]	1.57[e]	1.35[e]	0.26[e]
NOx	5.35[c]	12[b]	0.2[b]	0.92[b]	0.61[e]	0.69[e]	0.2[e]	0.61[e]	2.12[e]	6.77[e]
PM_{10}	0.0065[i*]	1.213	0.03[b]	0.02[b]	0.011[e]	0.347[e]	0.045[e]	0.011[e]	0.475[e]	1.075[e]
SO_2	0[b]	2[i]	0.053[f]	0[f]	0.029[f]	0[h]	0.023[f]	0.023[f]	0.37[f]	0.37[f]
Pb	0[i]	0[i]	0.003[f]	0[l]	0[l]	0[j]	0.003[j]	0.002[j]	0[f]	0[f]
VOC	1.33[j]	1.6[d]	2.5[d]	1.9[j]	1[e]	2.05[g]	2.13[a]	0.7[a]	1.6[d]	1.6[d]
CH_4	6.5[g]	0.09[k]	0.17[k]	2.28[g]	0.08[g]	1.3[g]	0.18[k]	0.18[k]	0.09[g]	0.09[g]
BC	0.002[g]	1.52[g]	0.16[g]	0.001[g]	0.01[g]	0.008[g]	0.013[l]	0.013[l]	1.12[l]	1.24[l]
OC	0.005[g]	1.48[g]	0.17[g]	0.003[g]	0.19[g]	0.024[g]	0.015[l]	0.015[l]	0.42[l]	0.48[l]

[a] Iyer (2002)
[b] Mashelkar et al.(2002)
[c] Narain and Krupnick (2007)
[d] Gurjar et al. (2004)
[e] ARAI (2007)
[f] UNEP(1999)
[g] Reynolds and Kandlikar (2008)
[h] CPCB(2010)
[i] TERI (2006)
[j] Nagpure et al. (2013)
[k] Ramachandra and Shwetmala (2009)
[l] values were not available from either of the sources , so value was taken as 35% and 72% less than $PM_{2.5}$ EF for BC and OC respectively
[*] values for PM_{10} EF were not available from either of the sources, so value was taken 35% less than TSP EF for PM_{10}

Table S2. Comparison of transport emission estimates taken from Goyal et al., 2013 and IIT study for the year 2008-2009

Pollutants (Gigagrams)	Goyal et al. (2013) (for the year 2008-09)	Present Study (for the year 2008-09)
CO	186	298
NO_x	70	75
PM_{10}	5	9.1

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Table S3. Reduction in emissions on application of three different scenarios

	2010	Scenario 1 (2020)	Scenario 2 (2020)	Scenario 3 (2020)
CO	258	100%	25%*	44%*
HC	261	100%	10%*	34%*
NO_x	82	127%	14%*	42%*

* Denotes represents reduction w.r.t scenario 1 PM_{10} has not been considered in Table 1 due to unavailability of the EFs for Bharat stage IV.

Table S4. Uncertainty Estimates w.r.t Vehicle Kilometer Travelled

Vehicle Type	VKT (Transport fuel quality, 2005) (km/year)	VKT (IIT Study) (km/year)
PCs	15000	10000
Buses	60000	50000
HCV	30000	30000
LCV	40000	30000
2W	10000	27000
3W	45000	36000
Total	200000	183000

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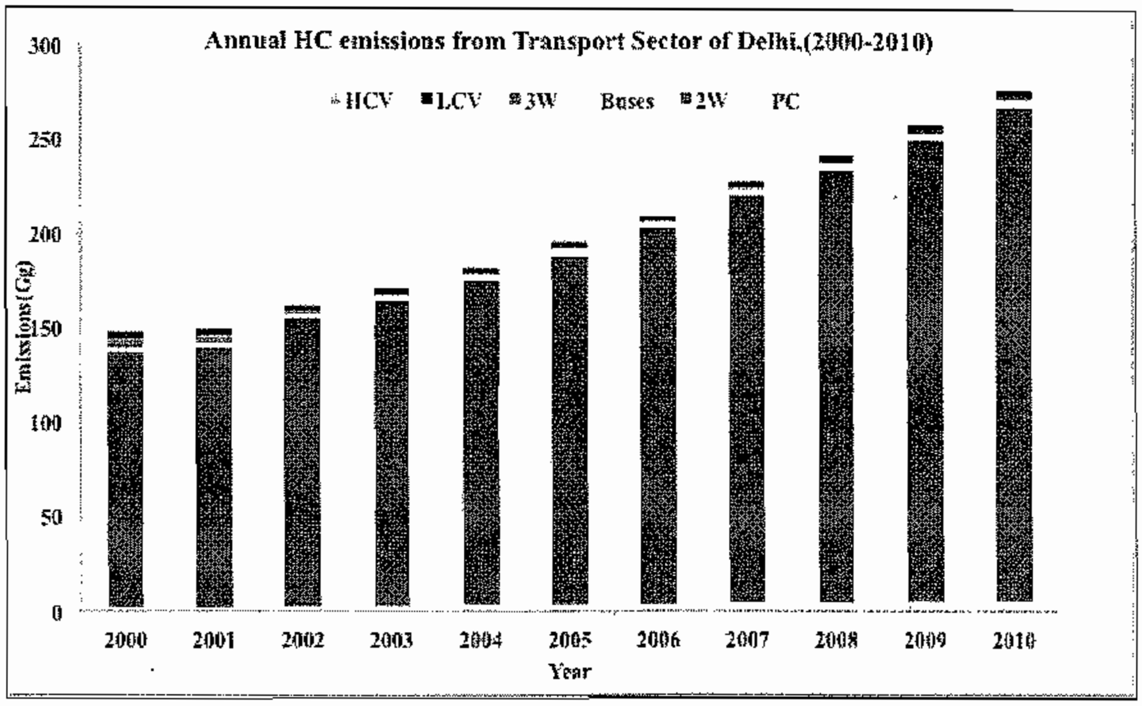

Figure S1. Annual HC emissions from transport sector of Delhi, 2000-2010.

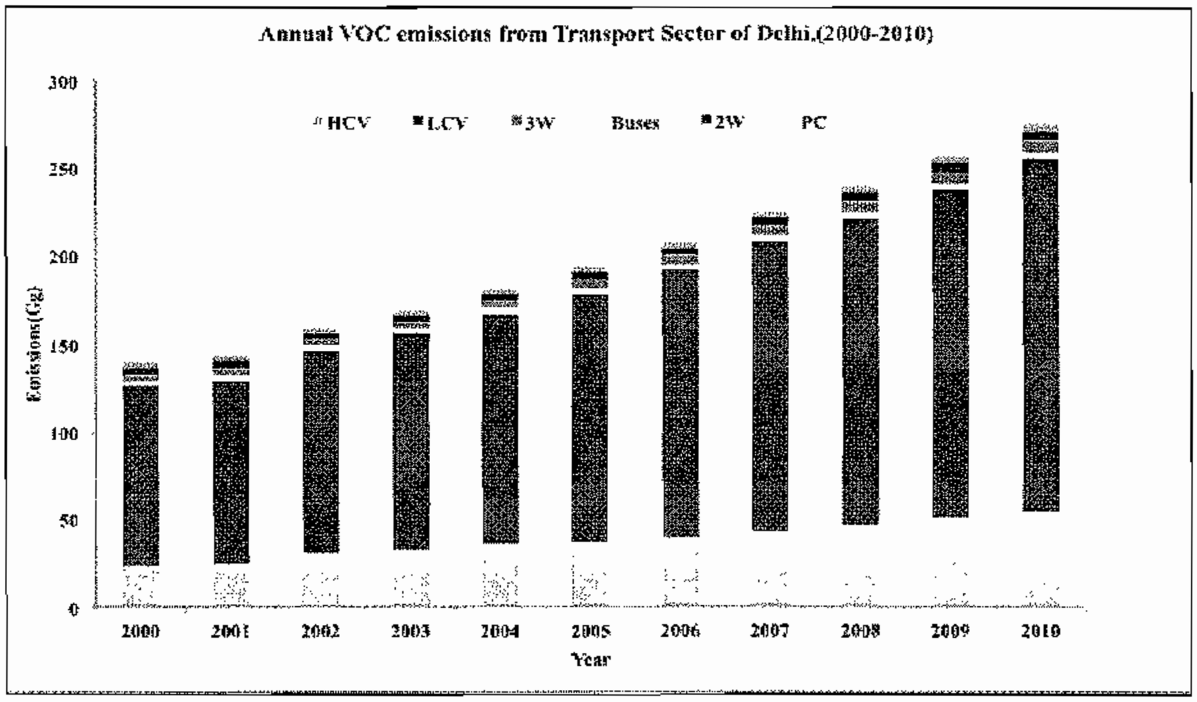

Figure S2. Annual VOC emissions from transport sector of Delhi, 2000-2010.

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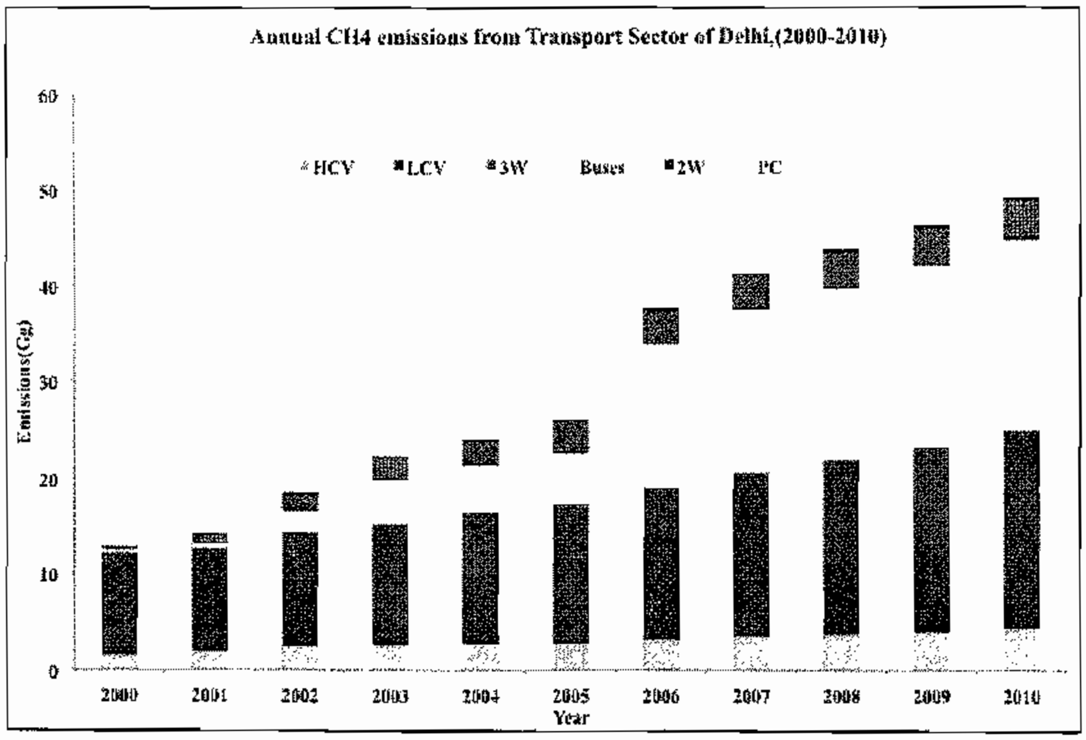

Figure S3. Annual CH_4 emissions from transport sector of Delhi, 2000-2010.

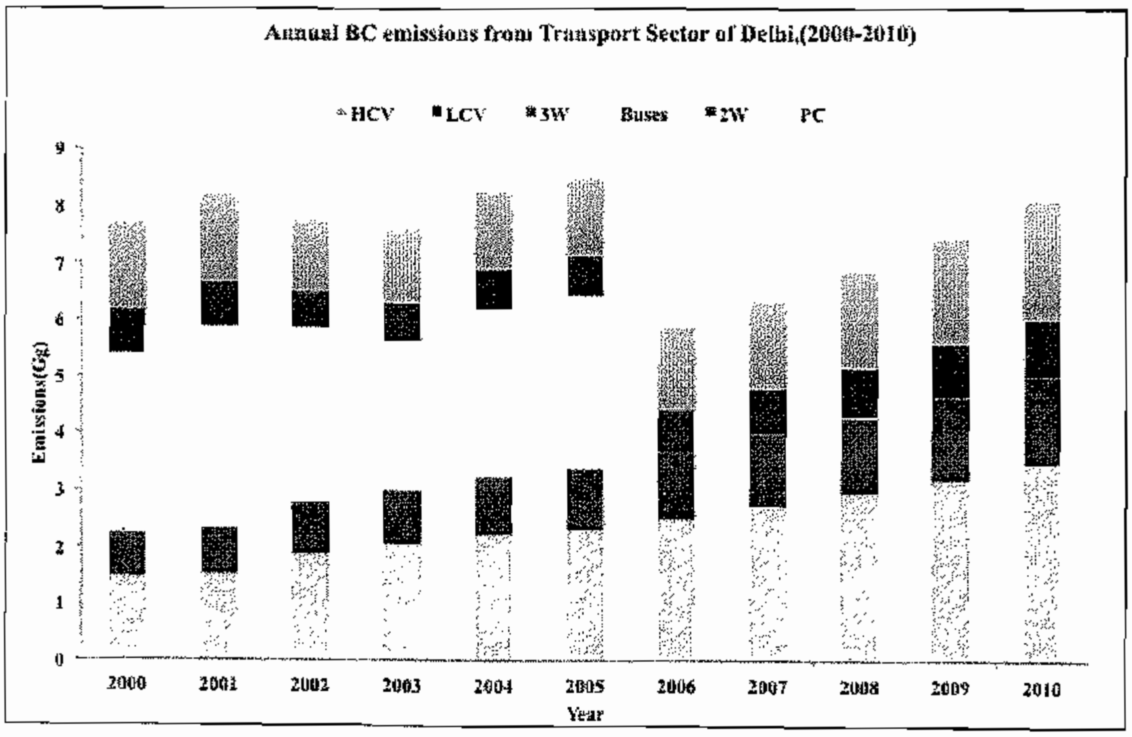

Figure S4. Annual BC emissions from transport sector of Delhi, 2000-2010.

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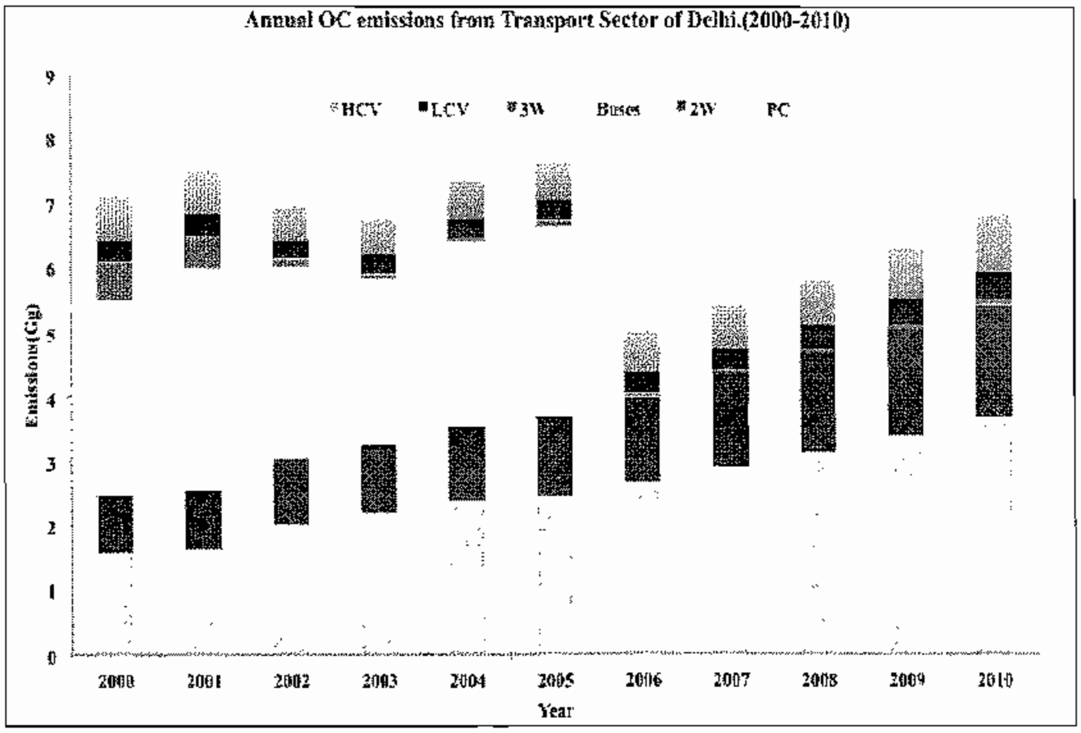

Figure S5. Annual OC emissions from transport sector of Delhi, 2000-2010.

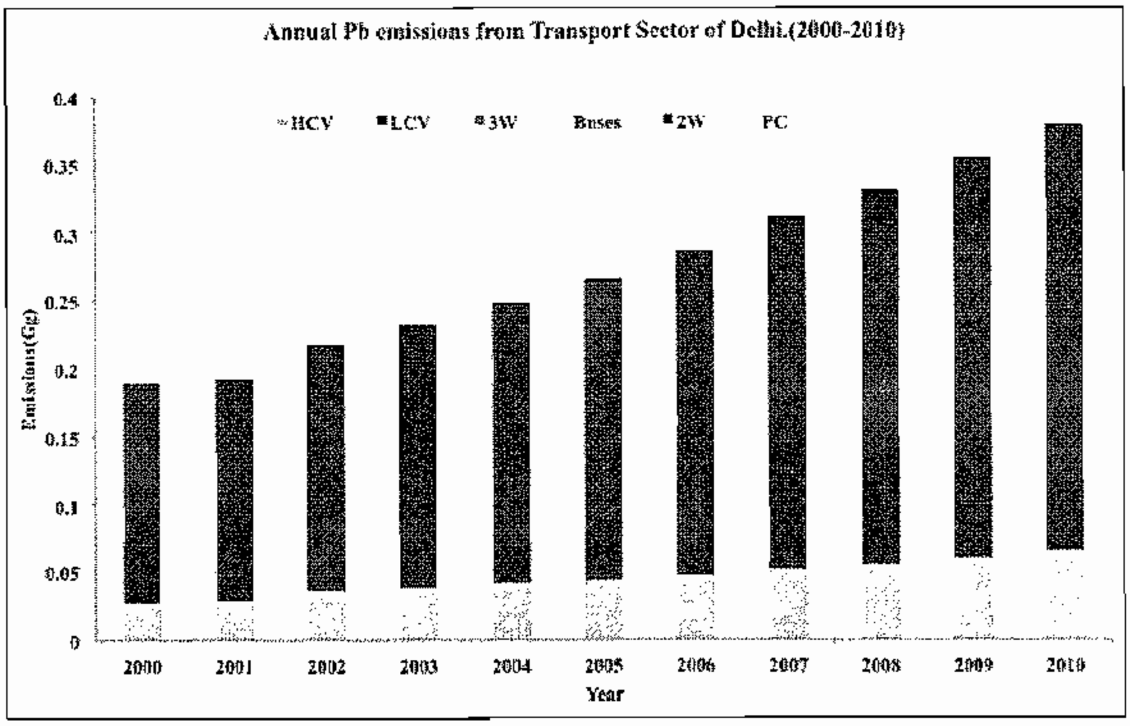

Figure S6. Annual Pb emissions from transport sector of Delhi, 2000-2010.

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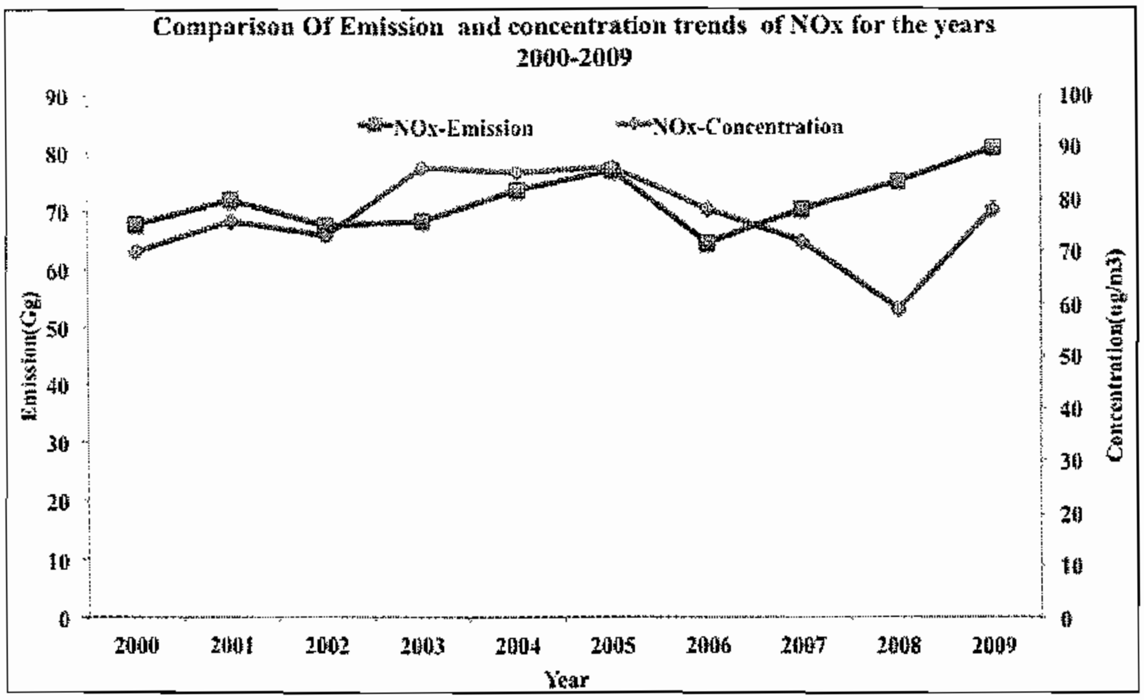

Figure S7. Comparison of emission and concentration trends of NO_x for (2000-2009).

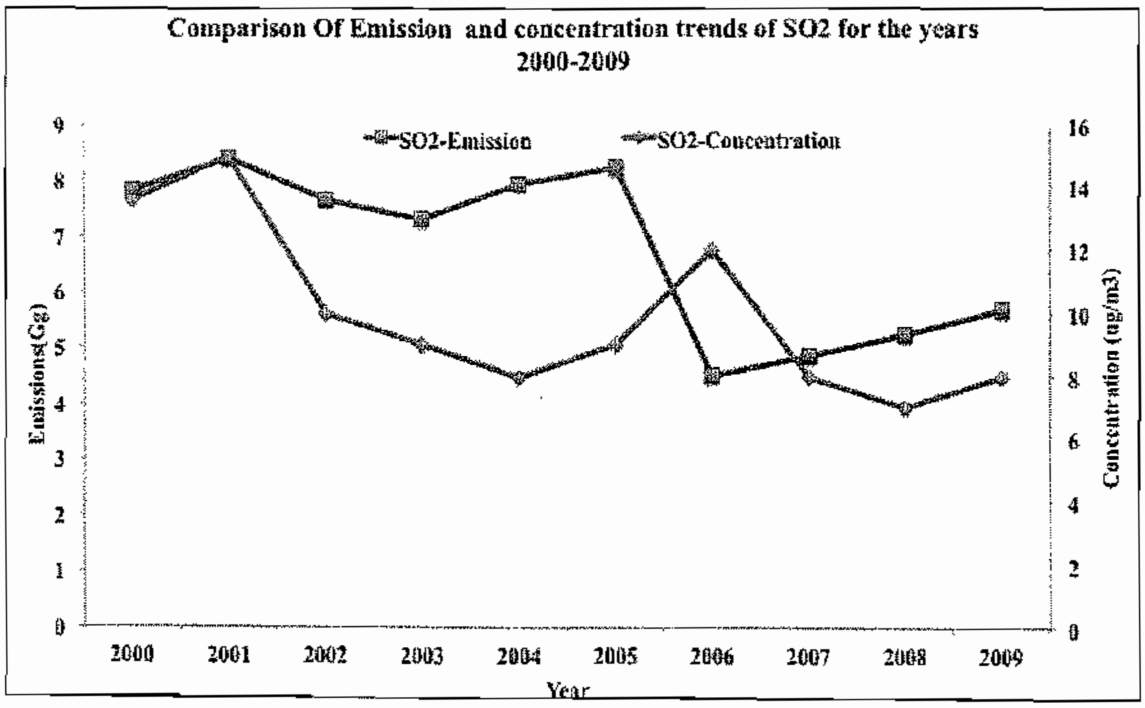

Figure S8. Comparison of emission and concentration trends of SO_2 for (2000-2009).

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On-road emissions of CO, CO_2 and NO_X from four wheeler and emission estimates for Delhi

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ABSTRACT

This study presents the emission factor of gaseous pollutants (CO, CO_2, and NO_X) from on-road tailpipe measurement of 14 passenger cars of different types of fuel and vintage. The trolley equipped with stainless steel duct, vane probe velocity meter, flue gas analyzer, Nondispersive infra red (NDIR) CO_2 analyzer, temperature, and relative humidity (RH) sensors was connected to the vehicle using a towing system. Lower CO and higher NO_X emissions were observed from new diesel cars (post 2010) compared to old cars (post 2005), which implied that new technological advancement in diesel fueled passenger cars to reduce CO emission is a successful venture, however, the use of turbo charger in diesel cars to achieve high temperature combustion might have resulted in increased NO_X emissions. Based on the measured emission factors (g/kg), and fuel consumption (kg), the average and 95% confidence interval (CI) bound estimates of CO, CO_2, and NO_X from four wheeler (4W) in Delhi for the year 2012 were 15.7 (1.4–37.1), 6234 (386–12,252), and 30.4 (0.0–103) Gg/year, respectively. The contribution of diesel, gasoline and compressed natural gas (CNG) to total CO, CO_2 and NO_X emissions were 7:84:9, 50:48:2 and 58:41:1 respectively. The present work indicated that the age and the maintenance of vehicle both are important factors in emission assessment therefore, more systematic repetitive measurements covering wide range of vehicles of different age groups, engine capacity, and maintenance level is needed for refining the emission factors with CI.

Introduction

Due to urbanization and motorization, on-road vehicles have significant apportion to regional and global climate change issues and also adversely affects human health. Passenger cars emit substantial quantities of pollutants such as hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxides (NO_X), Sulfur oxides (SO_2) and particulate matter (PM) (Ramachandra and Shwetmala, 2009). For real-world emission assessment of vehicles, viable studies need to characterize the mixture of gas and particles under typical driving condition in urban environments where gases would appear soon after exiting the source, cooling, and equilibrating to ambient conditions (Lipsky and Robinson, 2005; Giechaskiel et al., 2014; Wang et al., 2012). Previous studies have been approached to characterize vehicle emissions including chassis dynamometer studies (Zielinska et al., 2004; Lim et al., 2006; Fontaras et al., 2007, 2012), remote sensing studies (Carslaw et al., 2011; Schifter et al., 2008; Hueglin et al., 2006), tunnel studies (Gillies et al., 2001; McGaughey et al., 2004; Phuleria et al., 2006; Handler et al., 2008), and on-board studies (Liu et al., 2009; Weiss et al., 2011; Bishop et al., 1996).

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Generally, vehicle and engine emissions are performed by engine and chassis dynamometer but these facilities are associated with very high cost (Wang et al., 2012) and do not represent the real-world emissions. Remote sensing and tunnel studies represent only the emissions on the road fleet, but real-world emissions could be more variable depending upon technology, driver's habit, road conditions, traffic flow, etc. (Chen et al., 2007; Fontaras et al., 2012).

Recently, few studies have measured on-road emission factor of gaseous pollutant (Choudhary and Gokhale, 2016) and particulate matter (Wang et al., 2012). However, such efforts are very limited and in developing countries, numerous factors such as road fleet, driving pattern, driver's behavior, engine capacity, fuel composition, and road conditions pose great challenge in on-road measurement. According to Intergovernmental Panel on Climate Change (2007) the tier 2 emission estimates need detailed information of regional source emission profile and activity data. Following tier 2 methodology to improve emission estimate from road transport sector a large data set on vehicular emissions encompassing effect of all possible region specific variables is needed. The region specific information on activity data including in-use technology, fuel adulteration, annual vehicle run, and vehicle mileage are also important.

Therefore, this article presents the emission factor of CO, CO_2, and NO_X (a precursor of aerosol) from on-road measurement of diesel, gasoline, and compressed natural gas (CNG) passenger cars in Indian Institute of Technology (IIT) Delhi Campus. The study also aimed to estimate fuel use in passenger car using on-road vehicle population of various age groups, vehicle annual travel and vehicle mileage.

1. Materials and methods

1.1. Experimental set-up

A trolley (Fig. 1) equipped with sampling system consists of stainless steel heated duct (0.06-m-diameter, 1.0-m-long), vane probe velocity meter, flue gas analyzer, and relative humidity (RH) and temperature measuring device was connected to the tailpipe of the vehicle with a flexible connection pipe and hose. The trolley followed the vehicle driven by the vehicle owner on the fixed route (3.9 km) inside the IIT Delhi Campus (Fig. 2). The exhaust from the vehicle tailpipe was entrained inside the stainless steel duct and the concentration of gaseous pollutants (CO, CO_2, and NO_X) in ppm, exhaust velocity (m/s), temperature (°C), and RH (%) were monitored each minute. A flue gas analyzer (Testo India Pvt. Ltd., model Testo 350XL) based on electrochemical sensors to measure NO_X (0–500 ppm), SO_2 (0–5000 ppm), and CO (0–10,000 ppm), and Nondispersive infra red (NDIR) sensor to measure CO_2 (0–50%) was used. A vane probe velocity meter (Testo 0635–6045), was deployed to measure the velocity in the range of 0.6–20 m/sec of hot gas (0–350°C). Relative humidity was monitored using an RH sensor (model PEM.EM.HFB-2, range 0–100% from Polltech Instrument Pvt. Ltd.). The specifications of various instruments are published in Jaiprakash et al. (2016). The ambient CO_2 concentration was also determined before each experiment using NDIR based CO_2 analyzer (Testo 445). Data from all the instruments were collected in the 8 multi-channel (ATOMBERG Model: AB 102, Mumbai, India) data acquisition system in real time. The mobile sampling system, with instruments and one person for monitoring that weighted around 130 kg was driven by vehicle. Therefore, the experiments can be considered as done on fully loaded vehicle. The emissions from 8 gasoline, 3 diesel vehicles and 3 CNG of pre 2005, post 2005 and post 2010 (Table 1) were assessed. The diesel and gasoline fuel used in India (Delhi NCR) typically composed of 10 mg/kg of sulfur, the octane number is 95 for gasoline, and the cetane number is 52–54 for diesel.

1.2. Emission factor

The concentrations (C, g/m³) of CO, NO_X (NO, and NO_2 in ppm) and CO_2 (%) were converted into and corrected for standard temperature and pressure (STP: 25°C, 1 atmospheric pressure). Similarly, exhaust velocity (V, in m/sec) was also corrected for STP and the total exhaust volume was calculated by multiplying with duct area A_d (m²). The total mass of pollutant emitted during the experiment was calculated by multiplying the emission rate (g/sec) with sampling time t (sec). The emission factor was calculated as grams of pollutant emitted per km of distance traveled (d) using Eq. (1). Fuel based emission factors (EF (g/kg)) were calculated following Eq. (2).

$$\mathrm{EF} = \frac{C \times V \times A_d \times t}{d} \tag{1}$$

$$\mathrm{EF} = \frac{\mathrm{EF} \times \text{Vehicle mileage (km/L)}}{\text{fuel denstiy (kg/L)}} \tag{2}$$

Previous studies suggests that on-road diesel and gasoline cars consume 17%–25% more fuel than the rated mileage

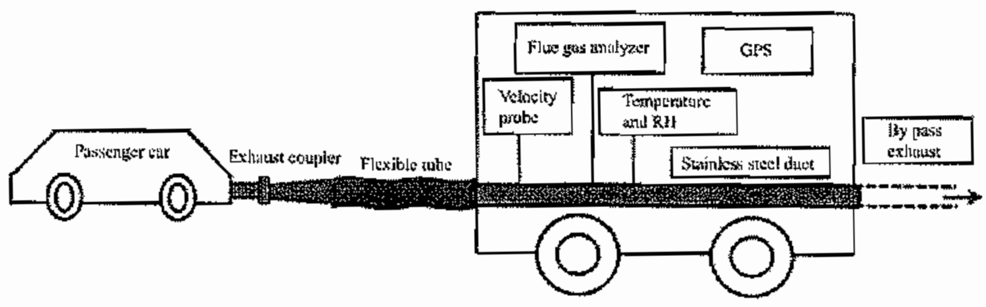

Fig. 1 – On-road mobile sampling system and measuring instruments.

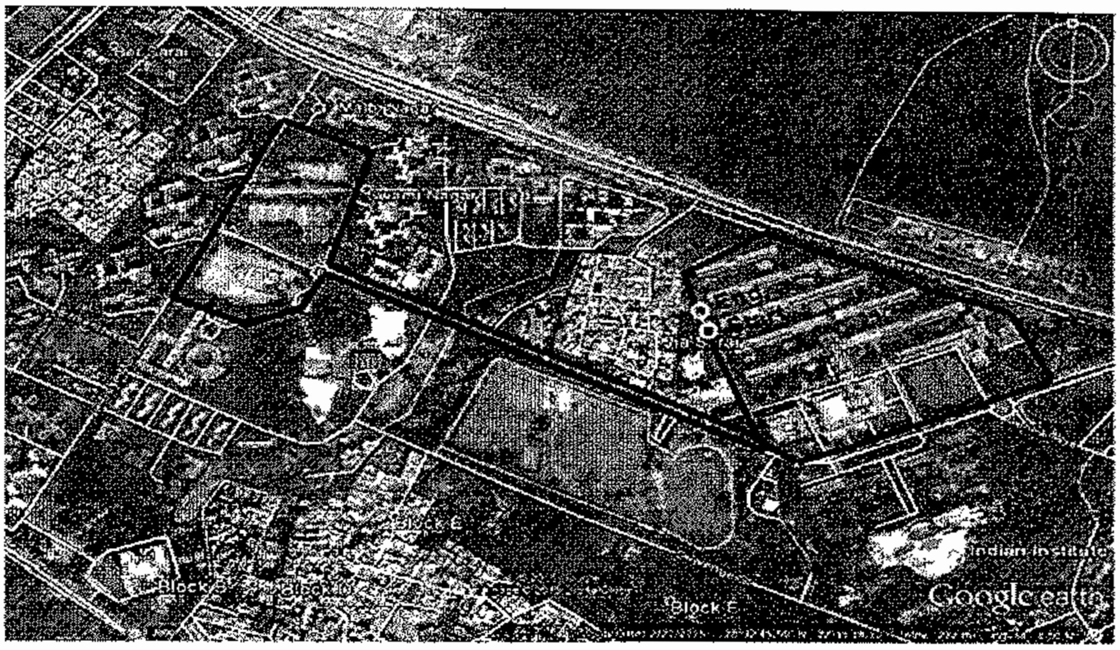

Fig. 2 – Selection route for on-road emission measurement at IIT campus. IIT: Indian Institute of Technology.

(Cames and Helmers, 2013) for new vehicle reported based on dynamometer assessment. The rated mileage of vehicles was recorded for each type of vehicles tested here and the same was reduced by 25% to estimate on-road mileage. The values of estimated mileage were close to those reported by Goel et al. (2015) for diesel, gasoline and CNG fueled four wheelers. Fuel densities of diesel and gasoline vehicle were collected by Society of Indian Automobile Manufacturers (SIAM) (2010).

1.3. *Emission estimate*

Total emission for year 2012 (E_n) of a given pollutant (n) from four wheelers for each fuel type (k) was estimated using fuel use (F_k) (kg) and emission factor ($EF_{k,n}$) (g/kg).

$$E_n = \sum_k F_k \times EF_{k,n} \tag{3}$$

The consumption of diesel and gasoline by different categories of vehicle (*e.g.* 4-wheeler, 3-wheeler, and 2-wheeler) is reported as percentage, however, total mass based consumption of each type of fuel has not been reported. Therefore, in the present study, fuel consumption (F_k) of type k for 4-wheelers was calculated for Delhi city following He et al. (2005). The fuel consumption was estimated using (1) registered vehicle population (N) reported by Ministry of Road Transport and Highways (2012), (2) on-road fraction of vehicle of each category reported by Pandey and Venkataraman (2014) for India, (3) annual distance traveled (Vm) by vehicle in 1000 km reported by Goel and Guttikunda (2015), (4) fuel density F_d (kg/l) reported by Society of Indian Automobile Manufacturers (2010) for fuel used in India and (5) vehicle mileage Fe_k of vehicle category k (km/L) reported by Goel and Guttikunda (2015). Fuel use estimation can be expressed as Eq. (4).

$$F_k = \sum_k \frac{N * r * Vm * F_d}{Fe_k} \tag{4}$$

Total passenger cars, taxis and jeeps registered in Delhi from year 1951–2012 were reported in Ministry of Road Transport and Highways (2012). The historical year wise cumulative registration data for 4-wheeler (cars, taxis, jeep) from 1951 to 2012 is reported at national level. From year wise historical data the fraction of 4W registered in 30 years (1982–2012) at national level was derived. The same fraction was applied on cumulative registration data (1951–2012) of passenger cars, taxis and jeeps for Delhi and the vehicles registered in 30 years (1982–2012) were estimated. The on-road population of these vehicles was estimated by using the fraction of onroad population to registered population, reported by Pandey and Venkataraman (2014) for 4W. The taxis and jeeps are reported as diesel fueled vehicles by Pandey and Venkataraman, (2014). However in the case of passenger cars all the three types (diesel, gasoline and CNG) of vehicles are reported together. Therefore, we first deducted the cumulative number of CNG passenger cars from year 1999 to 2012 reported by Ministry of Petroleum and Natural Gas (2012) and considered the rest as diesel and gasoline fueled passenger cars.

The fraction of diesel and gasoline fueled passenger cars was initially assumed as 0.5 each. The annual distances traveled by 4W diesel, gasoline and CNG fueled vehicles were reported by Goel and Guttikunda (2015) and same were used in present work. The fuel mileage of each vehicle category was used to estimate liter of diesel and gasoline and kg of CNG consumed. The fuel density reported for diesel and gasoline (Society of Indian Automobile Manufacturers, 2010) was used to convert consumption in kg. The assumed fraction of diesel and gasoline fueled passenger cars was revised until the estimated fuel consumption matched with the national level consumption of gasoline and diesel reported by the Ministry of Petroleum and Natural Gas (MOPNG) (2012) from survey of retail outlets in states consuming 85% of the total. The final fraction of diesel

Table 1 – Characteristics of selected passenger cars.

Vehicle make	Model	Year	Fuel	Odometer (km)	Engine capacity (cc)	After treatment devices
Maruti Suzuki	Eeco	2008	CNG	90236	1196	2W catalyst
Maruti Suzuki	Eeco	2010	CNG	53234	1196	3W catalyst
Maruti Suzuki	Eeco	2012	CNG	32238	1196	3W catalyst
Toyota	Innova	2006	Diesel	81345	2400	DOC
Hyundai	Verna	2008	Diesel	66300	1582	DOC
Hyundai	Accent	2011	Diesel	46500	1599	DOC
Hyundai	Santro	2001	Gasoline	43250	1086	2W catalyst
Honda	City	2003	Gasoline	40105	1497	2W catalyst
Maruti Suzuki	Wagon R	2005	Gasoline	65800	1197	2W catalyst
Maruti Suzuki	Swift	2008	Gasoline	55623	1197	2W catalyst
Hyundai	Santro	2010	Gasoline	56228	1086	3W catalyst
Hyundai	Accent	2010	Gasoline	45345	1599	3W Catalyst
Maruti Suzuki	Swift Dzire	2010	Gasoline	25678	1197	3W catalyst
Toyota	Etios	2013	Gasoline	15234	1496	3W catalyst

2W catalyst: BS-III two-way catalytic convertor; 3W catalyst: BS-IV three-way catalytic convertor; DOC: Diesel oxidation catalyst.

and gasoline cars was found as 0.35 and 0.65 respectively at national level. This same fractions were applied on on-road population of combined passenger cars for Delhi city and the number of diesel and gasoline fueled cars were calculated.

The age distribution reported by Goel et al. (2015) was used to derive the number of on-road vehicle of various age groups. The age distribution for on-road diesel passenger cars comprised of 4% (11–30 years), 27% (6–10 years), and 69% (0–5 years) while the age distribution for gasoline and CNG driven vehicles was taken as 16% (11–30 years), 32% (6–10 years) and 52% (0–5 years). Thus, fuel use was estimated for vehicles of various age groups.

1.4. *Uncertainties*

The uncertainties in emissions were calculated by propagation of uncertainties (standard deviation ÷ mean) on emission factors, vehicle population, vehicle annual distance travel, and vehicle mileage using statistical method. The propagated standard deviation around mean emission was multiplied by 1.96 and applied on mean value to derive lower and upper bound at 95% confidence interval (CI). The uncertainties on on-road vehicle population and distance traveled were taken as 10%, while it was assumed as 20% on vehicle mileage (Pandey and Venkataraman, 2014). The uncertainties on emission factors were derived either from estimated standard deviation from 3 or more numbers of experiments or assumed 125% (i.e., maximum uncertainty observed in present work for CO) and applied for single values. In the case of two values available for any vehicle, we used geometric mean and geometric standard deviation for propagation.

2. Results and discussion

2.1. *On-road measured emission factor*

The emission factors of CO, CO_2 and NO_X for diesel, gasoline and CNG passenger cars are compared with values reported in literature (Table 2). The emission factors of CO, CO_2 and NO_X from diesel vehicle for the post 2010 were 0.13 ± 0.10, 556 ± 261, and 3.1 ± 2.9 g/km, respectively. The present average CO emission factor is little higher than values reported in literature (Hu et al., 2012; ARAI, 2008), however, the CO_2 and NO_X emission factors are respectively 3.7 times, and 3.3 to 12 times higher than values reported in literature (Table 2). The CO/CO_2 ratios (in percentage) indicate the proportion of unburned gases and are used as indicator of engine maintenance (Pierson et al., 1996; Chiang et al., 2008; Chen et al., 2007). With vehicle aging and poor maintenance, the catalyst deteriorates over time, resulting in higher CO and NO_X emissions. The standard CO/CO_2 ratio for a Euro-III vehicle is 0.04% (Table 2). Our CO/CO_2 ratio for post 2010 diesel vehicle was (0.02%) lower than the standard value indicating good maintenance of vehicle and proper working of catalytic convertor (diesel oxidation catalyst).

The geometric mean and range of CO, CO_2 and NO_X emission factors for two post 2005 diesel fueled vehicles were 0.2 (0.1–0.4), 138.0 (128.0–151.0), and 1.1 (0.8–1.3) g/km respectively (Table 2). For post 2005 diesel vehicles the average CO emission factor was 1.7 times higher than post 2010 vehicles, while the CO_2 and NO_X emission factors for post 2005 were 3–4 times lower than the values for post 2010 vehicles. For post 2005 vehicles the CO/CO_2 ratio (0.17%) was higher than standard CO/CO_2 ratio of Euro-III (0.04%) implying the poor maintenance of post 2005 vehicles.

The CO, CO_2 and NO_X emission factors for single post 2010 gasoline fueled vehicle were 0.14 ± 0.18, 512 ± 640, and 2.2 ± 2.8 g/km respectively (Table 2). The standard deviation is derived from the highest coefficient of variance observed in the case of NO_X emission factor measured for post 2000 gasoline fueled vehicles (3 Nos.). The emission factors of CO and NO_X reported by Choudhary and Gokhale (2016) for gasoline vehicles with odometer reading of 9200 km for free flow condition were 0.18 ± 0.15 and 0.05 ± 0.04 g/km respectively. Our CO emission factor for post 2010 vehicle is within the range reported by Choudhary and Gokhale (2016) and NO_X emission factor from the present study is higher than the values reported by Choudhary and Gokhale (2016). The vehicle used in present work was traveled comparably greater distance 46,500 km (Table 1) than the vehicle used by Choudhary and Gokhale (2016). Also the emissions of CO, NO_X strongly depend

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Table 2 – Measured distance based emission factor (g/km) from on-road operation of passenger cars.

Vehicle type	Present study				Literatures		
	CO	CO_2[#]	NO_X	CO/CO_2 (%)[$]	CO	CO_2[#]	NO_X
4W-diesel							
Post 2005 (n = 2)[+]	0.2 (0.1–0.4)	1.4 (1.3–1.5)	1.1 (0.8–1.3)	0.02 (0.04)	(0.1–1.7)[a, c, h, m, q, s]	1.50[a]	(0.22–4.60)[a, c, h, m, q, s]
Post 2010 (n = 1)[*]	0.13 ± 0.10	5.6 ± 2.6	3.1 ± 2.9	0.17 (0.04)	(0.01–1.5)[c, f, h, q]	(1.30–2.00)[f]	(0.33–0.93)[c, f, h, q]
4W-gasoline							
Pre 2005 (n = 3)	1.60 ± 0.24	1.9 ± 0.6	0.8 ± 1.0	0.03 (0.43)	(0.10–14.3)[a–b, c–d, f–i, k–l, n–p, r–s]	(1.03–2.80)[a–b, d, f–i, s]	(0.01–1.81)[a–b, c–d, f–i, k–l, n–p, r–s]
Post 2005 (n = 4)	3.70 ± 2.70	2.0 ± 0.2	0.8 ± 0.8	1.90 (0.47)	(0.10–6.00)[a, c, f, h, n–o]	(1.41–2.83)[a, f–g]	(0.02–1.92)[a, c, f, h, n–o, r]
Post 2010 (n = 1)[*]	0.14 ± 0.18	5.1 ± 6.4	2.2 ± 2.8	0.81 (0.21)	(0.20–1.90)[c, f, h, i, r]	(1.10–2.41)[f]	(0.01–0.50)[c, f, h, i, r]
4W-CNG							
Post 2005 (n = 2)[+]	0.5 (0.4–0.6)	0.5 (0.4–0.7)	0.01 (0.01–0.02)	0.61 (0.47)	(0.20–0.80)[b]	(1.04–1.60)[b]	(0.12–0.42)[b]
Post 2010 (n = 1)[*]	0.16 ± 0.20	0.2 ± 0.3	0.08 ± 0.10	1.01 (0.21)	–	–	–

Vintage group classifications (Post 2000: 2000–2005; Post 2005: 2006–2010; Post 2010: 2010–2015 modeled age vehicles; –: not measured; CNG; compressed natural gas.

[a–e]Based on chassis dynamometer measurements from [a–b]ARAI (2008, 2009), [c]Alves et al. (2015), [d]Ntziachristos and Samaras (2000), [e]Chen et al. (2007).

[f–k]Based on on-board measurements from [f]Chikhi et al. (2014), [g]Boughédaoui et al. (2008), [h]Weiss et al. (2011), [i]Choudhary and Gokhale (2016), [j]Adak et al. (2016), [k]Wang et al. (2014).

[m–t]Based on on-road measurements from [l]Yao et al. (2007), [m]Yao et al. (2011), [n]Wang et al. (2008), [o]Oliver et al. (2009), [p]Oliver (2008), [q]Huo et al. (2012a), [r]Huo et al. (2012b), [s]Hu et al. (2012).

[+] Given geometric mean and range for $n = 2$ experiment.

[*] Calculated maximum uncertainty 125% for given one standard deviation.

[#] CO_2 emission factor $10^2 \times$ g/km.

[$] Given maintenance indicator as (CO/CO_2) in % and in bracket value reported from Euro II, III, and IV-standard.

on driving cycle and fuel combustion rate (Chen et al., 2007) therefore, by investigating more numbers of vehicles of same age group which have approximately close odometer reading would provide a better idea about the emissions.

The average emission factors of CO, CO_2, and NO_X for post 2005 gasoline vehicles (5 Nos.) were 3.70 ± 2.70, 196 ± 19, 0.80 ± 0.76 g/km respectively (Table 2). The variations in CO and NO_X emission factors are as high as 73% and 95% respectively. The post 2005 gasoline fueled vehicles used in present work were traveled 15,000–56,000 km. The emissions of CO and NO_X showed opposite trend with odometer reading (Fig. 3). The CO/CO_2 ratio is an indicator of vehicle maintenance that also increased with increasing odometer reading implying poor maintenance of vehicles which have traveled long distances. Previous studies (Choudhary and Gokhale, 2016; Alves et al., 2015) have shown that the CO emission is highly sensitive and it increases with increase in traveled distance however, NO_X emission did not show such increase. One should note the emission factors reported in present work are from limited measurements however, by increasing the number of repeated measurement of same vehicle the relationship between emission and vehicle age, distance traveled and maintenance can be refined. Average emission factor of CO_2 from present work is close to the values reported in literatures (Chikhi et al., 2014; Boughédaoui et al., 2008; Hu et al., 2012; Huo et al., 2012b; ARAI, 2008, 2009; Ntziachristos and Samaras, 2000) (Table 2).

Gasoline fueled pre 2005 vehicles (3 Nos.) were assessed for CO, CO_2 and NO_X emissions. The emission factors were 1.60 ± 0.24, 195 ± 61, and 0.8 ± 1.0 g/km for CO, CO_2 and NO_X respectively (Table 2). The average CO emission factor for post 2000 vehicle is lower than the average value for post 2005 and higher than the value measured for post 2010 vehicles (Table 2). The CO_2 and NO_X emission factors are close to values observed for post 2005 vehicles. The emission factors measured in the present study are within the range of values reported in literatures (Choudhary and Gokhale, 2016; Adak et al., 2016; Alves et al., 2015; Chikhi et al., 2014; Wang et al., 2008, 2014; Boughédaoui et al., 2008; Hu et al., 2012; Huo et al., 2012b; Weiss et al., 2011; Yao et al., 2007, 2011; Oliver et al., 2008, 2009; ARAI, 2008, 2009; Ntziachristos and Samaras, 2000) (Table 2).

The emission factors of CO, CO_2, and NO_X for post 2010 CNG operated vehicle (1 No.) were measured as 0.16 ± 0.20, 25 ± 31, and 0.08 ± 0.10 g/km, respectively (Table 2). As expected the CO_2 and NO_X emission factors from CNG operated vehicle are considerably lower than values observed for diesel and gasoline fueled vehicles. None has reported the emissions from CNG fueled post 2010 vehicles. The geometric mean and range of emission factors of CO, CO_2 and NO_X for post 2005 CNG operated vehicle were 0.5 (0.43–0.59), 48 (35–66), and 0.01 (0.01–0.02) g/km respectively. Our CO emission factors are close to the values reported by ARAI (2008) for Indian 4-wheeler, while our CO_2 and NO_X emission factors are respectively 3 and 6 times lower than

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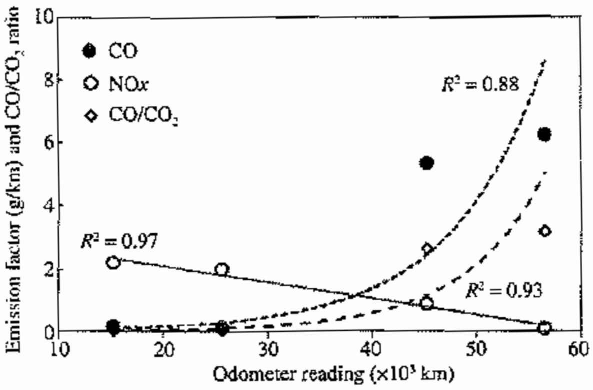

Fig. 3 – Variation of CO, NO_X and CO/CO_2 ratio with odometer reading of gasoline passenger cars for post 2010.

ARAI (2008) values. Overall, the present work indicated that the age and the maintenance level of vehicle both are important factors in emission assessment therefore, more systematic repetitive measurements covering wide range of vehicles of different age groups, engine capacity, and maintenance level are needed for refining the emission factors with CI.

The distance based emission factors (g/km) were converted into fuel based emission factors (g/kg) using Eq. (2) (Table 3). The fuel based emission factors were multiplied by fuel use (kg) to derive total emissions (Gg) for Delhi as discussed in the next section.

Table 3 – Fuel based emission factor (g/kg) of passenger cars for emission estimate.

Present study	Emission factor (g/kg)		
	CO	CO_2	NO_X
Diesel			
Post 2005 (n = 2)*	3.5 (1.3–5.7)	2076 (132–4020)	16.0 (13.1–18.5)
Post 2010 (n = 1)**	2.2 (0.0–7.6)	9139 (723–17555)	50.0 (0.0–172.5)
Gasoline			
Pre 2005 (n = 3)	29.5 (17.5–41.5)	3647 (1338–5966)	13.7 (0.0–49.4)
Post 2005 (n = 4)	67.3 (0.0–159.4)	3698 (2708–4688)	16.5 (0.0–49.6)
Post 2010 (n = 1)*	2.4 (0.0–8.3)	8630 (680–16580)	36.4 (0.0–82.3)
CNG			
Post 2005 (n = 2)*	9.4 (7.2–11.5)	897 (72–1722)	0.25 (0.0–2.8)
Post 2010 (n = 1)**	2.9 (0.0–10.0)	473 (0–1632)	1.60 (0.0–5.5)

The values in bracket are lower and upper bound at 95% confidence interval. CNG: compressed natural gas.
* Given geometric mean and lower and upper range for n = 2 experiment.
** Calculated maximum uncertainty 125% for single experiment one standard deviation.

2.2. Fuel use estimate

The fuel use was estimated following the methodology described in Section 1.3 using information listed in Table 4. The average and 95% CI of consumption of diesel by passenger cars, jeep and taxis in Delhi was estimated at 0.44 (0.23–0.65) MT/year for the year 2012. The diesel consumption is highest for cars (60%), followed by taxis (26%), and jeep (14%) (Table 4). While gasoline and CNG consumption by passenger cars were estimated at 0.48 (0.25–0.71) and 0.23 (0.12–0.34) MT/year for the year 2012. Although none has reported the diesel, gasoline and CNG consumption separately for 4W. Therefore, we compared our estimated traffic volume with the values reported in literature (Pandey and Venkataraman, 2014; Goel and Guttikunda, 2015). For diesel and gasoline passenger cars (excluding taxis and jeep) our traffic volume that was 15.0 billion vehicle/km was 15% higher than the value (13.0 billion vehicle/km) reported by Pandey and Venkataraman (2014) (Table 4). This increase accounts for little higher distance travel (10,400 km) used in present work and 9.3% increase in vehicle number for year 2012 compared to year 2010 used in Pandey and Venkataraman (2014). Similarly our traffic volume (16.2 billion vehicle/km) for 4W including passenger cars, jeep and taxis of both diesel and gasoline was 25% higher than the value (12.9 billion vehicle/km) reported by Goel and Guttikunda, 2015). This difference arose from higher on-road vehicle estimated in present work than the model predicted number reported by Goel and Guttikunda, 2015) for year 2012. Based on this analysis we expect the fuel use estimated for 4W in present work would be approximately 15% to 25% higher than the values used in recent literatures.

2.3. Emission estimate

According to Intergovernmental Panel of Climate Change (IPCC) the tier 2 methodology for emission estimates should include detailed region specific data including activity and emission factors. Following tier 2 methodology we have estimated the emissions of CO, CO_2 and NO_X from 4W in Delhi city. Based on the measured emission factors (g/kg), and fuel consumption (kg), the average and 95% CI bound estimates of CO, CO_2, and NO_X from 4W in Delhi for the year 2012 were 15.7 (1.4–37.1), 6234

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Table 4 – Utilization parameters and fuel consumption of passenger cars.

Utilization parameters	Passenger cars (Year 2012)					Remarks/References
	Diesel			Gasoline	CNG	
	Cars	Taxis	Jeep			
On-road vehicle (number)	504529	52314	68410	936983	343242	Fraction adopted from Pandey and Venkataraman (2014)
Distance travel (km)	10400	29700	10400	10400	10400	Goel et al. (2015)
Traffic volume (Billion vehicle/km)	5.20	1.60	0.70	9.70	3.60	
Vehicle mileage (km/L)	16.70	11.30	10.00	15.70	15.70*	Goel et al. (2015)
Density (kg/L)	0.845	0.845	0.845	0.775	–	Society of Indian Automobile Manufacturers (2010)
Fuel consumption (MT/year)	0.26 (0.14–0.39)	0.11 (0.06–0.17)	0.06 (0.03–0.09)	0.48 (0.25–0.71)	0.23 (0.12–0.34)	

* Mileage is in km/kg.

(386–12,252), and 30.4 (0.0–103) Gg/year respectively (Fig. 4). The CO emissions were highest from gasoline (84%) and lowest from diesel (7%). CNG contributed 9% of the total (15.7 Gg/year). The contribution of post 2005 passenger cars was 73% of the total (15.7 Gg/year) followed by pre 2005 (17%) and post 2010 (10%). The CO_2 emissions were highest from diesel (50%), followed by

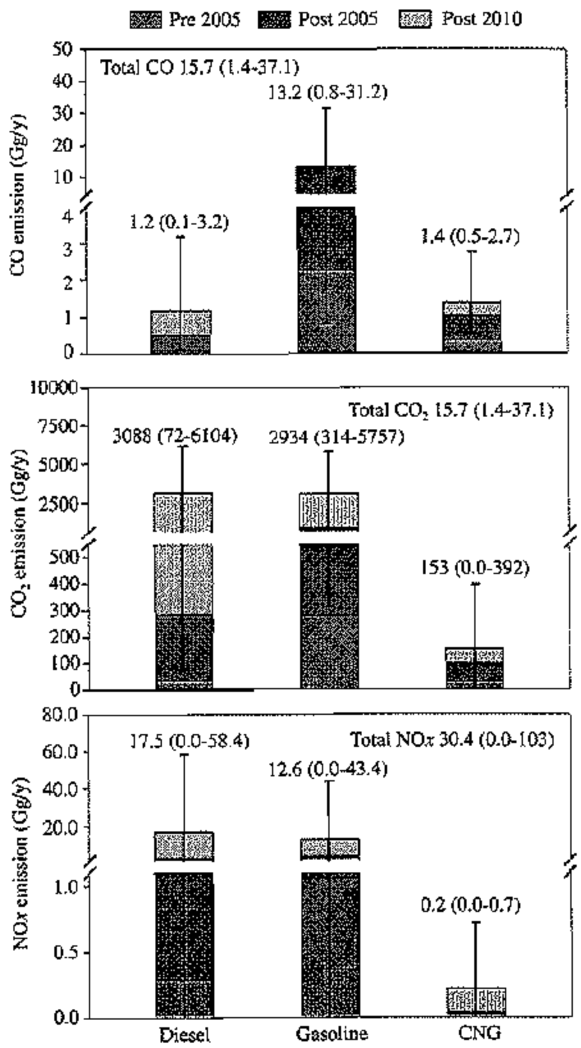

Fig. 4 – Emissions of CO, CO_2 and NO_X from on-road diesel, gasoline and CNG passenger cars for year 2012 for Delhi. CNG: compressed natural gas.

gasoline (48%), and CNG (2%). CO_2 emissions were highest from post 2010 vehicles (80%) followed by post 2005 (14%) and pre 2005 (6%). Similarly, NO_X emissions were also highest from diesel (58%) followed by gasoline (41%) and CNG (1%). Post 2010 vehicles contributed 81% of the total (30.4 Gg/year) NO_X emission, followed by post 2005 vehicles (15%) and pre 2005 vehicles (4%) (Fig. 4).

Our emission estimates for CO were 4–6 times lower than the values reported in literature (Goel and Guttikunda, 2015; Goyal et al., 2013; Nagpure et al., 2013). The emission factors used in Goel et al. (2015), Goyal et al. (2013) were derived from emission models (COmputer Programme to calculate Emissions from Road Transport, COPERT and international vehicle emission, IVE) and were factors of 2–29 times higher than the values observed in present work. The major discrepancy between present work and Nagpure et al. (2013) lies in emission factors adopted from Central Road Research Institute (CRRI), vehicle population considered without age distribution and vehicle annual distance traveled.

CO_2 emissions from present work were 1.5 times higher than the values reported by Goel and Guttikunda (2015) and probably higher traffic volume (25%) and emission factor resulted in higher emissions in present work. Due to same reason our NO_X emission was 3 times higher than values reported by Goel and Guttikunda (2015).

3. Conclusions

In this work the emissions of CO, CO_2 and NO_X from on-road operation of 14 passenger cars fueled with diesel, gasoline and CNG and of different vintages were assessed. The CO emissions were lower and NO_X emissions were higher from new diesel cars (post 2010) compared to old cars (post 2005). The result implies that new technological advancement in diesel fueled passenger cars has successfully reduced the CO emissions however, at the same time the NO_X emissions have increased probably because of use of turbo charger in diesel cars to achieve high temperature combustion. The emission factors measured in present work were incorporated with estimated diesel, gasoline and CNG consumption in on-road passenger cars, jeeps and taxis in NCR Delhi and total emissions for CO, CO_2 and NO_X were estimated. The CO, CO_2, and NO_X from 4-wheeler passenger cars, jeep and taxis in Delhi for the year 2012 were estimated at 15.7 (1.4–37.1) Gg/year, 6234 (386–12,252) Gg/year, and 30.4 (0.0–103) Gg/year respectively. The contributions of diesel, gasoline and CNG to total CO, CO_2 and NO_X emissions were 7:84:9, 50:48:2 and 58:41:1 respectively Interestingly, CO_2 and NO_X emissions were highest from new vehicles (post 2010) and lowest from old vehicles (pre 2005), while CO showed different trends and was highest from old vehicles (post 2005) and lowest from new vehicles (post 2010).

Overall, the present work indicated that the age and the maintenance level of vehicle both are important factors in emission assessment therefore, more systematic repetitive measurements covering wide range of vehicles of different age groups, engine capacity, and maintenance level are needed for refining the emission factors and thus emission estimates. Secondly, the technological advances should address not only fuel efficiency and reduction on CO emissions but also target NO_X emissions.

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ANNEXURE-A-8

सत्यमेव जयते

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power

REPORT ON FLY ASH GENERATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS AND ITS UTILIZATION IN THE COUNTRY FOR THE YEAR 2018-19

CENTRAL ELECTRICITY AUTHORITY
THERMAL CIVIL DESIGN DIVISION
NEW DELHI

JANUARY 2020

प्रकाश मस्के
अध्यक्ष तथा पदेन सचिव भारत सरकार
Prakash Mhaske
Chairperson & Ex-officio Secretary
to the Government of India

सत्यमेव जयते

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FOREWORD

Presently, the Electricity generation in the country comprises about 72% from coal based generating stations. In near future also the coal-based generation is likely to remain substantial. The Indian coal is of high ash content of the order of 30 - 45%, generating large quantity of fly ash at coal/lignite based Thermal Power Stations. At present, the Ash utilization is lower than its production on all India basis. As a result, there is surplus ash stock, which has been increasing every year. The management of fly ash has thus been a matter of concern in view of requirement of large area of land for its disposal because of its potential of causing pollution of air and water.

To address the above concerns, Ministry of Environment & Forests and Climate Change (MoEF&CC) has issued various Notifications on fly ash utilization prescribing therein the targets for fly ash utilization for Coal/Lignite based Thermal Power Stations with an aim to achieve 100% utilization in a phased manner. Central Electricity Authority has been monitoring since 1996 the status of fly ash generation and its utilization in the country.

The utilization of fly ash has increased from 7 million tons in 1996-97 to a level of 168.40 million-ton in 2018-19. The percentage of fly ash utilization during 2018-19 is 77.59%. To materialize 100% utilization of fly ash on all India basis, in line with MOEF&CC Notification extra efforts by all Thermal Power Stations are needed.

I wish to express my sincere thanks to all the Power Utilities and Thermal Power stations in the country for providing data/information on fly ash generation and its utilization to CEA for bringing out this report.

Subhash

(Prakash Mhaske)

New Delhi
January, 2020

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PREFACE

Management of Fly Ash at coal/lignite based Thermal Power Stations in the country is a challenging task in view of large quantity of ash being generated and target of achieving 100% utilization of fly ash in time bound manner as prescribed in MoEF Notification of 14th September, 1999 and its subsequent amendment. The land for creating ash dykes for ash disposal facilities at thermal power plants is becoming difficult to be acquired. Fly ash, if not managed well, may pose environmental challenges.

Fly Ash Mission, a Technology Project in Mission Mode of Government of India was commissioned during 1994 as a joint activity of Department of Science & Technology (DST), Ministry of Power (MOP) and Ministry of Environment & Forests (MoEF) with Department of Science & Technology as nodal agency. The Fly Ash Mission was set up to promote research in the area of fly ash utilization so that fly ash could be gainfully utilized instead of its disposal in ash ponds. Ministry of Environment & Forests, Government of India also issued 1st Notification on Fly Ash Utilization in September, 1999, which was subsequently amended in 2003,2009 and 2016 stipulating targets for fly ash utilization for Thermal Power Stations and use of fly ash by construction agencies within prescribed radius of any thermal power station.

These initiatives and policy decisions by Government of India have led to increased utilization of fly ash in various construction activities like making of fly ash based building products, manufacturing of Portland pozzolana cement, construction of roads/highways/ flyovers, reclamation of low lying areas, back filling and stowing of mines, waste land development, construction of Roller Compacted concrete dams etc. Though, in 2018-19, the ash utilization level has reached to about 77.59% (168.40 MT) as compared to less than 10% (6.64 MT) during the year 1996-97, a lot more needs to be done.

This report brings out present status of fly ash generation at 195 coal/lignite based Thermal Power Stations and its utilization in the country. It also brings out the status of level of fly ash utilization achieved by various thermal power stations in the country vis-à-vis targets prescribed in MoEF's Notification of 14th September, 1999 and its subsequent amendments in 2003, 2009 & 2016. I am confident that the report will also be useful to all the stakeholders involved in fly ash management in the country for planning the utilization of fly ash and having necessary tie-up with the concerned thermal power station.

Data collection, its compilation, reconciliation & analysis is quite a vast task. Moreover, to provide a dependable/accurate data in desired formats is equally a major job. We acknowledge and express our gratitude to all Power Utilities and Thermal Power Station for furnishing data in a timely manner. I would also like to place on record my appreciation of the efforts made by the officers and staff of Thermal Civil Design Division. We solicit suggestion from all concerned for further improving the presentation made in the report. All suggestions/views as well as intimations for any unintended errors observed in this document may kindly be sent to Chief Engineer, TCD, CEA, Room No. 901(N), Sewa Bhawan, R.K. Puram, New Delhi (E-mail Address: tcdcea@nic.in).

New Delhi
January-2020

(P.D. SIWAL)
Member (Thermal)

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I express my sincere thanks to all the power utilities and the Thermal Power Stations for furnishing the data and information for bringing out this report on Fly Ash Generation and its utilization in the country for the year 2018-19. Timely furnishing the required data and information by various Power Utilities and Thermal Power Stations to CEA is important for bringing out the report.

I am grateful to Chairperson as well as Member (Thermal), CEA for the valuable suggestions and guidance in preparation of this report.

I also express my thanks to the team comprising S/Shri Baleshwar Thakur, Director, Ranjeet Kumar, Deputy Director, Vijender Singh, Sr. Manager Bhagaban Bhattacharya, Assistant Director and other officers of TCD Division, CEA in preparation of this report.

New Delhi
January-2020

(R. S. RAM)
Chief Engineer (TCD)

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1	Mode of fly ash utilization during 2018-19	28
2	Progressive generation & utilization of fly ash during the Period from 1996-97 to 2018-19	30
3	Progressive utilization of fly ash in cement manufacturing and concrete during the Period from 1998-99 to 2018-19	31
4	Progressive utilization of fly ash in reclamation of low lying areas during the period from 1998-99 to 2018-19	31
5	Progressive utilization of fly ash in construction of roads/embankments/ash dyke raising during the period from 1998-99 to 2018-19	32
6	Progressive utilization of fly ash in Mine filling during the period from 1998-99 to 2018-19	32
7	Progressive utilization of fly ash in manufacture of fly ash based brick/blocks/ tiles during the period from 1998-99 to 2018-19	33
8	Progressive utilization of fly ash in agriculture during the period from 1998-99 to 2018-19	33

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CENTRAL ELECTRICITY AUTHORITY
THERMAL CIVIL DESIGN DIVISION

FLY ASH GENERATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS AND ITS UTILIZATION IN THE COUNTRY
(FOR THE YEAR 2018-19)

1.0 BACKGROUND

Coal/Lignite based Thermal Power Generation has been the backbone of power capacity addition in the country. Indian coal is of low grade with ash content of the order of 30-45 % in comparison to imported coals which have low ash content of the order of 10-15%. Large quantity of ash is, thus being generated at coal/lignite based Thermal Power Stations in the country, which not only requires large area of precious land for its disposal but is also one of the sources of pollution of both air and water.

Central Electricity Authority (CEA) has been monitoring the fly ash generation and its utilization at coal/ lignite based thermal power stations in the country since 1996. Data on fly ash generation and utilization including modes of utilization is obtained from thermal power stations on half yearly as well as on yearly basis. The data thus obtained is analyzed and a report bringing out the status of fly ash generation and its utilization in the country is prepared. The report is forwarded to Ministry of Power, Ministry of Science & Technology and Ministry of Environment, Forests and Climate Change. It is also uploaded on the web site of CEA for bringing out the information in the public domain so that users of fly ash have access to the information on the availability of fly ash at different thermal power stations in the country, in order to facilitate and promote the utilization of fly ash.

In order to reduce the requirement of land for disposal of fly ash in ash ponds and to address the problem of pollution caused by fly ash, Ministry of Environment, Forests and Climate Change (MoEF&CC) has issued various Notifications on fly ash utilization. First Notification was issued on 14th September, 1999 which was subsequently amended in year 2003, 2009 and 2016 vide Notifications dated 27th August, 2003; 3rd November, 2009 and 25th January,2016 respectively. The amendment Notification of year 2009 prescribes the targets of Fly Ash utilization in a phased manner for all Coal/Lignite based Thermal Power Stations in the country so as to achieve 100% utilization of fly ash.

The Thermal Power Stations in operation before the date of the Notification (i.e. 3rd November, 2009) are to achieve the target of fly ash utilization in successive 5 years; 50% in first year; 60% in second year; 75% in third year; 90% in fourth year and 100% in fifth year. The new Thermal Power Stations coming into operation after the MoEF's notification (i.e. 3rd November, 2009) are to achieve the target of fly ash utilization as 50% in the first year, 70% during in second year, 90% during third year and 100% during fourth year depending upon their date of commissioning. Ministry of Environment, Forest and Climate change has recently issued an amendment to the Notification on 25th January, 2016 in order to widen the scope of fly ash utilization, besides engraining upon Power Utilities to bear the cost of the transportation.

The report on "fly ash generation and its utilization at coal/lignite based thermal power stations" provides information and the status of fly ash utilization in the country. It also facilitates to ascertain the level of fly ash utilization achieved by various power stations in relation to targets prescribed in MoEF's amended notifications of 3rd November, 2009 and to take corrective measures in cases of Thermal Power Stations lagging behind in achieving the prescribed targets of fly ash utilization.

2.0 ASH GENERATION & UTILIZATION DURING THE YEAR 2018-19

2.1 A Brief Summary

Fly ash generation & utilization data for the Year 2018-19 (April 2018 to March 2019) has been received from **195** (One hundred ninety Five) coal/lignite based thermal power stations of various power utilities in the country. Data received has been analyzed to derive conclusions on present status of fly ash generation and its utilization in the country as a whole. A brief summary of status is given in Table-I below:

TABLE-I

SUMMARY OF FLY ASH GENERATION AND UTILIZATION DURING THE YEAR 2018-19

Description		Year 2018-19
• Nos. of Thermal Power Stations from which data was received	:	**195**
• Installed capacity (MW)	:	**197966.50**
• Coal consumed (Million tons)	:	**667.43**
• Fly Ash Generation (Million tons)	:	**217.04**
• Fly Ash Utilization (Million tons)	:	**168.40**
• Percentage Utilization	:	**77.59**
• Percentage Average Ash Content (%)	:	**32.52**

Power Station wise fly ash generation & its utilization status including modes of utilization for the 2018-19 for all the **195** thermal power stations is given in the statement at **Annex-I** and State wise fly ash generation & its utilization status is given in **Annex-II.**

2.2 Data Provided by Thermal Power Units Commissioned during the Year 2018-19:

During the Year 2018-19, Nine (9) Thermal power plant with total installed capacity of **4100 MW** as given in Table-II below was commissioned:

TABLE-II

DATA PROVIDED BY THERMAL POWER UNITS COMMISSIONED DURING THE YEAR 2018-19

Sl. No.	Name of Thermal Power Station	Name of Power Utility	Unit No.	Capacity (MW)	Date of Commission
1	2	3	4	5	6
		2018-19			
1	MAHAN	ESSAR POWER MP LTD.(M.P.)	2	600.00	07.10.2018
2	SHREE SINGAJI TPS	M.P.P.G.C.L. (M.P.)	3	660.00	18.11.2018
3	NABI NAGAR TPP	BHARATIYA RAIL BIJLEE COMPANY LIMITED (Bihar)	3	250.00	26.02.2019
4	UNCCHPINDA	R.K.M.POWERGEN PVT. LTD (PGCIL) (Chhattisgarh)	4	360.00	20.03.2019
5	BONGAIGAON TPP	NTPC LTD. (Assam)	3	250.00	26.03.2019
6	SHREE SINGAJI TPS	M.P.P.G.C.L. (M.P.)	4	660.00	27.03.2019
7	SOLAPUR STPP	NTPC LTD. (Maharashtra)	2	660.00	29.03.2019
8	GADARWARA	NTPC LTD.(Madhya Pradesh)	1	800.00	29.03.2019
9	Meja TTP	MEJA URJA NIGAM PVT. LTD.	1	660.00	31.03.2019
			Total for 2018-19	**4100.00**	

2.3 Retirement of Thermal Power Units during the Year 2018-19:

During the Year 2018-19, the following units with installed capacity as given in Table-III below have been decommissioned:

TABLE-III

THERMAL POWER UNITS RETIRED/DECOMMISSIONED DURING THE YEAR 2018-19

Sl. No.	Name of Thermal Power Station	Name of Power Utility	Unit No.	Capacity (MW)	Date of Decommissioning
(1)	(2)	(3)	(4)	(5)	(6)
			2018-19		
1	OBRA TPS	UPRVUNL	8	1X94	03.04.2018
2	BANDEL TPS	WBPDCL	3 & 4	2X60	20.04.2018
3	LAKWA TPS	APGCL	2 & 3	2x15	02.07.2018
4	BATHINDA TPS	PSPCL	1,2,3,4	4X110	31.08.2018
5	ROPAR	PSPCL	1 & 2	2X210	31.08.2018
6	BADARPUR TPS	NTPC Ltd	1,2,3,4 & 5	3x95 & 2x210	30.10.2018
7	NEVELI TPS-I		7	1X100	06.02.2019
8	KOTHAGUNDEM TPS	TSPGCL	3,6 & 8	1X60 & 2X120	19.03.2019
			Total for 2018-19	**2,209.00**	

2.4 Power Utility Wise Status of Fly Ash Generation & its Utilization during the Year 2018-19

The status of fly ash generation & utilization for the year 2018-19 for various power utilities in the country has been assessed based on data received from Thermal Power Stations and the same is given in Table-IV:

TABLE-IV

POWER UTILITY WISE FLY ASH GENERATION AND UTILIZATION FOR THE YEAR 2018-19

Sl. No.	Name of Power Utility	No. of TPS	Installed Capacity (MW)	Fly Ash Generation (Million-tonne)	Fly Ash Utilization (Million-tonne)	Percentage Utilization %
1	2	3	4	5	6	7
1	Andhra Pradesh Power Generation Corporation (APGENCO)	2	3410.00	6.0389	5.8924	97.58
2	APPDCL(Andhra Pradesh)	1	1600.00	1.2120	0.7926	65.40
3	ACB (INDIA) Ltd. (Chhattisgarh)	4	390.00	1.4348	1.4348	100.00
4	ADANI POWER (MUNDRA) LIMITED (Gujrat)	1	4620.00	0.7740	0.7951	102.73
5	APCPL (Haryana)	1	1500.00	1.5034	1.5545	103.40
6	ADANI POWER MAHARASHTRA LTD. (Maharashtra)	1	3300.00	4.3630	3.6847	84.45
7	ADANI POWER RAJASTHAN LTD. (Rajasthan)	1	1320.00	1.2800	1.5198	118.74
8	AMNEPL (Maharashtra) (No Generation)	1	246.00	0.0000	0.0000	No Generation
9	ADANI ELECTRICITY MUMBAI	1	500.00	0.5640	0.7324	129.85

Sl. No.	Name of Power Utility	No. of TPS	Installed Capacity (MW)	Fly Ash Generation (Million-tonne)	Fly Ash Utilization (Million-tonne)	Percentage Utilization %
1	2	3	4	5	6	7
	LIMITED (Maharashtra)					
10	ADHUNIK POWER & NATURAL RESOURCES LTD. (Jharkhand)	1	540.00	0.7484	0.8805	117.65
11	BEPL (UP)	5	450.00	0.2561	0.2562	100.03
12	BHARATIYA RAIL BIJLEE COMPANY LIMITED (Bihar)	1	750.00	0.6101	0.1744	28.59
13	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	2	1740.00	2.7982	2.8655	102.41
14	BHADRESHWAR VIDYUT PRIVATE LIMITED (Gujarat)	1	300.00	0.0493	0.0487	98.89
15	C.E.S.C. Ltd. (West Bengal)	3	1125.00	1.2700	1.2700	100.00
16	Chhattisgarh State Power Generation Company Ltd. (C.S.P.G.C.L.)	4	3280.00	6.0980	2.8422	46.61
17	COASTAL ENERGEN PVT. LTD (Tamil Nadu)	1	1200.00	0.0703	0.0705	100.23
18	C.G.P.L (Gujarat)	1	4150.00	0.7900	0.7410	93.80
19	CHEMPLAST SANMAR LIMITED(Tamil Nadu)	1	48.50	0.0183	0.0184	100.44
20	Damoadar Valley Corporation (D.V.C.)	7	7090.00	9.9244	6.9338	69.87
21	Durgapur Projects Ltd. (D.P.L.)	1	550.00	0.6539	0.5707	87.29
22	Dhariwal Infrastructure Ltd. (Maharashtra)	1	600.00	0.6910	0.7246	104.86
23	EASTERN COALFIELDS LIMITED (West Bengal)(No Generation)	1	30.00	0.0000	0.0000	No Generation
24	ESSAR POWER MP LTD.(M.P.)	1	1200.00	0.5629	0.4834	85.89
25	Gujarat Industries Power Corporation Ltd. (G.I.P.C.L.)	1	500.00	0.6033	0.6033	100.00
26	Gujarat Mineral Development Corporation Ltd. (G.M.D.C.L.)	1	250.00	0.2665	0.3765	141.28
27	G.S.E.C.L. (Gujarat)	6	4500.00	0.4348	0.5410	124.42
28	GMR Warora Energy LTD. (Maharashtra)	1	600.00	0.7574	0.8280	109.32
29	GMR Kamalanga Energy LTD. (Odisha)	1	1050.00	1.7867	1.7887	100.11
30	GUPTA ENERGY PRIVATE LIMITED(Maharashtra) (No Generation)	1	120.00	0.0000	0.0000	No Generation
31	Haryana Power Generation Cor. Ltd. (H.P.G.C.L.)	3	2720.00	2.7481	2.9607	107.74
32	HALDIA ENERGY LIMITTED (W.B.)	1	600.00	1.0488	1.0488	100.00
33	HINDUJA NATIONAL POWER CORPORATION LIMITED (Andhra Pradesh)	1	1040.00	0.1991	0.5201	261.18
34	IPGCL (Delhi)(No Generation)	1	135.00	0.0000	0.0000	No Generation
35	INDIA POWER CORPORATION Ltd. (W.B)	1	12.00	0.0171	0.0171	100.00
36	INDIAN METALS & FERRO ALLOYS LTD. (Odisha)	1	258.00	0.4367	0.4368	100.02
37	IL&FS TAMIL NADU POWER COMPANY LIMITED (Tamil Nadu)	1	1200.00	0.1300	0.1280	98.46
38	IDEAL ENERGY PROJECTS LIMITED (Maharashtra)	1	270.00	0.0306	0.0000	0.00

Sl. No.	Name of Power Utility	No. of TPS	Installed Capacity (MW)	Fly Ash Generation (Million-tonne)	Fly Ash Utilization (Million-tonne)	Percentage Utilization %
1	2	3	4	5	6	7
39	J.H.P.L (HR)	1	1320.00	1.6480	2.2565	136.92
40	J.P.L (Chhattisgarh)	2	3400.00	3.3650	3.4360	102.11
41	JAIPRAKSH POWER VENTURES LIMITED (MP)	2	1820.00	1.6062	1.6286	101.40
42	JSW Energy Ltd.	2	2060.00	0.6632	0.6956	104.88
43	JINDAL INDIA THERMAL POWER LIMITED (Odisha)	1	1200.00	1.3740	0.9460	68.85
44	JINDAL STEEL AND POWER LIMITED (CHHATTISGARH)	2	1386.00	1.8179	1.7921	98.58
45	JSW ENERGY (BARMER) LIMITED (Formerly Raj Westpower Ltd.) (Rajasthan)	1	1080.00	0.0880	0.1090	123.86
46	JSW STEEL LIMITED (Tamil Nadu)	1	60.00	0.0127	0.0127	100.11
47	Karnataka Power Corporation Ltd.(K.P.C.L.)	2	3420.00	3.0100	2.2885	76.03
48	KANTI BIJLEE UTPADAN NIGAM LIMITED (Bihar)	1	610.00	0.8118	0.3022	37.22
49	KSK MAHANADI POWER COMPANY LIMITED (Chhattisgarh)	1	1800.00	1.6041	1.6339	101.86
50	LANCO AMARKANTAK POWER LIMITED (Chhattisgarh)	1	600.00	1.1500	0.5755	50.05
51	LALITPUR POWER GENERATION COMPANY LIMITED (UP)	1	1980.00	1.1334	1.1334	100.00
52	LANCO ANPARA POWER LIMITED (Uttar Pradesh)	1	1200.00	1.2200	0.3600	29.51
53	MPL (Jharkhand)	1	1050.00	1.7344	1.7738	102.27
54	M.P.P.G.C.L. (M.P.)	4	5400.00	6.7342	2.6099	38.76
55	M.S.P.G.C.L.(Maharashtra)	7	9950.00	12.4260	8.0367	64.68
56	MARUTI CLEAN COAL AND POWER LIMITED (Chhattisgarh)	1	300.00	0.7290	0.7290	100.00
57	MEENAKSHI ENERGY PRIVATE LIMITED (Andhra Pradesh)	1	300.00	0.0014	0.0085	622.26
58	M/S JHABUA POWER LIMITED (MP)	1	600.00	0.5691	0.3456	60.74
59	M/s KORBA WEST POWER COMPANY LIMITED (Chhattisgarh)	1	600.00	0.0000	0.0600	No Generation
60	MB POWER (MADHYA PRADESH) LIMITED (M.P.)	1	1200.00	1.5779	1.6359	103.68
61	MEJA URJA NIGAM PRIVATE LIMITED(Uttar Pradesh)	1	660.00	0.0630	0.0001	0.22
62	Neyvelli Lignite Corporation Ltd. (N.L.C.LTD)	5	3140.00	1.3284	2.1880	164.71
63	NLC TAMIL NADU POWER LIMITED (Tamil Nadu)	1	1000.00	1.0347	1.0343	99.96
64	NSPCL	4	814.00	1.7242	1.6280	94.42
65	NTECL (Tamil Nadu)	1	1500.00	2.2570	1.5250	67.57
66	N.T.P.C.LTD.	21	40765.00	60.3834	38.5892	63.91
67	NTPC Ltd-BSPGCL(JV) (Bihar)	1	220.00	0.0000	0.0000	No Generation
68	NABHA POWER PROJECT (Punjab)	1	1400.00	1.4395	1.3055	90.69
69	NATIONAL ALUMINIUM COMPANY LIMITED (NALCO) (Odisha)	1	1200.00	2.4760	1.8206	73.53
70	O.P.G.C.L.(Odisha)	1	420.00	1.0141	0.3434	33.86

Sl. No.	Name of Power Utility	No. of TPS	Installed Capacity (MW)	Fly Ash Generation (Million-tonne)	Fly Ash Utilization (Million-tonne)	Percentage Utilization %
1	2	3	4	5	6	7
71	OPG POWER GENERATION PRIVATE LIMITED (Tamil Nadu)	1	414.00	0.0885	0.0961	108.55
72	Punjab State Power Corporation Ltd. (P.S.P.C.L).	4	2760.00	1.4883	3.0250	203.25
73	PRAYAGRAJ POWER GENERATION COMPANY LTD. (U.P.)	1	1980.00	1.3490	1.2555	93.07
74	R.K.M.POWERGEN PVT. LTD (PGCIL) (Chhattisgarh)	1	1440.00	0.5501	0.5417	98.47
75	Rajasthan Rajya Vidyut Utpadan Nigam Ltd. (R.R.V.U.N.L.)	3	3700.00	3.7222	4.0399	108.54
76	RPSCL (UP)	1	1200.00	0.8224	0.9553	116.16
77	RATTANINDIA POWER LTD. (Maharashtra)	1	1350.00	0.7214	0.8329	115.46
78	RAICHUR POWER CORPORATION LIMITED (Karnataka)	1	1600.00	0.1215	0.0400	32.91
79	RASHTRIYA ISPAT NIGAM LIMITED (Andhra Pradesh)	1	315.00	0.7628	0.2202	28.87
80	RAIPUR ENERGEN LIMITED(Formerly GMR CHHATTISGARH Energy Ltd) (Chhattisgarh)	1	1370.00	0.4964	0.5173	104.21
81	REILIANCE POWER LIMITED (Madhya Pradesh)	1	3960.00	4.0222	1.4916	37.08
82	SEPL(Andhra Pradesh)	1	600.00	0.0020	0.0020	100.00
83	SPECTRUM COAL & POWER LTD.(Chhattisgarh)	1	100.00	0.7169	0.5516	76.95
84	SAILILAGARH POWER GENERATION LIMITED (Chhattisgarh) (No Generation)	1	86.00	0.0000	0.0000	No Generation
85	SEMBCORP ENERGY INDIA Ltd. (Formerly Thermal Powertech Corporation India Ltd) (Andhra Pradesh)	1	1320.00	0.8874	0.7780	87.67
86	SWASTIK POWER & MINERALS RESOURCES PVT. LTD (Chhattisgarh) (No Generation)	1	25.00	0.0000	0.0000	No Generation
87	SKS POWER GENERATION(CHHATTISGARH) LIMITED (Chhattisgarh)	1	600.00	0.5582	0.3961	70.96
88	THE SINGARENI COLLIERIES COMPANY LIMITED (Telengana)	1	1200.00	1.8241	1.8736	102.71
89	TAQA NEYVELLY POWER CO.PVT. LTD. (Tamil Nadu)	1	250.00	0.1067	0.0803	75.22
90	T.P.CO. (Jharkhand)	2	1297.50	0.1573	0.1456	92.54
91	TORRENT POWER LTD.(Gujarat)	1	422.00	0.3319	0.3319	100.00
92	T.N.G & D Corporation (Tamil Nadu)	5	4320.00	5.2312	3.8536	73.67
93	TSGENCO (Telengana)	6	2582.50	5.2594	3.4865	66.29
94	TRN ENERGY PRIVATE LIMITED (Chhattisgarh)	1	600.00	1.0634	0.7895	74.25
95	TENUGHAT VIDHYUT NIGAM LIMITED (Jharkhand)	1	420.00	0.4931	0.6419	130.19
96.	TALWANDI SABO POWER LTD (Punjab)	1	1980.00	2.2800	2.5100	110.09

Sl. No.	Name of Power Utility	No. of TPS	Installed Capacity (MW)	Fly Ash Generation (Million-tonne)	Fly Ash Utilization (Million-tonne)	Percentage Utilization %
1	2	3	4	5	6	7
97	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.(U.P.R.V.U.N.L.)	5	5590.00	7.3049	2.1795	29.84
98	UPCL (Karnataka)	1	1200.00	0.1260	0.1261	100.08
99	VIDARBHA INDUSTRIES POWER LTD. (Maharashtra)	1	600.00	0.4705	0.7488	159.16
100	VS LIGNITE POWER PRIVATE LIMITED (Rajasthan)	1	135.00	0.0540	0.0455	84.29
101	VEDANTA LIMITED	2	3615.00	5.5514	6.4910	116.93
102	West Bengal Power Development Corporation Limited (W.B.P.D.C.L)	5	4745.00	5.0456	5.7105	113.18
103	WPCL (KSKEV Ltd.) (Maharashtra)	1	540.00	0.2630	0.3016	114.66
	GRAND TOTAL	**195**	**197966.50**	**217.0381**	**168.3976**	**77.59**

It may be seen from the Table-IV above that:

The data of fly ash generation and utilization for year 2018-19 was received from **103** Power Utilities out of which **41** Power Utilities have achieved fly ash utilization level of 100% or more and **11** Power Utilities have achieved fly ash utilization level in the range of 90% to less than 100%.

2.5 State wise Status of Fly Ash Generation & its Utilization during the Year 2018-19

The state wise status of fly ash generation & utilization in the country based on data received from Thermal Power Stations/ Power Utilities has also been assessed and the same is given in Table-V below:

TABLE-V

STATE WISE FLY ASH GENERATION AND ITS UTILIZATION DURING THE YEAR 2018-19

Sl. No.	Name of State	Nos. of TPS	Installed Capacity (MW)	Fly Ash Generation (Million-tonne)	Fly Ash Utilization (Million-tonne)	Percentage Utilization %
1	2	3	4	5	6	7
1	ANDHRA PRADESH	10	13185.00	16.3557	15.9110	97.28
2	ASSAM	1	750.00	0.4670	0.1410	30.19
3	BIHAR	5	5240.00	8.0389	3.7176	46.25
4	CHHATISGARH	29	23871.00	33.6561	24.5095	72.82
5	DELHI	2	840.00	0.2940	0.2900	98.64
6	GUJARAT	12	14742.00	3.2498	3.4376	105.78
7	HARYANA	5	5540.00	5.8995	6.7716	114.78
8	JHARKHAND	7	4897.50	6.3994	6.1448	96.02
9	KARNATAKA	6	9480.00	4.8656	3.6055	74.10
10	MADHYA PRADESH	12	19740.00	23.3303	10.8710	46.60
11	MAHARASHTRA	21	23666.00	23.8370	19.2967	80.95
12	ODISHA	10	11323.00	21.5589	17.0270	78.98
13	PUNJAB	6	6140.00	5.2078	6.8405	131.35
14	RAJASTHAN	7	6485.00	5.3645	6.7760	126.31

Sl. No.	Name of State	Nos. of TPS	Installed Capacity (MW)	Fly Ash Generation (Million-tonne)	Fly Ash Utilization (Million-tonne)	Percentage Utilization %
1	2	3	4	5	6	7
15	TAMILNADU	17	12882.50	10.0573	7.9449	79.00
16	TALANGANA	7	3782.50	7.0834	5.3601	75.67
17	UTTAR PRADESH	20	21370.00	23.0508	14.2799	61.95
18	WEST BENGAL	18	14032.00	18.2340	15.4729	84.86
	GRAND TOTAL	**195**	**197966.50**	**217.0381**	**168.3976**	**77.59**

It may be seen from Table-V above that:

(i) 8 states namely Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, Uttar Pradesh and West Bengal have generated more than 10 million-ton of fly ash each with Chhattisgarh highest 33.6561 million tons during the Year 2018-19.

(ii) During the Year 2018-19 -states of Gujarat, Haryana, Punjab and Rajasthan have achieved fly ash utilization level of more than 100 %. Similarly, Union territory of Delhi and States of Andhra Pradesh and Jharkhand achieved the fly ash utilization level of more than 95 %.

(iii) Assam, Bihar and Madhya Pradesh utilized less than 50% of fly ash.

3.0 TARGETS FOR FLY ASH UTILIZATION AS PER MoEF'S NOTIFICATION OF 3rd NOVEMBER, 2009

The notification set the target for the thermal power stations which were in operation before the date of notification i.e 3.11.2009 as well as the new thermal power stations to be commissioned after the notification i.e 3.11.2009. The same have been brought out below:

3.1 Thermal Power Station in Operation as on 3rd November, 2009

All coal and, or lignite based thermal Power Stations and, or expansion units in operation before the date of MoEF's notification i.e. 03.11.2009 were to achieve the target of fly ash utilization as per the Table-VI given below:

TABLE-VI

TARGETS FOR FLY ASH UTILIZATION FOR THERMAL POWER STATIONS IN OPERATION BEFORE 3rd NOVEMBER, 2009

Sl. No.	Target of Fly Ash Utilization (In Percentage)	Target Date
(1)	(2)	(3)
1	At least 50% of Fly Ash generation	One year from the date of issue of notification
2	At least 60% of Fly Ash generation	Two years from the date of issue of notification
3	At least 75% of Fly Ash generation	Three years from the date of issue of notification
4	At least 90% of Fly Ash generation	Four years from the date of issue of notification
5	100% of Fly Ash generation	Five years from the date of issue of notification

The unutilized fly ash, if any, in relation to the target during a year would be required to be utilized within next two years in addition to the targets stipulated for those years and the balance unutilized fly ash accumulated during first five years (the difference between the generation and the utilization target) would be required to be utilized progressively over the next five years in addition to 100% utilization of current generation of fly ash.

3.2 Thermal Power Station Commissioned after 3rd November, 2009

New coal and, or lignite based thermal Power Stations and, or expansion units commissioned after issue of MoEF's notification of 3rd November, 2009 are to achieve the target of fly ash utilization as per Table-VII given below:

TABLE-VII

TARGETS FOR FLY ASH UTILIZATION FOR THERMAL POWER STATION COMMISSIONED AFTER 3rd NOVEMBER, 2009

Sl. No.	Fly Ash Utilization Level	Target Date
(1)	(2)	(3)
1	At least 50% of fly ash generation	One year from the date of Commissioning
2	At least 70% of fly ash generation	Two years from the date of Commissioning
3	90% of fly ash generation	Three years from the date of Commissioning
4	100% of fly ash generation	Four years from the date of commissioning

The unutilized fly ash, if any, in relation to the target during a year would be required to be utilized within next two years in addition to the targets stipulated for these years and the balance unutilized fly ash accumulated during first four years (the difference between the generation and utilization target) would be required to be utilized progressively over next five years in addition to 100% utilization of current generation of fly ash.

4.0 TARGET OF FLY ASH UTILIZATION DURING 2018-19 AS PER MoEF&CC's NOTIFICATION OF 3rd NOVEMBER, 2009

Fly ash generation and utilization data received from Thermal Power Stations/Power Utilities in the country for the year 2018-19 has been broadly analyzed to ascertain the power stations which have achieved the targets of fly ash utilization as prescribed in MoEF's notification of 3rd November, 2009.

During the Year 2018-19, all those thermal power stations which were in operation on the date of issue of MoEF's notification (i.e. 3rd November, 2009) should have achieved the target of fly ash utilization of 100% within five years from the date of notification i.e. by 3rd November, 2014. All those thermal power stations which have come in operation after the date of issue of MoEF's notification (i.e. 3rd November, 2009) should have achieved the target of fly ash utilization in four years from the date of Commissioning as specified in Table-VII above.

4.1 Status during the Year 2018-19

Based on target indicated under PARA 4.0 above, the status of achievement of fly ash utilization for the Year 2018-19 has been assessed and the same is given in Table-VIII below.

TABLE-VIII

STATUS OF UTILIZATION OF FLY ASH AS PER MOEF'S NOTIFICATION DATED 3rd NOVEMBER, 2009 FOR THE YEAR 2018-19

Sl. No.	Description	Nos. of TPS
(1)	(2)	(3)
1	Nos. of TPS which have achieved the target of fly ash utilization as	103

Sl. No.	Description	Nos. of TPS
(1)	(2)	(3)
	per MoEF's Notification of 3rd November, 2009 (Refer table XVI)	
2	Nos. of TPS which have not been able to achieve the target of fly ash utilization as per MoEF's Notification of 3rd November, 2009(Refer table- XVII)	**83**
3	Nos. of TPS which have not generated any significant fly ash or any fly ash(Refer table- XVIII)	**9**
	Total	**195**

It may be seen from Table-VIII above that:

During the Year 2018-19, out of **195** (one hundred ninety five) thermal power stations for which data was received, **100 (one hundred)** power stations have achieved the targets of fly ash utilization as stipulated in MoEF's Notification of 3rd November, 2009.

4.2 Range of Fly Ash Utilization during the Year 2018-19

Based on the fly ash utilization data received from Thermal Power Stations/Power Utilities, the Thermal Power Stations have been grouped into 6 (six) categories as noted below depending upon range of utilization of fly ash by the stations:

TABLE-IX

RANGE OF PERCENTAGE FLY ASH UTILIZATION DURING THE YEAR 2018-19

Sl. No.	Level of Fly Ash utilization	Nos. of Power Stations
(1)	(2)	(3)
1	100% and more than 100% (Refer table- X)	**92**
2	90% to less than 100% (Refer table- XI)	**20**
3	70% to less than 90% (Refer table- XII)	**25**
4	50% to less than 70% (Refer table- XIII)	**14**
5	Less than 50% (Refer table- XIV)	**35**
6	Nos. of TPS which have not generated any significant fly ash or any fly ash (Refer table- XV)	**9**
	Total	**195**

4.3 Thermal Power Stations that have achieved Fly Ash utilization level of 100% or more during the Year 2018-19

The Thermal Power Stations with fly ash utilization in the range of 100% or more during the year 2018-19 is given in Table-X below:

TABLE-X

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	Dr. N.T.R (Vijawada)	APGENCO (Andhra Pradesh)	1760.00	4.1149	4.2752	103.90
2	KASAIPALI	ACB(INDIA)L (Chhattisgarh)	270.00	1.0789	1.0789	100.00

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
3	SVPPL Renki	ACB India Limited (Chhattisgarh)	60.00	0.0098	0.0098	100.00
4	CHAKABURA TPP	ACB (INDIA) Ltd. (Chhattisgarh)	30.00	0.17872	0.17872	100.00
5	CHAKABURA TPP (EXTN)	ACB (INDIA) Ltd. (Chhattisgarh)	30.00	0.16733	0.16733	100.00
6	INDIRA GANDHI	APCPL (Haryana)	1500.00	1.50337	1.55450	103.40
7	MUNDRA TPS	ADANI POWER (MUNDRA) LIMITED (Gujrat)	4620.00	0.77400	0.79510	102.73
8	KAWAI	ADANI POWER RAJASTHAN LTD. (Rajasthan)	1320.00	1.27995	1.51981	118.74
9	ADANI DAHANU	ADANI ELECTRICITY MUMBAI LIMITED (Maharashtra)	500.00	0.56400	0.73235	129.85
10	ADHUNIK PNR LTD.(MAHADEV PRASAD STPP)	ADHUNIK POWER & NATURAL RESOURCES LTD. (Jharkhand)	540.00	0.74844	0.88052	117.65
11	BARKHERA	BEPL (UP)	90.00	0.04699	0.04708	100.18
12	KHAMBER KHERA	BEPL (UP)	90.00	0.04580	0.04580	100.00
13	KUNDARKI	BEPL (UP)	90.00	0.06184	0.06184	100.00
14	MAQSOODAPUR	BEPL (UP)	90.00	0.04319	0.04319	100.00
15	UTRAULA	BEPL (UP)	90.00	0.05824	0.05824	100.00
16	BALCO CPP-II	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	540.00	1.04020	1.10760	106.48
17	B.B.G.S.	C.E.S.C. (West Bengal)	750.00	1.2160	1.2160	100.00
18	S.G.S.	C.E.S.C. (West Bengal)	135.00	0.0540	0.0540	100.00
19	KORBA (EAST)	C.S.P.G.C.L (Chhattisgarh)	440.00	0.7112	0.7726	108.64
20	MUTIARA	COASTAL ENERGEN PVT. LTD (Tamil Nadu)	1200.00	0.0703	0.0705	100.23
21	CHEMPLAST LIMITED TPS	CHEMPLAST SANMAR LIMITED(Tamil Nadu)	48.50	0.0183	0.0184	100.44
22	DHARIWAL INFRASTRUCTURE Ltd.	DHARIWAL INFRASTRUCTURE LIMITED(Maharashtra)	600.00	0.6910	0.7246	104.86
23	SURAT LIGNITE	G.I.P.C.L. (Gujarat)	500.00	0.6033	0.6033	100.00
24	AKRIMOTA	G.M.D.C.L. (Gujarat)	250.00	0.2665	0.3765	141.28
25	GANDHINAGAR	G.S.E.C.L. (Gujarat)	630.00	0.0744	0.1923	258.49
26	KUTCH LIGNITE	G.S.E.C.L. (Gujarat)	290.00	0.0438	0.0439	100.23
27	SIKKA	G.S.E.C.L. (Gujarat)	600.00	0.0100	0.0339	339.00
28	GMR WARORA ENERGY Ltd.	GMR WARORA ENERGY LTD. (Maharashtra)	600.00	0.7574	0.8280	109.32
29	GMR KAMALANGA TPP	GMR KAMALANGA ENERGY LTD. (Odisha)	1050.00	1.7867	1.7887	100.11
30	YAMUNANAGAR	H.P.G.C.L.(Haryana)	600.00	0.8591	1.0741	125.02
31	PANIPAT	H.P.G.C.L.(Haryana)	920.00	0.8244	1.2384	150.21
32	HALDIA ENERGY LIMITED	HALDIA ENERGY LIMITED (W.B)	600.00	1.0488	1.0488	100.00
33	Vizag TPS	HINDUJA NATIONAL POWER CORPORATION LIMITED (Andhra Pradesh)	1040.00	0.1991	0.5201	261.18
34	DISHERGARH POWER STATION	INDIA POWER CORPORATION Ltd. (W.B)	12.00	0.0171	0.0171	100.00
35	INDIAN METALS	INDIAN METALS &	258.00	0.4367	0.4368	100.02

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	& FERRO ALLOYS LTD.	FERRO ALLOYS Ltd.(Odisha)				
36	MAHATMA GANDHI	JHPL (Haryana)	1320.00	1.6480	2.2565	136.92
37	O.P.Jindal Super TPP (Stage-I)	JPL (Chhattisgarh.)	1000.00	1.0610	1.0870	102.45
38	O.P.Jindal Super TPP(Stage-II)	JPL (Chhattisgarh.)	2400.00	2.3040	2.3490	101.95
39	JAYPEE BINA TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	500.00	0.5362	0.5416	101.01
40	JAYPEE NIGRIE SUPER TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	1320.00	1.0700	1.0870	101.59
41	RATNAGIRI	JSW ENERGY LIMITED (Maharashtra)	1200.00	0.4254	0.4277	100.54
42	VIJAYANAGAR	JSW ENERGY LIMITED (Karnataka)	860.00	0.2378	0.2679	112.65
43	DANGAMAHUA CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (CHHATTISGARH)	576.00	0.7748	0.7754	100.08
44	JALIPA KAPURDI	JSW ENERGY (BARMER) LIMITED (Formerly Raj Westpower Ltd.) (Rajasthan)	1080.00	0.0880	0.1090	123.86
45	JSW STEEL LIMITED CPP-II	JSW STEEL LIMITED (Tamil Nadu)	60.00	0.0127	0.0127	100.11
46	KMPCL (AKALTARA)	KSK MAHANADI POWER COMPANY LIMITED (Chhattisgarh)	1800.00	1.6041	1.6339	101.86
47	LALITPUR	LALITPUR POWER GENERATION COMPANY LIMITED (UP)	1980.00	1.1334	1.1334	100.00
48	MAITHON RBTPP	MPL (Jharkhand)	1050.00	1.7344	1.7738	102.27
49	NASHIK	M.S.P.G.C.L.(Maharashtra)	630.00	0.7022	1.4340	204.20
50	PARLI	M.S.P.G.C.L.(Maharashtra)	750.00	0.8578	2.5058	292.11
51	MCCPL BANDHAKHAR	MARUTI CLEAN COAL AND POWER LIMITED (Chhattisgarh)	300.00	0.7290	0.7290	100.00
52	THAMMINAPATNAM TPS	MEENAKSHI ENERGY PRIVATE LIMITED (Andhra Pradesh)	300.00	0.0014	0.0085	622.26
53	ANUPPUR TPS	MB POWER (MADHYA PRADESH) LIMITED (M.P.)	1200.00	1.5779	1.6359	103.68
54	NEYVELI -I EXPN	NLC LTD.(Tamil Nadu)	420.00	0.1421	0.1421	100.00
55	NEYVELI - II	NLC LTD.(Tamil Nadu)	1470.00	0.6663	0.7520	112.86
56	BARSINGSAR LIGNITE	NLC LTD. (Rajasthan)	250.00	0.2205	1.0618	481.63
57	BHILLAI TPS (BhILLAI PP-III)	NSPCL (Chhattisgarh)	500.00	0.9195	1.0585	115.12
58	BhILLAI TPS (BhILLAI PP-II)	NSPCL (Chhattisgarh)	74.00	0.1431	0.1438	100.51

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
59	DURGAPUR CPP	NSPCL (Odisha)	120.00	0.2060	0.2602	126.34
60	DADRI	NTPC LTD. (U.P.)	1820.00	2.2340	2.2369	100.13
61	FEROZE GANDHI UNACHAR	NTPC LTD.(U.P.)	1050.00	1.7190	2.0290	118.03
62	TANDA	NTPC LTD. (U.P.)	440.00	0.5430	1.5590	287.11
63	RAMAGUNDAM	NTPC LTD. (Andhra Pradesh).	2600.00	4.2750	4.7150	110.29
64	SIMHADRI	NTPC LTD. (Andhra Pradesh).	2000.00	2.9770	2.9820	100.17
65	TALCHAR(TPS)	NTPC LTD (Odisha).	460.00	1.1290	1.1323	100.29
66	SOLAPUR	NTPC LTD. (Maharashtra)	1320.00	0.4265	0.5400	126.61
67	OPG POWER GENERATION PRIVATE LIMITED	OPG POWER GENERATION PRIVATE LIMITED (Tamil Nadu)	414.00	0.0885	0.0961	108.55
68	ROPAR	P.S.P.C.L. (Punjab)	705.00	0.3965	1.2771	322.11
69	CHHABRA	RRVUNL (Rajasthan)	1000.00	1.3707	1.4274	104.14
70	SURATGARH	RRVUNL (Rajasthan)	1500.00	1.4324	1.5319	106.95
71	KALISINDH	RRVUNL (Rajasthan)	1200.00	0.9191	1.0806	117.57
72	ROSA PHASE-I	RPSCL(U.P)	1200.00	0.8224	0.9553	116.16
73	AMRAVATI TPS	RATTANINDIA POWER LTD. (Maharashtra)	1350.00	0.7214	0.8329	115.46
74	GMR Chhattisgarh	RAIPUR ENERGEN LIMITED(Formerly GMR CHHATTISGARH Energy Ltd) (Chhattisgarh)	1370.00	0.4964	0.5173	104.21
75	SIMHAPURI	SEPL(Andhra Pradesh)	600.00	0.0020	0.0020	100.00
76	SINGARENI TPP	THE SINGARENI COLLIERIES COMPANY LIMITED (Telengana)	1200.00	1.8241	1.8736	102.71
77	TROMBAY	T.P.CO.(Maharashtra)	750.00	0.0502	0.0514	102.39
78	SABARMATI	TORRENT POWER LTD.(Gujarat)	422.00	0.3319	0.3319	100.00
79	RAMAGUNDAM'B'	TSPGCL (Telengana)	62.50	0.0921	0.1457	158.22
80	KOTHAGUDEM-VI	TSPGCL (Telengana)	500.00	0.6805	0.7168	105.34
81	KAKATIA (Stage-I)	T.S.G.E.N.C.O. (Telangana)	500.00	0.8088	0.8209	101.49
82	KAKATIA (Stage-II)	T.S.G.E.N.C.O. (Telangana)	600.00	0.7735	0.7852	101.52
83	TENUGHAT TPS	TENUGHAT VIDHYUT NIGAM LIMITED (Jharkhand)	420.00	0.4931	0.6419	130.19
84	M/s TALWANDI SABO POWER LTD	TALWANDI SABO POWER LTD (Punjab)	1980.00	2.2800	2.5100	110.09
85	UDUPI	UDUPI POWER CORPORATION LIMITED (Karnataka)	1200.00	0.1260	0.1261	100.08
86	BUTIBORI	VIDARBHA INDUSTRIES POWER LTD. (Maharashtra)	600.00	0.4705	0.7488	159.16
87	VEDANTA LTD TPP	VEDANTA LIMITED (Odisha)	2400.00	3.0881	3.7198	120.46
88	VEDANTA LTD CPP	VEDANTA LIMITED (Odisha)	1215.00	2.4633	2.7713	112.50
89	KOLAGHAT	W.B.P.D.C.L(W.B.)	1260.00	1.6165	2.1411	132.45
90	SANTALDIH	W.B.P.D.C.L (W.B.)	500.00	0.1090	0.1103	101.25
91	BAKRESWAR	W.B.P.D.C.L(W.B.)	1050.00	1.6057	1.8783	116.98

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
92	SAI WARDHA POWER Ltd. ,WARORA	WPCL (Maharashtra)	540.00	0.2630	0.3016	114.66

It may be seen from Table-X above that:

During the Year 2018-19, **92** Thermal Power Stations have achieved the fly ash utilization of 100% or more. More than 100% fly ash utilization means utilization of ash generated during current year and utilization of un-utilized accumulated ash before current year.

4.4 Thermal Power Stations with Fly Ash Utilization in the Range of 90% to less than 100% during the Year 2018-19

The Thermal Power Stations with fly ash utilization in the range of 90% to less than 100% during the year 2018-19 are given in Table-XI below:

TABLE-XI

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	BALCO CPP-III	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	1200.00	1.7580	1.7579	99.995
2	BHADRESHWAR VIDYUT PRIVATE LTD TPS	BHADRESHWAR VIDYUT PRIVATE LIMITED (Gujarat)	300.00	0.0493	0.0487	98.889
3	MUNDRA UMPP	CGPL (Gujrat)	4150.00	0.7900	0.7410	93.797
4	CHANDRAPURA	D.V.C.(Jharkhand)	630.00	0.8719	0.8495	97.430
5	KODERMA	D.V.C. (Jharkhand)	1000.00	1.6171	1.6061	99.317
6	WANAKBORI	G.S.E.C.L. (Gujarat)	1470.00	0.1686	0.1570	93.090
7	IL&FS TAMIL NADU POWER COMPANY Ltd.	IL&FS TAMIL NADU POWER COMPANY LIMITED (Tamil Nadu)	1200.00	0.1300	0.1280	98.462
8	ANGUL CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (Chhattisgarh)	810.00	1.0431	1.0167	97.465
9	BALLARI	K.P.C.L (Karnataka)	1700.00	0.7940	0.7317	92.154
10	BHUSAWAL	M.S.P.G.C.L.(Maharashtra)	1210.00	1.7556	1.6756	95.444
11	NEYVELI - II EXPN	NLC LTD. (Tamil Nadu)	500.00	0.1070	0.1044	97.571
12	NLC TAMILNADU POWER Ltd	NLC TAMIL NADU POWER LIMITED (Tamil Nadu)	1000.00	1.0347	1.0343	99.962
13	BADARPUR	NTPC LTD (Delhi).	705.00	0.2940	0.2900	98.639
14	MOUDA TPS	NTPC LTD. (Maharashtra)	2320.00	2.6480	2.3880	90.181
15	RAJPURA TPS	NABHA POWER PROJECT (Punjab)	1400.00	1.4395	1.3055	90.691
16	GVK POWER(GOINDWALSAHIB)LTD.,GOINDWALSAHIB	PSPCL (Punjab)	540.00	0.4669	0.4658	99.756
17	PRAYAGRAJ TPS	PRAYAGRAJ POWER	1980.00	1.3490	1.2555	93.067

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		GENERATION COMPANY LTD. (U.P.)				
18	UNCCHPINDA	R.K.M.POWERGEN PVT. LTD (PGCIL) (Chhattisgarh)	1440.00	0.5501	0.5417	98.466
19	HARDUAGANJ	U.P.R.V.U.N.L. (U.P.)	610.00	0.7889	0.7624	96.639
20	SAGARDIGHI	W.B.P.D.C.L(W.B.)	1600.00	1.2283	1.1470	93.379

It may be seen from Table-XI above that **20** thermal power stations during the year 2018-19 have achieved fly ash utilization level in the range of 90% to less than 100%.

4.5 Thermal Power Stations with Fly Ash Utilization in the Range of 70% to less than 90% during the Year 2018-19

The Thermal Power Stations with fly ash utilization in the range of 70% to less than 90% during the year 2018-19 are given in Table-XII below:

TABLE-XII

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	RAYALSEEMA	APGENCO (Andhra Pradesh)	1650.00	1.9240	1.617234	84.06
2	TIRODA	ADANI POWER MAHARASHTRA LTD. (Maharashtra)	3300.00	4.3630	3.6847	84.45
3	MEJIA	D.V.C.(West Bengal)	2340.00	3.8591	2.8519	73.90
4	DURGAPUR STEEL	D.V.C. (West Bengal)	1000.00	1.6118	1.2234	75.91
5	D.P.P.S.	D.P.L (West Bengal).	550.00	0.6539	0.5707	87.29
6	MAHAN	ESSAR POWER MP LTD.(M.P.)	1200.00	0.5629	0.4834	85.89
7	UKAI	G.S.E.C.L. (Gujarat)	1110.00	0.1312	0.1080	82.32
8	BHAVNAGAR LIGNITE	G.S.E.C.L. (Gujarat)	500.00	0.0068	0.0059	86.76
9	RAICHUR	K.P.C.L.(Karnataka)	1720.00	2.2160	1.5568	70.25
10	SANJAY GANDHI	M.P.P.G.C.L. (M.P.)	1340.00	2.0203	1.4539	71.96
11	FARAKKA	NTPC LTD. (W.B.)	2100.00	3.1350	2.5110	80.10
12	NALCO,CPP AUNGAL	NATIONAL ALUMINIUM COMPANY LIMITED (NALCO) (Odisha)	1200.00	2.4760	1.8206	73.53
13	LEHRA MOHABAT	P.S.P.C.L. (Punjab)	920.00	0.6249	0.5394	86.3173
14	RATIZA TPS	SPECTRUM COAL & POWER LTD.(Chhattisgarh)	100.00	0.7169	0.5516	76.9492
15	SEMBCORP ENERGY INDIA Ltd.(PAINAMPURAM TPP) (SGPL-TPP)	SEMBCORP ENERGY INDIA Ltd. (Formerly Thermal Powertech Corporation India Ltd) (Andhra Pradesh)	1320.00	0.8874	0.7780	87.6697
16	SKS POWER GENERATION(CC)LTD (Binjkote	SKS POWER GENERATION(CHHATTISGARH) LIMITED	600.00	0.5582	0.3961	70.9608

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	TPP)	(Chhattisgarh)				
17	CUDDALORE	TAQA NEYVELLY POWER CO.PVT. LTD. (Tamil Nadu)	250.00	0.1067	0.0803	75.2246
18	JOJOBERA	T.P.CO. (Jharkhand)	547.50	0.1071	0.0942	87.9259
19	METTUR-I	T.N.G & D Corporation (Tamil Nadu)	840.00	1.1470	0.9373	81.7203
20	METTUR-II	T.N.G & D Corporation (Tamil Nadu)	600.00	0.6159	0.4889	79.3881
21	NORTH CHENNAI-II	T.N.G & D Corporation (Tamil Nadu)	1200.00	1.4326	1.0624	74.1576
22	RAIGARH TPP (NAWAPARA TPP)	TRN ENERGY PRIVATE LIMITED (Chhattisgarh)	600.00	1.0634	0.7895	74.2460
23	PARICHHA	U.P.R.V.U.N.L. (U.P.)	1140.00	1.3370	1.0942	81.8399
24	VS LIGNITE POWER PRIVATE LTD	VS LIGNITE POWER PRIVATE LIMITED (Rajasthan)	135.00	0.0540	0.0455	84.2933
25	BANDEL	W.B.P.D.C.L (W.B.)	335.00	0.4861	0.4337	89.2308

It may be seen from Table-XII above that **25** thermal power stations during the year 2018-19 have achieved fly ash utilization level of less than 90% and up to 70%.

4.6 Thermal Power Stations with Fly Ash Utilization in the range 50% to less than 70% during the Year 2018-19

The Thermal Power Stations with fly ash utilization in the range of 50% to less than 70% during the year 2018-19 are given in Table-XIII:

TABLE-XIII

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	SRI DAMODARAM SANJEEVAIAH	APPDCL(Andhra Pradesh)	1600.00	1.2120	0.7926	65.40
2	RAJIV GANDHI (HISAR)	H.P.G.C.L.(Haryana)	1200.00	1.0645	0.6482	60.89
3	DERANG TPP	JINDAL INDIA THERMAL POWER LIMITED (Odisha)	1200.00	1.3740	0.9460	68.85
4	AMARKANTAK TPS (PATHADI TPP)	LANCO AMARKANTAK POWER LIMITED (Chhattisgarh)	600.00	1.1500	0.5755	50.05
5	AMARKANTAK	M.P.P.G.C.L. (M.P.)	210.00	0.2477	0.1645	66.42
6	JHABUA POWER LIMITED (SEIONI TPP)(AVANTHA BHANDAR TPP)	M/S JHABUA POWER LIMITED (MP)	600.00	0.5691	0.3456	60.74
7	NEYVELI - I	NLC LTD.(Tamil Nadu)	500.00	0.1925	0.1277	66.33
8	VALLUR	NTPC TAMIL NADU ENERGY COMPANY LTD {(NTECL) (Tamil Nadu)}	1500.00	2.2570	1.5250	67.57

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
9	KORBA	NTPC (Chhattisgarh).	2600.00	5.4123	2.7650	51.09
10	BARH SUPER TPS	NTPC LTD (Bihar)	1320.00	2.2970	1.1520	50.15
11	TALCHAR(KAN)	NTPC LTD.(Odisha).	3000.00	7.5850	3.8080	50.20
12	KUDGI	NTPC LTD. (Karnataka)	2400.00	1.3703	0.8830	64.44
13	TUTICORIN	T.N.G & D Corporation (Tamil Nadu)	1050.00	1.0188	0.6922	67.94
14	NORTH CHENNAI-I	T.N.G & D Corporation (Tamil Nadu)	630.00	1.0169	0.6727	66.16

It may be seen from Table-XIII above that **14** thermal power stations during the year 2018-19 have achieved fly ash utilization in the range of 50% to less than 70%.

4.7 Thermal Power Stations with Fly Ash Utilization below 50% during the Year 2018-19

The Thermal Power Stations with fly ash utilization less than 50% during the year 2018-19 are given in Table-XIV:

TABLE-XIV

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	NABINAGAR	BHARATIYA RAIL BIJLEE COMPANY LIMITED (Bihar)	750.00	0.6101	0.1744	28.59
2	MARWA TENDUBHATA	C.S.P.G.C.L (Chhattisgarh)	1000.00	1.7260	0.4313	24.99
3	DSPM	C.S.P.G.C.L. (Chhattisgarh)	500.00	0.9719	0.3144	32.35
4	KORBA (WEST)	C.S.P.G.C.L Chhattisgarh	1340.00	2.6890	1.3239	49.23
5	BOKARO 'B'	D.V.C.(Jharkhand)	710.00	0.8274	0.2989	36.12
6	DURGAPUR	D.V.C.(West Bengal)	210.00	0.3347	0.0257	7.66
7	RAGHUNATHPUR	D.V.C. (West Bengal)	1200.00	0.8024	0.0783	9.76
8	BELA TPS	IDEAL ENERGY PROJECTS LIMITED (Maharashtra)	270.00	0.0306	0.0000	0.00
9	MUZAFFARPUR TPS	KANTI BIJLEE UTPADAN NIGAM LIMITED (Bihar)	610.00	0.8118	0.3022	37.22
10	ANPARA-C TPS	LANCO ANPARA POWER LIMITED (Uttar Pradesh)	1200.00	1.2200	0.3600	29.51
11	SATPURA	M.P.P.G.C.L. (M.P.)	1330.00	2.3059	0.7016	30.43
12	SHREE SINGAJI TPS	M.P.P.G.C.L. (M.P.)	210.00	2.1602	0.2899	13.42
13	CHANDRAPUR	M.S.P.G.C.L.(Maharashtra)	2920.00	3.0892	1.0361	33.54
14	KHAPARKHEDA	M.S.P.G.C.L.(Maharashtra)	1340.00	2.6952	0.3837	14.24
15	KORADI	M.S.P.G.C.L.(Maharashtra)	2600.00	2.6580	0.7740	29.12
16	PARAS	M.S.P.G.C.L.(Maharashtra)	500.00	0.6679	0.2274	34.05
17	KWPCL TPP	M/s KORBA WEST POWER COMPANY	600.00	0.0000	0.0600	No Generation

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		LIMITED (Chhattisgarh)				
18	MEJA TPP	MEJA URJA NIGAM PRIVATE LIMITED(Uttar Pradesh)	660.00	0.0630	0.0001	0.22
19	ROURKELA CPP	NSPCL (West Bengal)	120.00	0.4557	0.1654	36.30
20	SINGRAULI	NTPC LTD. (U.P.)	2000.00	2.8900	1.0130	35.05
21	RIHAND	NTPC LTD. (U.P.)	3000.00	3.5160	1.3020	37.03
22	VINDHYACHAL	NTPC LTD. (M.P.)	4760.00	8.2580	2.6760	32.40
23	SIPAT	NTPC LTD. (Chhattisgarh).	2980.00	4.7993	2.3770	49.53
24	KAHALGAON	NTPC LTD.(Bihar)	2340.00	4.3200	2.0890	48.36
25	BONGAIGAON	NTPC LTD. (Assam)	750.00	0.4670	0.1410	30.19
26	GADARWARA	NTPC LTD. (Madhya Pradesh)	800.00	0.0880	0.0000	0.00
27	IB VALLEY	O.P.G.C.L.(Odisha)	420.00	1.0141	0.3434	33.86
28	BATHINDA	P.S.P.C.L. (Punjab)	460.00	0.0000	0.7427	No Generation
29	YERAMARUS TPS	RAICHUR POWER CORPORATION LIMITED (Karnataka)	1600.00	0.1215	0.0400	32.91
30	RINL CAPTIVE TPP, VISAKHAPATNAM	RASHTRIYA ISPAT NIGAM LIMITED (Andhra Pradesh)	315.00	0.7628	0.2202	28.87
31	SASAN UMPP	REILIANCE POWER LIMITED (Madhya Pradesh)	3960.00	4.0222	1.4916	37.08
32	KOTHAGUDEM-V	TSPGCL (Telangana)	500.00	1.1195	0.2786	24.88
33	KOTHAGUDEM (Stage I to IV)	T.S.P.G.C.L (Telangana)	420.00	1.7849	0.7393	41.42
34	ANPARA 'A' & 'B'	U.P.R.V.U.N.L. (U.P.)	2630.00	4.3989	0.2326	5.29
35	OBRA	U.P.R.V.U.N.L. (U.P.)	1000.00	0.7802	0.0904	11.58

It may be seen from Table-XIV above that **35** Thermal Power Stations achieved fly ash utilization less than 50% during the year 2018-19.

4.8 THERMAL POWER STATIONS WITH NO ASH GENERATION DURING THE YEAR 2018-19

The Thermal Power Stations with no fly ash generation during the year 2018-19 are given in Table-XV:

TABLE-XV

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	MIHAN	AMNEPL (Maharashtra) (No Generation)	246.00	0.0000	0.0000	0.0000
2	T.G.S.	C.E.S.C. (West Bengal) (No Generation)	240.00	0.0000	0.0000	0.0000
3	CHINAKURI	EASTERN COALFIELDS LIMITED (West Bengal)(No Generation)	30.00	0.0000	0.0000	0.0000

Sl. No.	Name of TPS	Power Utility	Installed Capacity (MW)	Fly ash Generation (Mt)	Fly ash Utilization (Mt)	% age Utilization
(1)	(2)	(3)	(4)	(5)	(6)	(7)
4	GEPL TPP	GUPTA ENERGY PRIVATE LIMITED(Maharashtra) (No Generation)	120.00	0.0000	0.0000	0.0000
5	RAJGHAT	IPGCL (Delhi)(No Generation)	135.00	0.0000	0.0000	0.0000
6	BARAUNI	NTPC Ltd-BSPGCL(JV) (Bihar)	220.00	0.0000	0.0000	0.0000
7	SAILILAGARH POWER GENERATION Ltd.	SAILILAGARH POWER GENERATION LIMITED (Chhattisgarh) (No Generation)	86.00	0.0000	0.0000	0.0000
8	SWASTIK POWER & MINERALS RESOURCES PVT. LTD.	SWASTIK POWER & MINERALS RESOURCES PVT. LTD (Chhattisgarh) (No Generation)	25.00	0.0000	0.0000	0.0000
9	PANKI	U.P.R.V.U.N.L. (U.P.)(No Generation)	210.00	0.0000	0.0000	0.0000

It may be seen from Table-XV above that:

It may be seen from Table-XV above that **09** thermal power stations during the year 2018-19 have not generated fly ash.

5.0 FLY ASH UTILIZATION STATUS AS PER NOTIFICATION OF 3RD NOVEMBER, 2009 DURING THE YEAR 2018-19 (TARGET ACHIEVED AND NOT ACHIEVED)

As per the targets mandated by the MoEF&CC's notification of dated 3rd November, 2009 for fly ash utilization by the power stations, a total of **103** stations achieved their target and as many as **83** Nos. could not reach the targets. The details are given at Table- XVI and XVII respectively. However, the date of achieving the 100% ash utilization target is now extended to 31st December, 2017 as per new amendment notification dated 25th January, 2016.

TABLE-XVI
FLY ASH UTILIZATION STATUS AS PER NOTIFICATION OF 3RD NOVEMBER, 2009 DURING THE YEAR 2018-19 (TARGET ACHIEVED)

Sl. No	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity (MW)	Fly ash Generation	Fly ash Utilization	% age Utilization	Target in %age
1	2	3	4	5	6	7	8	9
1	Dr. N.T.R (Vijawada)	APGENCO (Andhra Pradesh)	01.11.1979	1760.00	4.1149	4.2752	103.90	100
2	KASAIPALI	ACB(INDIA)L (Chhattishgarh)	13.12.2011	270.00	1.0789	1.0789	100.00	100
3	SVPPL Renki	ACB India Limited (Chhattisgarh)	12.10.2011	60.00	0.0098	0.0098	100.00	100
4	CHAKABURA TPP	ACB (INDIA) Ltd. (Chhattisgarh)	27.02.2007	30.00	0.1787	0.1787	100.00	100
5	CHAKABURA TPP (EXTN)	ACB (INDIA) Ltd. (Chhattishgarh)	28.03.2014	30.00	0.1673	0.1673	100.00	100
6	INDIRA GANDHI	APCPL (Haryana)	31.10.2010	1500.00	1.5034	1.5545	103.40	100
7	MUNDRA TPS	ADANI POWER (MUNDRA) LIMITED (Gujrat)	04.08.2009	4620.00	0.7740	0.7951	102.73	100
8	KAWAI	ADANI POWER RAJASTHAN LTD. (Rajasthan)	31.05.2013	1320.00	1.2800	1.5198	118.74	100
9	ADANI DAHANU	ADANI ELECTRICITY MUMBAI LIMITED	01.07.1995	500.00	0.5640	0.7324	129.85	100

Sl. No	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity (MW)	Fly ash Generation	Fly ash Utilization	%age Utilization	Target in %age
1	2	3	4	5	6	7	8	9
		(Maharashtra)						
10	ADHUNIK PNR LTD.(MAHADEV PRASAD STPP)	ADHUNIK POWER & NATURAL RESOURCES LTD. (Jharkhand)	21.01.2013	540.00	0.7484	0.8805	117.65	100
11	BARKHERA	BEPL (UP)	29.10.2011	90.00	0.0470	0.0471	100.18	100
12	KHAMBER KHERA	BEPL (UP)	30.09.2011	90.00	0.0458	0.0458	100.00	100
13	KUNDARKI	BEPL (UP)	03.01.2012	90.00	0.0618	0.0618	100.00	100
14	MAQSOODAPUR	BEPL (UP)	27.10.2011	90.00	0.0432	0.0432	100.00	100
15	UTRAULA	BEPL (UP)	30.01.2012	90.00	0.0582	0.0582	100.00	100
16	BALCO CPP-II	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	6.2005	540.00	1.0402	1.1076	106.48	100
17	BALCO CPP-III	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	8.2015	1200.00	1.7580	1.7579	99.99	90
18	B.B.G.S.	C.E.S.C. (West Bengal)	16.09.1997	750.00	1.2160	1.2160	100.00	100
19	S.G.S.	C.E.S.C. (West Bengal)	12.08.1990	135.00	0.0540	0.0540	100.00	100
20	KORBA (EAST)	C.S.P.G.C.L (Chhattisgarh)	01.10.1966	440.00	0.7112	0.7726	108.64	100
21	MUTIARA	COASTAL ENERGEN PVT. LTD (Tamil Nadu)	23.12.2014	1200.00	0.0703	0.0705	100.23	100
22	CHEMPLAST LIMITED TPS	CHEMPLAST SANMAR LIMITED(Tamil Nadu)	07.03.2012	48.50	0.0183	0.0184	100.44	100
23	DHARIWAL INFRASTRUCTURE Ltd.	DHARIWAL INFRASTRUCTURE LIMITED(Maharashtra)	11.2.2014	600.00	0.6910	0.7246	104.86	100
24	SURAT LIGNITE	G.I.P.C.L. (Gujarat)	15.02.2000	500.00	0.6033	0.6033	100.00	100
25	AKRIMOTA	G.M.D.C.L. (Gujarat)	31.03.2005	250.00	0.2665	0.3765	141.28	100
26	GANDHINAGAR	G.S.E.C.L. (Gujarat)	20.03.1990	630.00	0.0744	0.1923	258.49	100
27	KUTCH LIGNITE	G.S.E.C.L. (Gujarat)	09.01.1990	290.00	0.0438	0.0439	100.23	100
28	SIKKA	G.S.E.C.L. (Gujarat)	14.09.2015	500.00	0.0100	0.0339	339.00	90
29	BHAVNAGAR LIGNITE	G.S.E.C.L. (Gujarat)	16.05.2016	500.00	0.0068	0.0059	86.76	70
30	GMR WARORA ENERGY Ltd.	GMR WARORA ENERGY LTD. (Maharashtra)	19.03.2013	600.00	0.7574	0.8280	109.32	100
31	GMR KAMALANGA TPP	GMR KAMALANGA ENERGY LTD. (Odisha)	30.04.2013	1050.00	1.7867	1.7887	100.11	100
32	YAMUNANAGAR	H.P.G.C.L.(Haryana)	14.04.2008	600.00	0.8591	1.0741	125.02	100
33	PANIPAT	H.P.G.C.L.(Haryana)	28.03.1989	920.00	0.8244	1.2384	150.21	100
34	HALDIA ENERGY LIMITED	HALDIA ENERGY LIMITED (W.B)	28.01.2015	600.00	1.0488	1.0488	100.00	100
35	Vizag TPS	HINDUJA NATIONAL POWER CORPORATION LIMITED (Andhra	11.01.2016	1040.00	0.1991	0.5201	261.18	90

Sl. No	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity (MW)	Fly ash Generation	Fly ash Utilization	% age Utilization	Target in %age
1	2	3	4	5	6	7	8	9
		Pradesh)						
36	DISHERGARH POWER STATION	INDIA POWER CORPORATION Ltd. (W.B)	25.09.2012	12.00	0.0171	0.0171	100.00	100
37	INDIAN METALS & FERRO ALLOYS LTD.	INDIAN METALS & FERRO ALLOYS Ltd.(Odisha)	2.1989	258.00	0.4367	0.4368	100.02	100
38	IL&FS TAMIL NADU POWER COMPANY Ltd.	IL&FS TAMIL NADU POWER COMPANY LIMITED (Tamil Nadu)	29.09.2015	1200.00	0.1300	0.1280	98.46	90
39	MAHATMA GANDHI	JHPL (Haryana)	29.03.2012	1320.00	1.6480	2.2565	136.92	100
40	O.P.Jindal Super TPP (Stage-I)	JPL (Chhattisgarh.)	08.12.2007	1000.00	1.0610	1.0870	102.45	100
41	O.P.Jindal Super TPP(Stage-II)	JPL (Chhattisgarh.)	14.03.2014	2400.00	2.3040	2.3490	101.95	100
42	JAYPEE BINA TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	31.08.2012	500.00	0.5362	0.5416	101.01	100
43	JAYPEE NIGRIE SUPER TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	03.09.2014	1320.00	1.0700	1.0870	101.59	100
44	RATNAGIRI	JSW ENERGY LIMITED (Maharashtra)	01.09.2010	1200.00	0.4254	0.4277	100.54	100
45	VIJAYANAGAR	JSW ENERGY LIMITED (Karnataka)	18.01.2000	860.00	0.2378	0.2679	112.65	100
46	DANGAMAHUA CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (CHHATTISGARH)	04.09.2010	576.00	0.7748	0.7754	100.08	100
47	JALIPA KAPURDI	JSW ENERGY (BARMER) LIMITED (Formerly Raj Westpower Ltd.) (Rajasthan)	26.11.2009	1080.00	0.0880	0.1090	123.86	100
48	JSW STEEL LIMITED CPP-II	JSW STEEL LIMITED (Tamil Nadu)	24.07.2006	60.00	0.0127	0.0127	100.11	100
49	KMPCL (AKALTARA)	KSK MAHANADI POWER COMPANY LIMITED (Chhattisgarh)	Sept,2013	1800.00	1.6041	1.6339	101.86	100
50	LALITPUR	LALITPUR POWER GENERATION COMPANY LIMITED (UP)	08.01.2016	1980.00	1.1334	1.1334	100.00	90
51	MAITHON RBTPP	MPL (Jharkhand)	01.09.2011	1050.00	1.7344	1.7738	102.27	100
52	NASHIK	M.S.P.G.C.L.(Maharashtra)	26.04.1979	630.00	0.7022	1.4340	204.20	100
53	PARLI	M.S.P.G.C.L.(Maharashtra)	01.11.2007	750.00	0.8578	2.5058	292.11	100
54	MCCPL BANDHAKHAR	MARUTI CLEAN COAL AND POWER LIMITED (Chhattisgarh)	30.07.2015	300.00	0.7290	0.7290	100.00	90
55	THAMMINAPATNAM TPS	MEENAKSHI ENERGY PRIVATE LIMITED (Andhra Pradesh)	07.10.2012	300.00	0.0014	0.0085	622.26	100

Sl. No	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity (MW)	Fly ash Generation	Fly ash Utilization	% age Utilization	Target in %age
1	2	3	4	5	6	7	8	9
56	ANUPPUR TPS	MB POWER (MADHYA PRADESH) LIMITED (M.P.)	20.05.2015	1200.00	1.5779	1.6359	103.68	90
57	MEJA TPP	MEJA URJA NIGAM PRIVATE LIMITED(Uttar Pradesh)	31.03.2019	660.00	0.0630	0.0001	0.22	*
58	NEYVELI -I EXPN	NLC LTD.(Tamil Nadu)	21.10.2002	420.00	0.1421	0.1421	100.00	100
59	NEYVELI - II	NLC LTD.(Tamil Nadu)	29.03.1986	1470.00	0.6663	0.7520	112.86	100
60	NEYVELI - II EXPN	NLC LTD. (Tamil Nadu)	22.04.2015	500.00	0.1070	0.1044	97.57	90
61	BARSINGSAR LIGNITE	NLC LTD. (Rajasthan)	27.10.2009	250.00	0.2205	1.0618	481.63	100
62	BHILLAI TPS (BhILLAI PP-III)	NSPCL (Chhattisgarh)	05.01.2009	500.00	0.9195	1.0585	115.12	100
63	BhILLAI TPS (BhILLAI PP-II)	NSPCL (Chhattisgarh)	25.08.1982	74.00	0.1431	0.1438	100.51	100
64	DURGAPUR CPP	NSPCL (Odisha)	17.02.1987	120.00	0.2060	0.2602	126.34	100
65	DADRI	NTPC LTD. (U.P.)	Oct,1991	1820.00	2.2340	2.2369	100.13	100
66	FEROZE GANDHI UNACHAR	NTPC LTD.(U.P.)	11/1/1988	1050.00	1.7190	2.0290	118.03	100
67	TANDA	NTPC LTD. (U.P.)	1/1/2000	440.00	0.5430	1.5590	287.11	100
68	RAMAGUNDAM	NTPC LTD. (Andhra Pradesh).	11/1/1983	2600.00	4.2750	4.7150	110.29	100
69	SIMHADRI	NTPC LTD. (Andhra Pradesh).	2/1/2002	2000.00	2.9770	2.9820	100.17	100
70	TALCHAR (TPS)	NTPC LTD (Odisha).	03.06.1995	460.00	1.1290	1.1323	100.29	100
71	SOLAPUR	NTPC LTD. (Maharashtra)	01.04.2017	1320.00	0.4265	0.5400	126.61	50
72	GADARWARA	NTPC LTD. (Madhya Pradesh)	29.03.2019	800.00	0.0880	0.0000	0.00	*
73	OPG POWER GENERATION PRIVATE LIMITED	OPG POWER GENERATION PRIVATE LIMITED (Tamil Nadu)	01.08.2010	414.00	0.0885	0.0961	108.55	100
74	ROPAR	P.S.P.C.L. (Punjab)	31.03.1988	840.00	0.3965	1.2771	322.11	100
75	GVK POWER(GOINDWALSAHIB) LTD.,GOINDWALSAHIB	PSPCL (Punjab)	2016	540.00	0.4669	0.4658	99.76	90
76	PRAYAGRAJ TPS	PRAYAGRAJ POWER GENERATION COMPANY LTD. (U.P.)	29.02.2016	1980.00	1.3490	1.2555	93.07	90
77	UCCHPINDA	R.K.M.POWERGEN PVT. LTD (PGCIL) (Chhattisgarh)	23.11.2015	1440.00	0.5501	0.5417	98.47	90

Sl. No	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity (MW)	Fly ash Generation	Fly ash Utilization	%age Utilization	Target in %age
1	2	3	4	5	6	7	8	9
78	CHHABRA	RRVUNL (Rajasthan)	11.06.2010	1000.00	1.3707	1.4274	104.14	100
79	SURATGARH	RRVUNL (Rajasthan)	31.10.1998	1500.00	1.4324	1.5319	106.95	100
80	KALISINDH	RRVUNL (Rajasthan)	07.05.2014	1200.00	0.9191	1.0806	117.57	100
81	ROSA PHASE-I	RPSCL(U.P)	12.03.2010	1200.00	0.8224	0.9553	116.16	100
82	AMRAVATI TPS	RATTANINDIA POWER LTD. (Maharashtra)	03.06.2013	1350.00	0.7214	0.8329	115.46	100
83	GMR Chhattisgarh	RAIPUR ENERGEN LIMITED(Formerly GMR CHHATTISGARH Energy Ltd) (Chhattisgarh)	1.06.2015	1370.00	0.4964	0.5173	104.21	90
84	SIMHAPURI	SEPL(Andhra Pradesh)	29.02.2012	600.00	0.0020	0.0020	100.00	100
85	SKS POWER GENERATION (CC)LTD (Binjkote TPP)	SKS POWER GENERATION(CHHATTISGARH) LIMITED (Chhattisgarh)	06.10.2017	100.00	0.7169	0.5516	76.95	50
86	SINGARENI TPP	THE SINGARENI COLLIERIES COMPANY LIMITED (Telengana)	25.09.2016	1200.00	1.8241	1.8736	102.71	70
87	TROMBAY	T.P.CO.(Maharashtra)	1984	750.00	0.0502	0.0514	102.39	100
88	SABARMATI	TORRENT POWER LTD.(Gujarat)	13.04.1997	422.00	0.3319	0.3319	100.00	100
89	RAMAGUNDAM 'B'	TSPGCL (Telengana)	17.10.1971	62.50	0.0921	0.1457	158.22	100
90	KOTHAGUDEM-VI	TSPGCL (Telengana)	20.10.2011	500.00	0.6805	0.7168	105.34	100
91	KAKATIA (Stage-I)	T.S.G.E.N.C.O. (Telangana)	31.03.2010	500.00	0.8088	0.8209	101.49	100
92	KAKATIA (Stage-II)	T.S.G.E.N.C.O. (Telangana)	24.03.2016	600.00	0.7735	0.7852	101.52	90
93	RAIGARH TPP (NAWAPARA TPP)	TRN ENERGY PRIVATE LIMITED (Chhattisgarh)	13.08.2016	600.00	1.0634	0.7895	74.25	70
94	TENUGHAT TPS	TENUGHAT VIDHYUT NIGAM LIMITED (Jharkhand)	14.04.1994	420.00	0.4931	0.6419	130.19	100
95	M/s TALWANDI SABO POWER LTD	TALWANDI SABO POWER LTD (Punjab)	05.07.2014	1980.00	2.2800	2.5100	110.09	100
96	UDUPI	UDUPI POWER CORPORATION LIMITED (Karnatak)	11.11.2010	1200.00	0.1260	0.1261	100.08	100
97	BUTIBORI	VIDARBHA INDUSTRIES POWER LTD. (Maharashtra)	04.04.2013	600.00	0.4705	0.7488	159.16	100
98	VEDANTA LTD TPP	VEDANTA LIMITED (Odisha)	09.11.2010	2400.00	3.0881	3.7198	120.46	100

Sl. No	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity (MW)	Fly ash Generation	Fly ash Utilization	%age Utilization	Target in %age
1	2	3	4	5	6	7	8	9
99	VEDANTA LTD CPP	VEDANTA LIMITED (Odisha)	30.07.2008	1215.00	2.4633	2.7713	112.50	100
100	KOLAGHAT	W.B.P.D.C.L(W.B.)	16.08.1990	1260.00	1.6165	2.1411	132.45	100
101	SANTALDIH	W.B.P.D.C.L (W.B.)	01.04.2009	500.00	0.1090	0.1103	101.25	100
102	BAKRESWAR	W.B.P.D.C.L(W.B.)	18.07.1999	1050.00	1.6057	1.8783	116.98	100
103	SAI WARDHA POWER Ltd. ,WARORA	WPCL (Maharashtra)	15.04.2010	540.00	0.2630	0.3016	114.66	100

Note: Target of fly ash utilization as per MoEF&CC Notification 3rd NOVEMBER, 2009

(1) At least 50% of fly ash generation- One year from the date of Commissioning
At least 70% of fly ash generation-Two years from the date of Commissioning
At least 90% of fly ash generation- Three years from the date of Commissioning
At least 100% of fly ash generation- Four years from the date of commissioning

(2)* (Less than 50% for Thermal Power Stations commissioned within one year from the date of commissioning)

(2) Cut-off Date for utilization target is 31.03.2019

TABLE-XVII
FLY ASH UTILIZATION STATUS AS PER NOTIFICATION OF 3RD NOVEMBER, 2009 DURING THE YEAR 2018-19 (THERMAL POWER STATIONS WHO HAVE NOT MET THEIR TARGET)

Sl. No.	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity	Fly ash Generation	Fly ash Utilization	% age Utilization	Target in % age
1	2	3	4	5	6	7	8	9
1	RAYALSEEMA	APGENCO (Andhra Pradesh)	16.11.1994	1650.00	1.9240	1.6172	84.06	100
2	SRI DAMODARAM SANJEEVAIAH	APPDCL(Andhra Pradesh)	05.02.2015	1600.00	1.2120	0.7926	65.40	100
3	TIRODA	ADANI POWER MAHARASHTRA LTD. (Maharashtra)	23.09.2012	3300.00	4.3630	3.6847	84.45	100
4	NABINAGAR	BHARATIYA RAIL BIJLEE COMPANY LIMITED (Bihar)	16.01.2017	750.00	0.6101	0.1744	28.59	70
5	BHADRESHWAR VIDYUT PRIVATE LTD TPS	BHADRESHWAR VIDYUT PRIVATE LIMITED (Gujarat)	04.01.2015	300.00	0.0493	0.0487	98.89	100
6	MARWA TENDUBHATA	C.S.P.G.C.L (Chhattisgarh)	31.03.2016	1000.00	1.7260	0.4313	24.99	90
7	DSPM	C.S.P.G.C.L. (Chhattisgarh)	21.10.2007	500.00	0.9719	0.3144	32.35	100
8	KORBA (WEST)	C.S.P.G.C.L Chhattisgarh	21.03.1983	1340.00	2.6890	1.3239	49.23	100
9	MUNDRA UMPP	CGPL (Gujrat)	07.03.2012	4150.00	0.7900	0.7410	93.80	100
10	BOKARO 'B'	D.V.C.(Jharkhand)	31.03.1993	710.0000	0.8274	0.2989	36.12	100
11	CHANDRAPURA	D.V.C.(Jharkhand)	07.07.1968	630.00	0.8719	0.8495	97.43	100
12	DURGAPUR	D.V.C.(West	Sep,1982	210.00	0.3347	0.0257	7.66	100

Sl. No.	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity	Fly ash Generation	Fly ash Utilization	% age Utilization	Target in % age
1	2	3	4	5	6	7	8	9
		Bengal)						
13	MEJIA	D.V.C.(West Bengal)	01.12.1997	2340.00	3.8591	2.8519	73.90	100
14	DURGAPUR STEEL	D.V.C. (West Bengal)	15.05.2012	1000.00	1.6118	1.2234	75.91	100
15	KODERMA	D.V.C. (Jharkhand)	18.07.2013	1000.00	1.6171	1.6061	99.32	100
16	RAGHUNATHPUR	D.V.C. (West Bengal)	31.03.2016	1200.00	0.8024	0.0783	9.76	70
17	D.P.P.S.	D.P.L (West Bengal).	30.04.2008	550.00	0.6539	0.5707	87.29	100
18	MAHAN	ESSAR POWER MP LTD.(M.P.)	29.04.2013	1200.00	0.5629	0.4834	85.89	100
19	UKAI	G.S.E.C.L. (Gujarat)	21.01.1979	1110.00	0.1312	0.1080	82.32	100
20	WANAKBORI	G.S.E.C.L. (Gujarat)	23.03.1982	1470.00	0.1686	0.1570	93.09	100
21	RAJIV GANDHI (HISAR)	H.P.G.C.L.(Haryana)	24.08.2010	1200.00	1.0645	0.6482	60.89	100
22	BELA TPS	IDEAL ENERGY PROJECTS LIMITED (Maharashtra)	18.07.2013	270.00	0.0306	0.0000	0.00	100
23	DERANG TPP	JINDAL INDIA THERMAL POWER LIMITED (Odisha)	05.06.2014	1200.00	1.3740	0.9460	68.85	100
24	ANGUL CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (Chhattisgarh)	13.05.2011	810.00	1.0431	1.0167	97.47	100
25	BALLARI	K.P.C.L (Karnataka)	25.03.2008	1700.00	0.7940	0.7317	92.15	100
26	RAICHUR	K.P.C.L.(Karnataka)	29.03.1985	1720.00	2.2160	1.5568	70.25	100
27	MUZAFFARPUR TPS	KANTI BIJLEE UTPADAN NIGAM LIMITED (Bihar)	11.2013	610.00	0.8118	0.3022	37.22	100
28	AMARKANTAK TPS (PATHADI TPP)	LANCO AMARKANTAK POWER LIMITED (Chhattisgarh)	01.05.2009	600.00	1.1500	0.5755	50.05	100
29	ANPARA-C TPS	LANCO ANPARA POWER LIMITED (Uttar Pradesh)	10.12.2011	1200.00	1.2200	0.3600	29.51	100
30	SANJAY GANDHI	M.P.P.G.C.L. (M.P.)	07.10.1993	1340.00	2.0203	1.4539	71.96	100
31	SATPURA	M.P.P.G.C.L. (M.P.)	07.01.1979	1330.00	2.3059	0.7016	30.43	100
32	AMARKANTAK	M.P.P.G.C.L. (M.P.)	10.09.2009	210.00	0.2477	0.1645	66.42	100
33	SHREE SINGAJI TPS	M.P.P.G.C.L. (M.P.)	01.02.2014	2520.00	2.1602	0.2899	13.42	90
34	BHUSAWAL	M.S.P.G.C.L. (Maharashtra)	18.09.1982	1210.00	1.7556	1.6756	95.44	100
35	CHANDRAPUR	M.S.P.G.C.L. (Maharashtra)	03.05.1985	2920.00	3.0892	1.0361	33.54	100
36	KHAPARKHEDA	M.S.P.G.C.L. (Maharashtra)	26.03.1989	1340.00	2.6952	0.3837	14.24	100
37	KORADI	M.S.P.G.C.L. (Maharashtra)	15.07.1978	2600.00	2.6580	0.7740	29.12	100
38	PARAS	M.S.P.G.C.L. (Maharashtra)	31.03.2008	500.00	0.6679	0.2274	34.05	100

Sl. No.	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity	Fly ash Generation	Fly ash Utilization	% age Utilization	Target in % age
1	2	3	4	5	6	7	8	9
39	JHABUA POWER LIMITED (SEIONI TPP)(AVANTHA BHANDAR TPP)	M/S JHABUA POWER LIMITED (MP)	03.05.2016	600.00	0.5691	0.3456	60.74	70
40	KWPCL TPP	M/s KORBA WEST POWER COMPANY LIMITED (Chhattisgarh)	31.03.2014	600.00	0.0000	0.0600	No Generation	100
41	NEYVELI - I	NLC LTD.(Tamil Nadu)	1962	500.00	0.1925	0.1277	66.33	100
42	NLC TAMILNADU POWER Ltd	NLC TAMIL NADU POWER LIMITED (Tamil Nadu)	08.03.2015	1000.00	1.0347	1.0343	99.96	100
43	ROURKELA CPP	NSPCL (West Bengal)	01.03.2001	120.00	0.4557	0.1654	36.30	100
44	VALLUR	NTPC TAMIL NADU ENERGY COMPANY LTD {(NTECL) (Tamil Nadu)}	09.03.2012	1500.00	2.2570	1.5250	67.57	100
45	BADARPUR	NTPC LTD (Delhi).	July/73	705.00	0.2940	0.2900	98.64	100
46	SINGRAULI	NTPC LTD. (U.P.)	February/82	2000.00	2.8900	1.0130	35.05	100
47	RIHAND	NTPC LTD. (U.P.)	March/88	3000.00	3.5160	1.3020	37.03	100
48	KORBA	NTPC (Chhattisgarh).	3/1/1983	2600.00	5.4123	2.7650	51.09	100
49	VINDHYACHAL	NTPC LTD.(M.P.)	10/1/1987	4760.00	8.2580	2.6760	32.40	100
50	SIPAT	NTPC LTD. (Chhattisgarh).	5/1/2007	2980.00	4.7993	2.3770	49.53	100
51	FARAKKA	NTPC LTD. (W.B.)	1/1/1986	2100.00	3.1350	2.5110	80.10	100
52	KAHALGAON	NTPC LTD.(Bihar)	3/1/1992	2340.00	4.3200	2.0890	48.36	100
53	BARH SUPER TPS	NTPC LTD (Bihar)	11/1/2014	1320.00	2.2970	1.1520	50.15	100
54	TALCHAR(KAN)	NTPC LTD.(Odisha).	2/1/1995	3000.00	7.5850	3.8080	50.20	100
55	MOUDA TPS	NTPC LTD. (Maharashtra)	4/1/2012	2320.00	2.6480	2.3880	90.18	100
56	BONGAIGAON	NTPC LTD. (Assam)	June,2015	750.00	0.4670	0.1410	30.19	90
57	KUDGI	NTPC LTD. (Karnataka)	12/1/2016	2400.00	1.3703	0.8830	64.44	70
58	RAJPURA TPS	NABHA POWER PROJECT (Punjab)	24.01.2014	1400.00	1.4395	1.3055	90.69	100
59	NALCO,CPP AUNGAL	NATIONAL ALUMINIUM COMPANY LIMITED (NALCO) (Odisha)	29.09.1986	1200.00	2.4760	1.8206	73.53	100
60	IB VALLEY	O.P.G.C.L.(Odisha)	21.12.1994	420.00	1.0141	0.3434	33.86	100

Sl. No.	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity	Fly ash Genaration	Fly ash Utilization	% age Utilization	Target in % age
1	2	3	4	5	6	7	8	9
61	BATHINDA	P.S.P.C.L. (Punjab)	22.09.1974	460.00	0.0000	0.7427	No Generation	100
62	LEHRA MOHABAT	P.S.P.C.L. (Punjab)	25.05.1998	920.00	0.6249	0.5394	86.32	100
63	YERAMARUS TPS	RAICHUR POWER CORPORATION LIMITED (Karnataka)	07.03.2017	1600.00	0.1215	0.0400	32.91	70
64	RINL CAPTIVE TPP, VISAKHAPATNAM	RASHTRIYA ISPAT NIGAM LIMITED (Andhra Pradesh)	12.03.1989	315.00	0.7628	0.2202	28.87	100
65	SASAN UMPP	REILIANCE POWER LIMITED (Madhya Pradesh)	16.08.2013	3960.00	4.0222	1.4916	37.08	100
66	RATIZA TPS	SPECTRUM COAL & POWER LTD.(Chhattisgarh)	27.02.2013	100.00	0.7169	0.5516	76.95	100
67	SEMBCORP ENERGY INDIA Ltd.(PAINAMPURAM TPP) (SGPL-TPP)	SEMBCORP ENERGY INDIA Ltd. (Formerly Thermal Powertech Corporation India Ltd) (Andhra Pradesh)	3/1/2015	1320.00	0.8874	0.7780	87.67	100
68	CUDDALORE	TAQA NEYVELLY POWER CO.PVT. LTD. (Tamil Nadu)	15.12.2002	250.00	0.1067	0.0803	75.22	100
69	JOJOBERA	T.P.CO. (Jharkhand)	September,1997	547.50	0.1071	0.0942	87.93	100
70	TUTICORIN	T.N.G & D Corporation (Tamil Nadu)	09.07.1979	1050.00	1.0188	0.6922	67.94	100
71	METTUR-I	T.N.G & D Corporation (Tamil Nadu)	07.01.1987	840.00	1.1470	0.9373	81.72	100
72	METTUR-II	T.N.G & D Corporation (Tamil Nadu)	11.10.2012	600.00	0.6159	0.4889	79.39	100
73	NORTH CHENNAI-I	T.N.G & D Corporation (Tamil Nadu)	25.10.1994	630.00	1.0169	0.6727	66.16	100
74	NORTH CHENNAI-II	T.N.G & D Corporation (Tamil Nadu)	20.03.2014	1200.00	1.4326	1.0624	74.16	100
75	KOTHAGUDEM-V	TSPGCL (Telangana)	27.03.1997	500.00	1.1195	0.2786	24.88	100
76	KOTHAGUDEM (Stage I to IV)	T.S.P.G.C.L (Telangana)	04.07.1966	420.00	1.7849	0.7393	41.42	100
77	ANPARA 'A' & 'B'	U.P.R.V.U.N.L. (U.P.)	01.01.1987	2630.00	4.3989	0.2326	5.29	100
78	HARDUAGANJ	U.P.R.V.U.N.L. (U.P.)	28.05.1978	610.00	0.7889	0.7624	96.64	100
79	OBRA	U.P.R.V.U.N.L. (U.P.)	26.01.1980	1000.00	0.7802	0.0904	11.58	100
80	PARICHHA	U.P.R.V.U.N.L. (U.P.)	31.03.1984	1140.00	1.3370	1.0942	81.84	100
81	VS LIGNITE POWER PRIVATE LTD	VS LIGNITE POWER PRIVATE LIMITED	2.2010	135.00	0.0540	0.0455	84.29	100

Sl. No.	Name of TPS	Power Utility	Date of Commissioning	Installed Capacity	Fly ash Generation	Fly ash Utilization	% age Utilization	Target in % age
1	2	3	4	5	6	7	8	9
		(Rajasthan)						
82	SAGARDIGHI	W.B.P.D.C.L(W.B.)	07.09.2008	1600.00	1.2283	1.1470	93.38	100
83	BANDEL	W.B.P.D.C.L (W.B.)	04.09.1965	335.00	0.4861	0.4337	89.23	100

From the above table it may be seen that **14** Thermal Power Stations have achieved utilization target of more than 90% but had failed with very less margin

6.0 MODES OF FLY ASH UTILIZATION DURING THE YEAR 2018-19

The data on fly ash utilization received from Thermal Power Stations/Power Utilities for the year 2018-19 has been analyzed to ascertain the modes in which fly ash was utilized and the quantity utilized in each mode.

The modes in which fly ash were utilized during the year 2018-19 along with utilization in each mode are given in Table-XVIII below:

TABLE-XVIII

MODES OF FLY ASH UTILIZATION DURING THE YEAR 2018-19

Sl. No.	Mode of utilization	Quantity of Fly Ash utilized in the mode of utilization (from Annexure – I)	
		Million-ton	Percentage (%)
(1)	(2)	(3)	(4)
1	Cement	58.3401	26.88
2	Mine filling	10.1002	4.65
3	Bricks & Tiles	21.6097	9.96
4	Reclamation of low lying area	29.3177	13.51
5	Ash Dyke Raising	21.5734	9.94
6	Roads & flyovers	9.7244	4.48
7	Agriculture	1.3769	0.63
8	Concrete	1.7742	0.82
9	Hydro Power Sector	0.0000	0.00
10	Others	14.5809	6.72
11	Unutilized Fly Ash	48.6405	22.41
	Total	**217.0380**	**100.00**

The pie diagram showing the modes of utilization of fly ash during the Year 2018-19 is given in Figure-1 below:

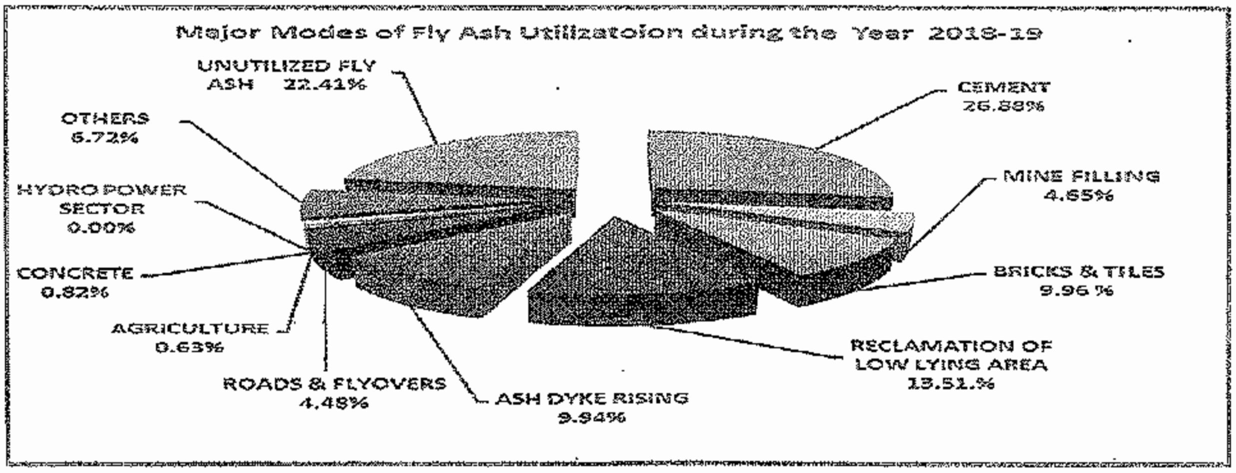

FIGURE-1

During the Year 2018-19, the maximum utilization of fly ash to the extent of 26.88% of total fly ash generated was in the Cement sector, followed by 13.51 % in Reclamation of Low lying area, 9.96 % in Bricks & Tiles, 9.94 in Ash Dyke, 4.65 % in Mine Filling, 4.48 % in roads & Flyovers, 0.82 % in Concrete, 0.63 % in Agriculture 0.00 % in Hydro Power Sector, 6.72 % in Others and 22.41% remained as unutilized fly ash.

7.0 PROGRESSIVE FLY ASH GENERATION & UTILIZATION DURING THE PERIOD FROM 1996-97 TO 2018-19

Central Electricity Authority has been monitoring since 1996-1997, the fly ash generation and its utilization at coal/lignite based thermal power stations in the country. Based on data of fly ash generation and utilization received from Thermal Power Stations/Power Utilities since 1996-97, the progressive fly ash generation and its utilization for the period from 1996-97 to 2018-19 is given in Table-XIX below:

TABLE-XIX

PROGRESSIVE FLY ASH GENERATION AND ITS UTILIZATION DURING THE PERIOD FROM 1996-97 TO 2018-19

Sl. No.	Year	Number of TPS Who provided data	Fly Ash Generation (Million-ton))	Fly Ash Utilization (Million-ton)	Fly Ash Utilization in % age
(1)	(2)	(3)	(4)	(5)	(6)
1	1996-97	-	68.88	6.64	9.63
2	1997-98	-	78.06	8.43	10.80
3	1998-99	-	78.99	9.22	11.68
4	1999-2000	-	74.03	8.91	12.03
5	2000-01	-	86.29	13.54	15.70
6	2001-02	-	82.81	15.57	18.80
7	2002-03	-	91.65	20.79	22.68
8	2003-04	-	96.28	28.29	29.39
9	2004-05	-	98.57	37.49	38.04
10	2005-06	-	98.97	45.22	45.69
11	2006-07	-	108.15	55.01	50.86
12	2007-08	-	116.94	61.98	53.00
13	2008-09	-	116.69	66.64	57.11
14	2009-10	-	123.54	77.33	62.60
15	2010-11	88	131.09	73.13	55.79
16	2011-12	124	145.41	85.05	58.48
17	2012-13	138	163.56	100.37	61.37
18	2013-14	143	172.87	99.62	57.63
19	2014-15	145	184.14	102.54	55.69
20	2015-16	151	176.74	107.77	60.97
21	2016-17	155	169.25	107.10	63.28
22	2017-18	167	196.44	131.87	67.13
23	2018-19	195	217.04	168.40	77.59

A graph showing progressive fly ash generation and its utilization for the period from 1996-97 to 2018-19 is given in Figure-2 below:

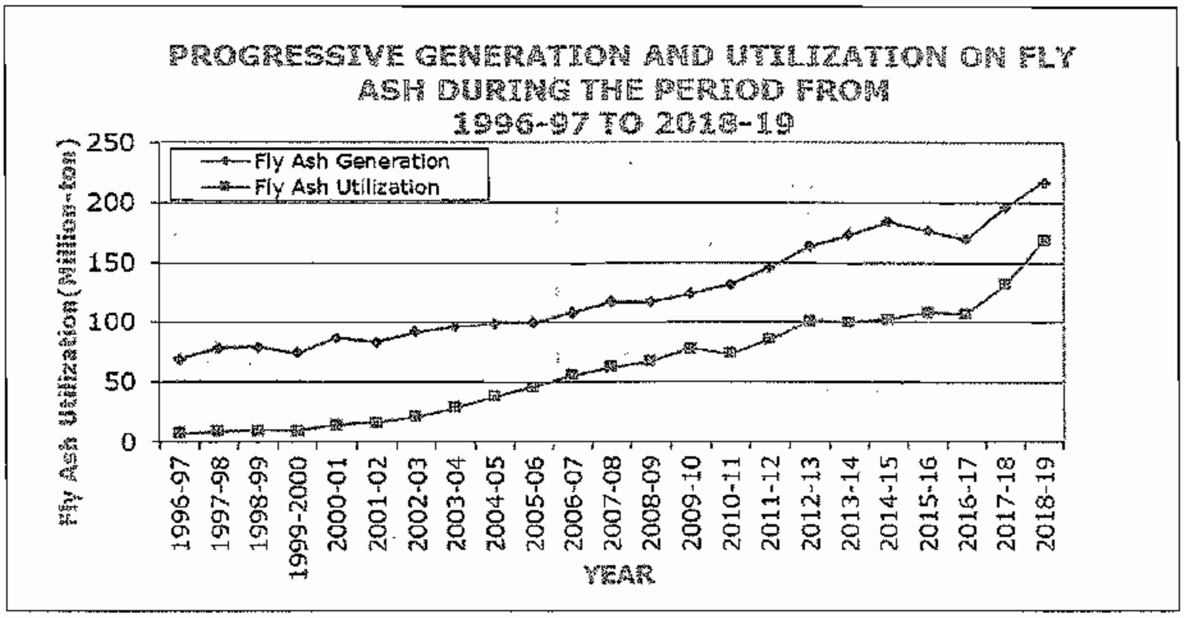

FIGURE-2

It may be seen from Table-XIX and Figure-2 above that:

(i) The fly ash generation as well as utilization has generally been increasing since 1996-97.However,the Fly ash generation has shown down trend for the year 2016-17 due to lesser coal utilization than 2014-15.

(ii) Fly ash utilization has increased from 9.63% in 1996-97 to the highest level of 77.59% during 2018-19.

(iii) The fly ash generation has increased from 68.88 million-ton in 1996-97 to 217.04 million-ton in 2018-19 i.e. nearly 3.15 times.

(iv) However, fly ash utilization has increased from 6.64 million-ton in 1996-97 to a level of 168.40 million ton in 2018-19 i.e. nearly more than 25.36 times over the same period.

(v) From the Table XIX, it is seen that quantities of fly ash generation during 2014-15, 2015-16, 2016-17,2017-18 and 2018-19 have been 184.14, 176.74 ,169.25, 196.44 and 217.04 million-ton respectively. Fly ash utilization during the said five years are 102.54, 107.77, 107.10, 131.87 and 168.40 million-ton. The utilization of fly ash during 2018-19 is the highest ever so far.

(vi) The number of Thermal Power Stations who have provided data has increased during succession years.

8.0 PROGRESSIVE FLY ASH UTILIZATION IN VARIOUS MODES DURING THEPERIOD FROM 1998-99 TO 2018-19

8.1 Cement Industry

Fly ash is being used by Cement Industry as a pozzolanic material in manufacturing of Portland Pozzolana Cement. It saves both precious lime stone and coal. The utilization of fly ash in manufacturing of cement is highly value added use. A graph showing progressive utilization of fly ash by Cement Industry for the period from 1998-99 to 2018-19 is given in Figure-3 below:

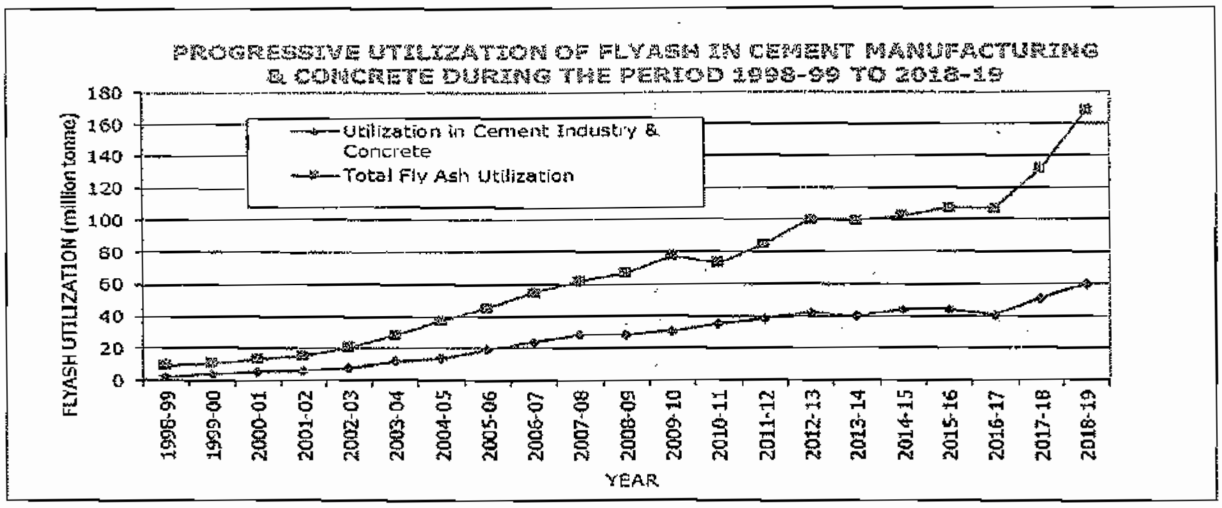

FIGURE-3

It may be seen from Figure-3 above that 2.45 million-ton of fly ash was used by Cement Industry in 1998-99 which increased to 60.11 million-ton during 2018-19 and constituted 27.71 % of total fly ash generation in the aforesaid year.

8.2 Reclamation of Low Lying Areas

Fly ash as a substitute of soil/sand is used for reclamation of low lying areas thereby saving top soil. A graph showing the progressive utilization of fly ash in reclamation of low lying area for the period from 1998-99 to 2018-19 is given in Figure-4.

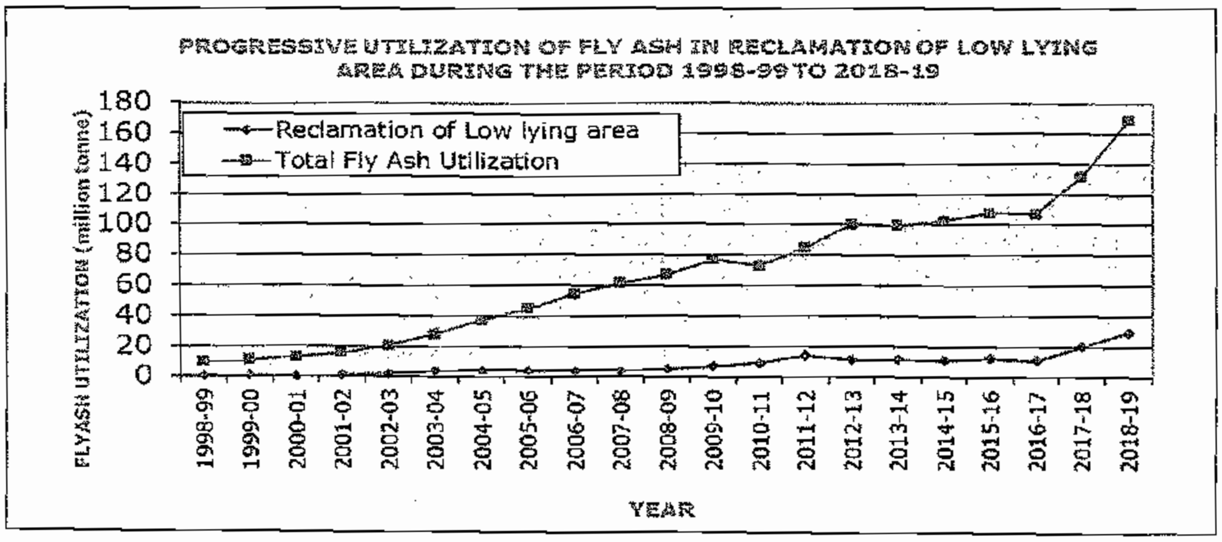

FIGURE-4

It may be seen from Figure-4 above that 4.17 million-ton of fly ash was used for reclamation of low lying area in 1998-99 which has increased to 29.32 million ton in 2018-19 constituting 13.51% of total fly ash generation during the aforesaid year.

8.3 Construction of Roads/Embankments/Flyovers and raising of Ash Dykes

Fly ash is being used in construction of roads/embankments/flyovers and the raising of ash dykes. It has a large potential for fly ash utilization. A graph showing the progressive utilization of fly ash in the construction of roads & embankments and the raising of ash dykes for the period from 1998-99 to 2018-19 is given in Figure-5 below:

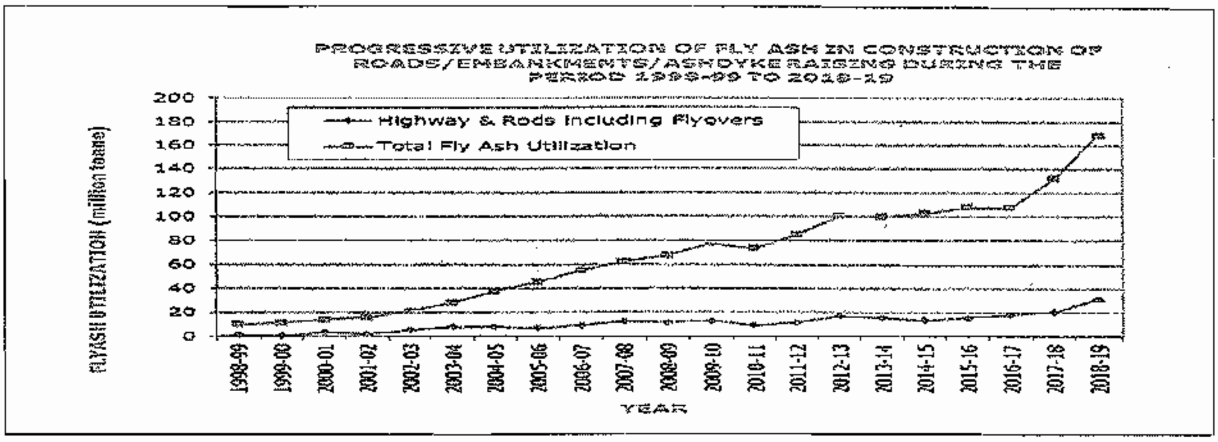

FIGURE-5

It may be seen from Figure-5 above that 1.055 million-ton of fly ash was used in the construction of roads/embankments/flyovers and raising of ash dykes etc. during 1998-99 which increased to 31.30 million-ton in 2018-19 and constituted 14.42 % of total fly ash generation in the aforesaid year. However, falling trend in recent past is seen.

8.4 Back Filling/Stowing of Mines

Fly ash is being used for backfilling of open cast mines and stowing of underground mines which results in saving of top fertile soil and precious river sand. It has large potential for fly ash utilization especially for pit head thermal power stations. A graph showing the progressive utilization of fly ash in backfilling/stowing of mines for the period from 1998-99 to 2018-19 is given in Figure-6:

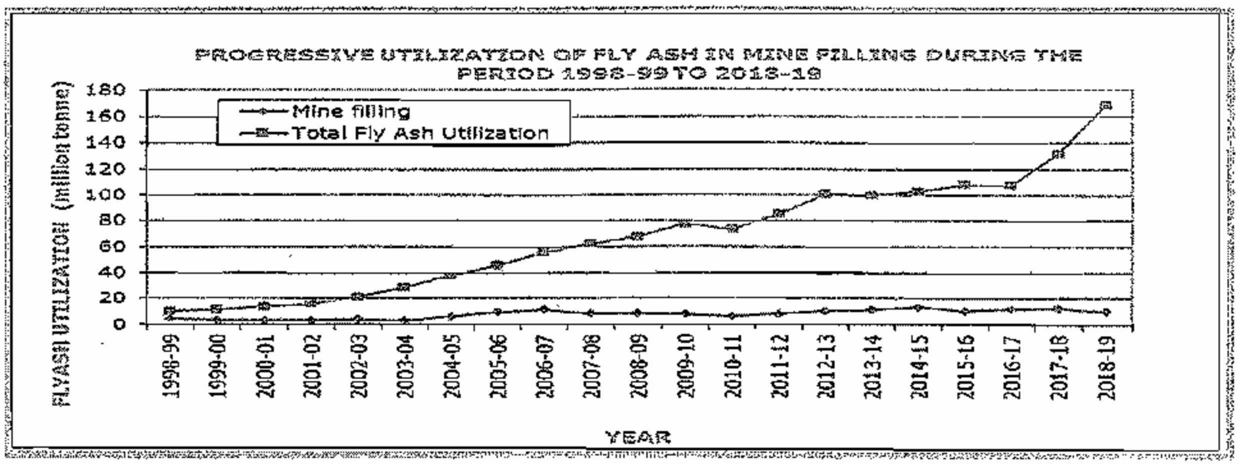

FIGURE-6

It may be seen from Figure-6 above that 0.65 million-ton of fly ash was used for backfilling/stowing of open cast and underground mines during 1998-99 which has slightly decreased 10.10 million-ton in 2018-19 constituting 4.65 % of total fly ash generation in the aforesaid year. The trend was on increasing side up to the year 2017-18 and slightly decreased during the year.

8.5 Building Materials like Bricks, Blocks and Tiles etc.

Fly ash is used in manufacturing of fly ash based building products like bricks, blocks, tiles etc which results in saving of fertile top soil. Fly ash based bricks/blocks/tiles are as good as clay based conventional building products. It has substantial potential of fly ash utilization especially for thermal power stations located near load centers. A graph showing progressive utilization of fly ash in making of fly ash based building products for the period from 1998-99 to 2018-19 is given in Figure -7.

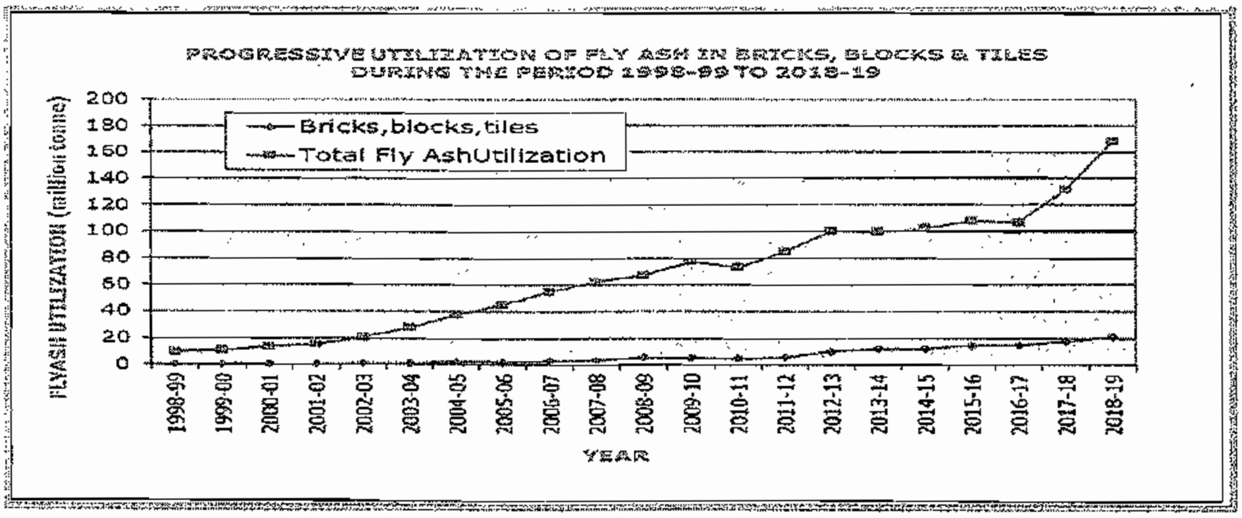

FIGURE-7

It may be seen from Figure-7 above that 0.70 million-ton of fly ash was used for making of fly ash based bricks/blocks/tiles etc during 1998-99 which increased to 21.61 million-ton in 2018-19 and constituted 9.96 % of total fly ash generation in the aforesaid year.

8.6 Agriculture

Fly ash is being used as manure in agricultural sector as it has many micronutrients. The progressive utilization of fly ash in Agricultural Sector for the period from 1998-99 to 2018-19 is given in Figure-8.

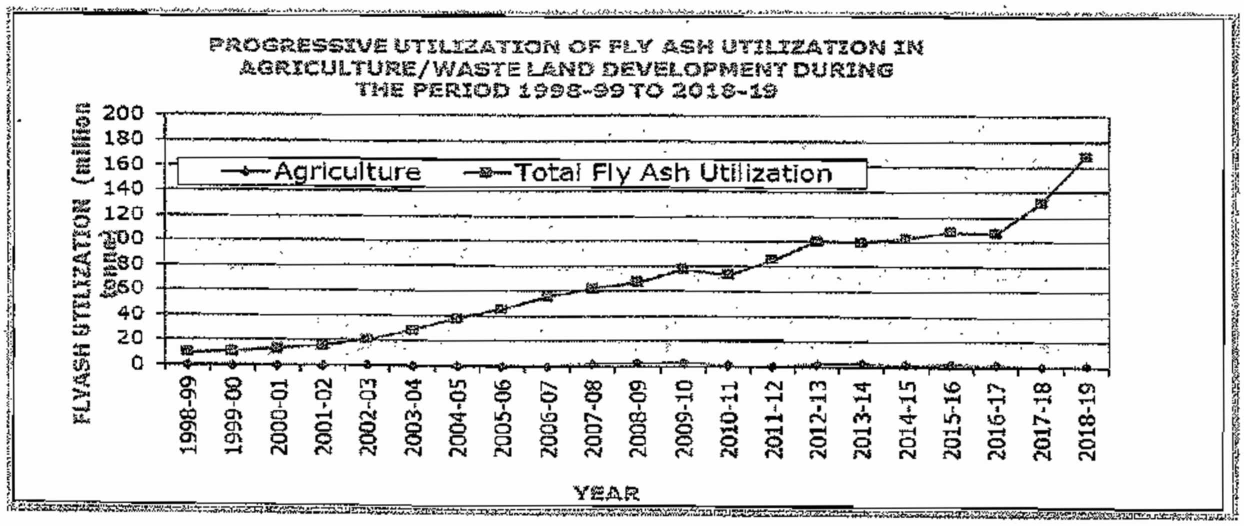

FIGURE-8

It may be seen from Figure-8 above that 0.13 million ton of fly ash was used in agricultural sector during 1998-99, which increased to 1.38 million ton in 2018-19 and constituted about 0.63 % of total fly ash generation in the aforesaid year.

9.0 WEB BASED MONITORING SYSTEM AND A MOBILE APPLICATION FOR UTILIZATION OF FLY ASH

Annual Fly ash utilization has remained 77.59 % of the fly ash generated and therefore, it has become a matter of concern in view of its environmental effect. Besides, progressive accumulation may lead to a situation when ash pond may not be in a position to accommodate fly ash further.

Due to the importance of utilization of fly ash & slag for reducing the burden on the environment, NITI AAYOG convened several meetings on policy framework on utilization of fly ash and slag. In a meeting held on 17.03.2017, it was decided by NITI AAYOG that an online repository of the fly ash generated by thermal power plants indicating the following parameters should be launched by Ministry of Power by 15th April, 2017:

- Cumulative amount of fly ash available in the ash ponds as on 31.3.2017
- Quantum of fly ash generated for the respective month (Ex. For the month of April 2017)
- Number of ash ponds available and their approved capacity in metric tonne
- Cumulative stock of fly ash available in the ponds for the month as on 30th April 2017
- Total quantum of fly ash disposed to the consuming industries, which is located within the vicinity of 100 Kms., 101-300 Kms., etc. along with the details of the consumers. In this detail, it should also be indicated whether the transportation was paid by the thermal power or not. Similarly, it should also indicate whether fly ash has been given free or it has been charged. If it has been charged then the rate should also be indicated for each consumer
- Balance stock of fly ash available in the ash ponds for the month ending April ,2017

Accordingly, a web based monitoring system and a mobile application (ASHTRACK) were developed by CEA in collaboration with M/s NTPC Limited on behalf of Ministry of Power. Login ID and password have been issued to those Power Utilities/Thermal Power Stations who had approached us for uploading the monthly data of fly ash generation and its utilization.

10.0 RECOMMANDATION OF EXPERT COMMITTEE

NITI Aayog vide O.M. No. 25(11)/2014-Minerals dated 12.06.2018 has constituted an Expert Committee under the chairmanship of Joint Secretary , MoEF&CC and represented by various concerned Ministries for developing a focus strategy for best utilization of fly ash to manufacture end products.

Expert Committee held two meetings on 5th September and 1st October, 2018 and finalized its recommendations. An inter-ministrial consultation meeting was also held on 21st January, 2018 under the chairmanship of Secretary, MoEF&CC to review the recommendations of the Expert Committee for effective utilization of fly ash, wherein the recommendations of the Committee were accepted.

The expert Committee had recommended following recommendations for implementation by all Thermal Power Plants for effective utilization of fly ash:

i. Tender/auction for sale of fly ash should be done by TPPs initially for end user/industry and not for traders. If fly ash is not taken by the end user/industry, then it could be given to traders. TPPs should also consider entering into longer term contracts with end users.

ii. TPPs may explore the possibility that once a tender for utilization of fly ash is allotted to a company, any unit/plant of the same company should be allowed to purchase and utilize the fly ash and TPPs can also directly raised the invoice to such Unit/Plant.

iii. Creation of fly ash parks/hubs on public-private-partnership mode. Such parks will act as facilities for enabling quality control of fly ash made products, generate employment and act as models which will promote use of innovative fly ash products which can be replicated at other locations.

iv. TPPs should give incentive to entities which can (through R&D) come up with fly ash products with ash content of at least 75% and established sustainable application of those fly ash products in the industry. The incentive could be given from the money available with the TPPs from auctioning of fly ash.

v. Ministry of Power should come up with awards/incentives for TPPs that innovate new methodology in fly ash disposal keeping all the environment and pollution norms in Consideration.

11.0 CONCLUSIONS & RECOMMENDATIONS

1. The fly ash generation during 2018-19 is 217.04 million tonne due to combustion of 667.43 million tonne Coal/Lignite. During 2017-18, 196.44 million tonne of fly ash was generated due to combustion of 624.88 million tonne Coal/Lignite. However, the fly ash utilizations during 2017-18 and 2018-19 are 131.87 million tonne and 168.40 million tonne respectively. It is seen that the absolute quantity of fly ash utilization has increased as compared to last year and similarly the percentage utilization of fly ash has also increased.

2. The highest level of fly ash utilization of about 77.59% is achieved during the year 2018-19. It would require a lot of efforts to achieve the target of 100% utilization of fly ash. The stipulations of notification of 2009 and subsequence amendments should be effectively implemented. As per this report about 22.44% un-utilized fly ash was dumped at the various Thermal Power Stations in the country during 2018-19.

3. A few strategies which need to be adopted to further increase the utilization level of fly ash are given below:

   - Renovation and modernization of coal/lignite based Thermal Power Stations need to include the technological advancement required to ensure development of dry fly ash collection, storage and disposal facilities so that fly ash in dry form could be made available to its users. Renovation and modernization should also include a marketing strategy for the development of fly ash based industries and making available fly ash and fly ash based building products in the nearby markets.

   - As per MoEF&CC's Amendment Notification dated 25.01.2016, Para 2 (14) "The coal or lignite based thermal power plants shall within a radius of three hundred kilometers bear the entire cost of transportation of ash to the site of road construction projects under Pradhan Mantri Gramin Sadak Yojana and asset creation programmes of the Government involving construction of building, road, dams and embankments". The meaning of the words "Asset Creation Programme of the Government" may be read in the context of projects carried out under certain plan scheme of the Government Department. In this regard, The Ministry of Environment, Forest and climate change (MoEF&CC) has clarified that road being constructed by NHAI as well as the State Government are covered by the Notification dated 25.01.2016 in order to fully utilize the fly ash.

   - Use of fly ash in the construction of embankments for laying railway lines has also significant potential for large scale utilization of fly ash. There are safety concerns in use of fly ash in the construction of railway embankments having passenger traffic. There is a need to address these concerns by carrying out necessary studies by organizations like RDSO, a research organization under the Ministry of Railways.

   - Thermal Power Stations have to ensure the utilization of fly ash and fly ash based building products within the thermal power station for the development of infrastructure like construction of buildings & roads, reclamation of low lying areas, etc.

   - A large number of technologies have been developed for gainful utilization and safe management of fly ash through research projects funded by Fly Ash Mission/ Fly Ash Unit under Ministry of Science & Technology, GOI since 1994. Propagation of these technologies by establishing 'Self-sustaining technology demonstration centers' would facilitate and accelerate the fly ash utilization in the country.

- Thermal Power Stations have to explore and promote all possible modes of fly ash utilization at their respective thermal power station for increasing the fly ash utilization in the country in line with MoEF's notifications.
- There is a need to encourage 'Industry–Institute Interactions' for entrepreneur development, creating awareness and organizing training programmes and workshops.
- Induction of 'Fly Ash' as a subject in academic curriculum of Engineering and Architecture is needed.

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12.0 Abbreviations

CEA	:	Central Electricity Authority
MoEF	:	Ministry of Environment & Forest
MoEF&CC	:	Ministry of Environment & Forest and Climate Change (erstwhile MoEF)
MW	:	Mega Watt
MoP	:	Ministry of Power
MT	:	Million Tonnes
TPS	:	Thermal Power Stations
APGENCO	:	Andhra Pradesh Power Generation Corporation Ltd.
APPDCL	:	Andhra Pradesh Power Distribution Company Limited
ACBPL	:	Aryan Coal Benefication Private Ltd.
APL	:	Adani Power Ltd.,
APCPL	:	Aravali Power Corporation Pvt.Ltd.
AMNEPL	:	Abhijet MADC Nagpur energy Pvt. Ltd.
BEPL	:	Bajaj Energy Pvt. Ltd.
BSPGC	:	Bihar State Power Generation Company
CESC	:	Calcutta Electric Supply Company
CGPL	:	Coastal Gujarat Power Ltd.
CSPGCL	:	Chattisgargh State Power Generation Company Ltd.
DVC	:	Damodar Valley Corporation
DPL	:	Durgapur Project Ltd.
DPSC	:	Dishergarh Power Supply Company Ltd.
EPGL	:	Essar Power Gujarat Ltd.
GIPCL	:	Gujarat Industries Power Corporation Ltd.
GMDCL	:	Gujarat Mineral Development Corporation Ltd.
GSECL	:	Gujarat State Electric Corporation Ltd.
HPGCL	:	Haryana Power Generating company Ltd.
IPGCL	:	Indraprastha Power Generation Company Ltd.
IPCL	:	IL&FS Tamil Nadu Power Company Ltd.
JSEB	:	Jharkhand State Electricity Board.
JHPL	:	Jhajjar Power Ltd.
JPL	:	Jindal Power Ltd.
JSW	:	Jindal Steel Works
KPCL	:	Karnataka Power Corporation Ltd.
KBUNL	:	Kanti Bijlee Utpadan Nigam Ltd.
MPPGCL	:	Madhya Pradesh Power Generating Company Ltd.
MPL	:	Maithon Power Ltd.
MSPGCL	:	Maharashtra State Power Generating Company Ltd.
NLC	:	Neyveli Lignite Corporation
NSPCL	:	NTPC -SAIL Power Corporation Ltd.
NTPC	:	National thermal Power Corporation
NTECL	:	NTPC – Tamilnadu Electric Company Ltd.
OPGCL	:	Odisha Power Generation Corporation Ltd.
PSPCL	:	Punjab State Power Corporation Ltd.
RRVUNL	:	Rajasthan Rajya Vidyut Utpadan Nigam Ltd.
RIL	:	Reliance Infrastructure Ltd.
RPSCL	:	Rosa Power Supply Company Ltd.
RWPL	:	Raj West Power Ltd.
SEL	:	Sterlite energy Ltd.
SVPPL	:	Shri Vardhman Power Pvt. Ltd.
ST-CMS	:	ST-CMS
TPCO	:	Tata Power Company Ltd.
TVNL	:	Tenunghat Vidyut Nigam Ltd.
TNG&D	:	Tamil Nadu Generating and Distribution Corporation Ltd.
UPCl	:	Udupi Power Company Ltd.
UPRVUNL	:	Uttar Pradeh Rajaya Vidyut Utpadan Nigam Ltd.
VESPL	:	Vandanca energy Supply Power Ltd.
WBPDCL	:	West Bengal Power Development Corporation Ltd.
WPCL	:	Wardha Power Company Ltd.

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GEPL	:	Gupta Power Company Ltd.
VIP:		Vidharbha Industries Power Ltd.
EPL:		Essar Power Ltd.
ACB	:	Aryan Coal Beneficiary Ltd.
AP	:	Andhra Pradesh
MP	:	Madhya Pradesh
TN	:	Tamil Nadu
UP	:	Uttar Pradesh
WB:		West Bengal

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (POWER UTILITY WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture /waste land Development	Others	Total Utilization	Date Of Commission	Total filled up data
			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)
1	Dr. N.T.R (Vijawada)	APGENCO (Andhra Pradesh)	1760.00	8.9415	46.02	4.1149	4.2752	103.90	2.2972	1.1738	0.0224	0.1598			0.4945			0.1276	4.2752	01.11.1979	1
2	RAYALSEEMA	APGENCO (Andhra Pradesh)	1650.00	4.8249	39.88	1.9240	1.6172	84.06	0.4403	1.1770									1.6172	16.11.1994	1
6	SRI DAMODARAM SANJEEVAIAH	APPDCL(Andhra Pradesh)	1600.00	4.4150	27.45	1.2120	0.7926	65.40	0.1570	0.4990					0.1366				0.7926	05.02.2015	1
7	KASAIPALI	ACB(INDIA)L (Chhattishgarh)	270.00	1.8834	57.29	1.0789	1.0789	100.00	0.0864						0.9852			0.0074	1.0789	13.12.2011	1
8	SVPPL Renki	ACB India Limited (Chhattisgarh)	60.00	0.0163	60.00	0.0098	0.0098	100.00							0.0098				0.0098	12.10.2011	1
9	CHAKABURA TPP	ACB (INDIA) Ltd. (Chhattisgarh)	30.00	0.3249	55.00	0.1787	0.1787	100.00	0.0146						0.1641				0.1787	27.02.2007	1
10	CHAKABURA TPP (EXTN)	ACB (INDIA) Ltd. (Chhattishgarh)	30.00	0.3044	54.98	0.1673	0.1673	100.00	0.0146						0.1527				0.1673	28.03.2014	1
11	INDIRA GANDHI	APCPL (Haryana)	1500.00	4.7101	31.92	1.5034	1.5545	103.40	0.3434	1.2111									1.5545	31.10.2010	1
12	MUNDRA TPS	ADANI POWER (MUNDRA) LIMITED (Gujrat)	4620.00	13.2500	5.84	0.7740	0.7951	102.73		0.3440					0.2180			0.2331	0.7951	04.08.2009	1
13	TIRODA	ADANI POWER MAHARASHTRA LTD. (Maharastra)	3300.00	13.6870	31.88	4.3630	3.6847	84.45	0.0576	0.0156	0.0287			0.7525	0.5332			2.2971	3.6847	23.09.2012	1
14	KAWAI	ADANI POWER RAJASTHAN LTD. (Rajasthan)	1320.00	4.3268	29.57	1.2800	1.5198	118.74	0.1401	0.9988					0.3560			0.0250	1.5198	31.05.2013	1
15	MIHAN	AMNEPL (Maharashtra) (No Generation)	246.00		#DIV/0!			#DIV/0!											0.0000	05.01.2011	1
16	ADANI DAHANU	ADANI ELECTRICITY MUMBAI LIMITED (Maharashtra)	500.00	2.1670	26.03	0.5640	0.7324	129.85	0.0004			0.3100		0.0560				0.3660	0.7324	01.07.1995	1
16A	ADHUNIK PNR LTD.(MAHADEV PRASAD STPP)	ADHUNIK POWER & NATURAL RESOURCES LTD. (Jharkhand)	540.00	1.9972	37.47	0.7484	0.8805	117.65	0.0452	0.1484		0.0049		0.0810	0.4690			0.1321	0.8805	21.01.2013	1
17	BARKHERA	BEPL (UP)	90.00	0.1146	41.02	0.0470	0.0471	100.18	0.0025	0.0086					0.0359				0.0471	29.10.2011	1
18	KHAMBER KHERA	BEPL (UP)	90.00	0.1089	42.06	0.0458	0.0458	100.00	0.0049	0.0349					0.0061				0.0458	30.09.2011	1
19	KUNDARKI	BEPL (UP)	90.00	0.1527	40.50	0.0618	0.0618	100.00	0.0067	0.0446					0.0106				0.0618	03.01.2012	1
20	MAQSOODAPUR	BEPL (UP)	90.00	0.1065	40.57	0.0432	0.0432	100.00	0.0001	0.0051					0.0345		0.0036		0.0432	27.10.2011	1
21	UTRAULA	BEPL (UP)	90.00	0.1464	39.78	0.0582	0.0582	100.00	0.0095	0.0334					0.0154				0.0582	30.01.2012	1
22	NABINAGAR	BHARATIYA RAIL BIJLEE COMPANY LIMITED (Bihar)	750.00	1.7080	35.72	0.6101	0.1744	28.59	0.0014	0.1730									0.1744	16.01.2017	1
22A	BALCO CPP-II	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	540.00	2.7172	38.28	1.0402	1.1076	106.48	0.0072	0.0013					0.4907	0.0023		0.6060	1.1076	6.2005	1
22B	BALCO CPP-III	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	1200.00	4.7820	36.76	1.7580	1.7579	99.99	0.0084	0.0017				0.4267	0.5811			0.7400	1.7579	8.2015	1
22C	BHADRESHWAR VIDYUT PRIVATE LTD TPS	BHADRESHWAR VIDYUT PRIVATE LIMITED (Gujarat)	300.00	1.2677	3.89	0.0493	0.0487	90.89										0.0487	0.0487	04.01.2015	1

Annex-I (POWER UTILITY WISE)

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019)

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			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) $\Sigma(10)$ to		
23	B.B.G.S.	C.E.S.C. (West Bengal)	750.00	3.5600	34.16	1.2160	1.2160	100.00	0.0530	0.9950	0.0090	0.0010		0.0030	0.1550				1.2160	16.09.1997	1
24	S.G.S.	C.E.S.C. (West Bengal)	135.00	0.1980	27.27	0.0540	0.0540	100.00	0.0140	0.0280	0.0070	0.0050							0.0540	12.08.1990	1
25	T.G.S.	C.E.S.C. (West Bengal) No Generation	240.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!	0.0000	0.0000	0.0000				0.0000				0.0000	05.03.1983	1
26	MARWA TENDUBHATA	C.S.P.G.C.L (Chhattisgarh)	1000.00	4.2014	41.08	1.7260	0.4313	24.99	0.0338	0.0872					0.3102				0.4313	31.03.2016	1
27	DSPM	C.S.P.G.C.L. (Chhattisgarh)	500.00	2.4645	39.44	0.9719	0.3144	32.35						0.1461	0.1416	0.0247	0.0019		0.3144	21.10.2007	1
28	KORBA (WEST)	C.S.P.G.C.L Chhattisgarh	1340.00	6.6700	40.31	2.6880	1.3239	49.23	0.0240			0.0169		0.2631	0.5409			0.4290	1.3239	21.03.1983	1
28A	KORBA (EAST)	C.S.P.G.C.L (Chhattisgarh)	440.00	1.5094	47.12	0.7112	0.7726	108.64	0.0011					0.0395	0.7321				0.7726	01.10.1966	1
29	MUTIARA	COASTAL ENERGEN PVT. LTD (Tamil Nadu)	1200.00	2.0116	3.49	0.0703	0.0705	100.23	0.0212	0.0492									0.0705	23.12.2014	1
30	MUNDRA UMPP	CGPL (Gujrat)	4150.00	11.5000	6.87	0.7900	0.7410	93.80	0.0090	0.4700		0.0300			0.0800	0.0020		0.1500	0.7410	07.03.2012	1
30A	CHEMPLAST LIMITED TPS	CHEMPLAST SANMAR LIMITED(Tamil Nadu)	48.50	0.2708	6.75	0.0183	0.0184	100.44	0.0184										0.0184	2009	1
31	BOKARO 'B'	D.V.C.(Jharkhand)	710.00	2.0851	39.68	0.8274	0.2989	36.12		0.0028						0.2960			0.2989	31.03.1993	1
32	CHANDRAPURA	D.V.C.(Jharkhand)	630.00	1.9458	44.81	0.8719	0.8495	97.43	0.0013	0.0781						0.7700			0.8495	07.07.1968	1
33	DURGAPUR	D.V.C.(West Bengal)	210.00	0.7356	45.50	0.3347	0.0257	7.66		0.0257									0.0257	Sep,1982	1
34	MEJIA	D.V.C.(West Bengal)	2340.00	8.2692	46.67	3.8591	2.8519	73.90	0.0736	1.2494						1.5290			2.8519	01.12.1997	1
35	DURGAPUR STEEL	D.V.C. (West Bengal)	1000.00	3.9377	40.93	1.6118	1.2234	75.91	0.0545	0.9881					0.1808				1.2234	15.05.2012	1
36	KODERMA	D.V.C. (Jharkhand)	1000.00	3.6054	44.85	1.6171	1.6061	99.32	0.0031	0.7534				0.0150	0.3393	0.4953			1.6061	18.07.2013	1
37	RAGHUNATHPUR	D.V.C. (West Bengal)	1200.00	1.9047	42.13	0.8024	0.0783	9.76	0.0062	0.0721									0.0783	31.03.2016	1
38	D.P.P.S.	D.P.L (West Bengal).	550.00	1.6204	40.35	0.6539	0.5707	87.29	0.0181	0.4732					0.0794				0.5707	30.04.2000	1
39	DHARIWAL INFRASTRUCTURE Ltd.	DHARIWAL INFRASTRUCTURE LIMITED(Maharashtra)	600.00	2.1088	32.77	0.6910	0.7246	104.86	0.0883	0.6070	0.0293								0.7246	11.2.2014	1
5	CHINAKURI	EASTERN COALFIELDS LIMITED (West Bengal)(No Genaration)	30.00		#DIV/0!	0.0000		#DIV/0!											0.0000	20.09.1990/shut down 21.11.2011	1
3	MAHAN	ESSAR POWER MP LTD.(M.P.)	1200.00	2.0770	27.10	0.5629	0.4834	85.89	0.0027	0.1737				0.2040	0.1030				0.4834	29.04.2011	1
40	SURAT LIGNITE	G.I.P.C.L. (Gujarat)	500.00	3.7073	16.27	0.6033	0.6033	100.00	0.4003									0.2030	0.6033	15.02.2000	1
41	AKRIMOTA	G.M.D.C.L. (Gujarat)	250.00	1.1993	22.22	0.2665	0.3765	141.28								0.3765			0.3765	31.03.2005	1
42	GANDHINAGAR	G.S.E.C.L. (Gujarat)	630.00	0.2342	31.77	0.0744	0.1923	258.49	0.0325	0.0775	0.0611	0.0212							0.1923	20.03.1990	1
43	KUTCH LIGNITE	G.S.E.C.L. (Gujarat)	290.00	0.1640	26.71	0.0438	0.0439	100.23		0.0055						0.0384			0.0439	09.01.1990	1
44	SIKKA	G.S.E.C.L. (Gujarat)	500.00	0.1358	7.36	0.0100	0.0339	339.00	0.0207	0.0132									0.0339	14.09.2015	1

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (POWER UTILITY WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture /waste land Development	Others	Total Utilization	Date Of Commission	Total filled up data
			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
45	UKAI	G.S.E.C.L. (Gujarat)	1110.00	0.4167	31.49	0.1312	0.1080	82.32	0.0521	0.0374		0.0002						0.0183	0.1080	21.01.1979	1
46	WANAKBORI	G.S.E.C.L. (Gujarat)	1470.00	0.5223	32.28	0.1686	0.1570	93.09	0.0182	0.0937				0.0195				0.0256	0.1570	23.03.1982	1
46A	BHAVNAGAR LIGNITE	G.S.E.C.L. (Gujarat)	500.00	0.0625	10.88	0.0068	0.0059	86.76	0.0020	0.0000						0.0039			0.0059	16.05.2016	1
47	GMR WARORA ENERGY Ltd.	GMR WARORA ENERGY LTD. (Maharashtra)	600.00	2.4976	30.32	0.7574	0.8260	109.32	0.0621	0.6161	0.0301					0.1177			0.8260	19.03.2013	1
48	GMR KAMALANGA TPP	GMR KAMALANGA ENERGY LTD. (Odisha)	1050.00	4.8016	37.21	1.7867	1.7887	100.11	0.8202	0.1150	0.2938						0.5597		1.7887	30.04.2013	1
50	GEPL TPP	GUPTA ENERGY PRIVATE LIMITED(Maharashtra) (No Generation)	120.00		#DIV/0!			#DIV/0!											0.0000	19.07 2012	1
+	RAJIV GANDHI (HISAR)	H.P.G.C.L.(Haryana)	1200.00	2.6974	39.47	1.0645	0.6482	60.89	0.1155	0.3944	0.0000	0.0041			0.1343				0.6482	24.08.2010	1
52	YAMUNANAGAR	H.P.G.C.L.(Haryana)	600.00	2.1322	40.29	0.8591	1.0741	125.02	0.0148	0.5223	0.0000							0.5370	1.0741	14.04.2008	1
53	PANIPAT	H.P.G.C.L.(Haryana)	920.00	2.1695	38.00	0.8244	1.2384	150.21	0.0759	0.7271	0.2455				0.1786			0.0113	1.2384	28.03.1989	1
54	HALDIA ENERGY LIMITED	HALDIA ENERGY LIMITED (W.B)	600.00	3.1024	33.81	1.0488	1.0488	100.00	0.0787	0.8990					0.0088			0.0623	1.0488	28.01.2015	1
55	Vizag TPS	HINDUJA NATIONAL POWER CORPORATION LIMITED (Andhra Pradesh)	1040.00	0.6047	32.93	0.1991	0.5201	261.18	0.1626	0.1228	0.1637							0.0709	0.5201	11.01.2016	1
56	RAJGHAT	IPGCL (Delhi)(No Genartion)	135.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000	20.02.1990	1
57	DISHERGARH POWER STATION	INDIA POWER CORPORATION Ltd. (W.B)	12.00	0.0336	50.88	0.0171	0.0171	100.00								0.0171			0.0171	25.09.2012	1
58	INDIAN METALS & FERRO ALLOYS LTD.	INDIAN METALS & FERRO ALLOYS Ltd.(Odisha)	258.00	0.9330	46.81	0.4367	0.4368	100.02	0.2918	0.0396	0.0053				0.0947			0.0053	0.4368	2.1989	1
58A	IL&FS TAMIL NADU POWER COMPANY Ltd.	IL&FS TAMIL NADU POWER COMPANY LIMITED (Tamil Nadu)	1200.00	3.1050	4.19	0.1300	0.1280	98.46	0.0000	0.1280									0.1280	29.09.2015	1
58B	BELA TPS	IDEAL ENERGY PROJECTS LIMITED (Maharashtra)	270.00	0.1126	27.20	0.0306	0.0000	0.00						0.0000					0.0000	18.07.2013	1
59	MAHATMA GANDHI	JHPL (Haryana)	1320.00	4.1308	39.90	1.6480	2.2565	136.92	0.0219	1.4766	0.7118							0.0462	2.2565	29.03.2012	1
60	O.P.Jindal Super TPP (Stage-I)	JPL (Chhattisgarh.)	1000.00	2.4770	42.83	1.0610	1.0870	102.45						0.7530	0.2630	0.0710			1.0870	08.12.2007	1
61	O.P.Jindal Super TPP(Stage-II)	JPL (Chhattisgarh.)	2400.00	5.3060	43.42	2.3040	2.3490	101.95	0.0540					1.7030		0.5920			2.3490	14.03.2014	1
62	JAYPEE BINA TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	500.00	1.6615	32.27	0.5362	0.5416	101.01	0.0474	0.4041					0.0900				0.5416	31.08.2012	1
63	JAYPEE NIGRIE SUPER TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	1320.00	4.0500	26.42	1.0700	1.0870	101.59	0.0270	1.0600									1.0870	03.09.2014	1
64	RATNAGIRI	JSW ENERGY LIMITED (Maharashtra)	1200.00	3.3561	12.67	0.4254	0.4277	100.54	0.0563	0.0397		0.3317							0.4277	01.09.2010	1
65	VIJAYANAGAR	JSW ENERGY LIMITED (Karnataka)	860.00	1.5269	15.58	0.2378	0.2679	112.65	0.0301	0.2083				0.0157				0.0138	0.2679	18.01.2000	1
66	DERANG TPP	JINDAL INDIA THERMAL POWER LIMITED (Odisha)	1200.00	3.3520	40.99	1.3740	0.9460	68.85	0.0970					0.4840	0.3620		0.0030		0.9460	05.06.2014	1
67	DANGAMAHUA CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (CHHATTISGARH)	576.00	1.6499	46.96	0.7748	0.7754	100.08	0.0012							0.7742			0.7754	04.09.2010	1

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FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) UTILITY WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture /waste land Development	Others	Total Utilization	Date Of Commission	Total filled up data
			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
67B	ANGUL CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (Chhattisgarh)	810.00	2.2474	46.41	1.0431	1.0167	97.47	0.0232						0.4511			0.5423	1.0167	13.05.2011	1
67A	JALIPA KAPURDI	JSW ENERGY (BARMER) LIMITED (Formerly Raj Westpower Ltd.) (Rajasthan)	1080.00	0.6110	14.40	0.0880	0.1090	123.86	0.0130	0.0830					0.0130				0.1090	26.11.2009	1
67D	JSW STEEL LIMITED CPP-II	JSW STEEL LIMITED (Tamil Nadu)	60.00	0.1197	10.61	0.0127	0.0127	100.11	0.0127										0.0127	24.07.2006	1
68	BALLARI	K.P.C.L (Karnataka)	1700.00	2.6201	30.30	0.7940	0.7317	92.15	0.0655	0.6662	0.0000								0.7317	25.03.2008	1
69	RAICHUR	K.P.C.L.(Karnataka)	1720.00	6.2060	35.71	2.2160	1.5568	70.25	0.3340	1.0090	0.0068			0.2070					1.5568	29.03.1985	1
70	MUZAFFARPUR TPS	KANTI BIJLEE UTPADAN NIGAM LIMITED (Bihar)	610.00	2.0444	39.71	0.8118	0.3022	37.22	0.0132						0.2890				0.3022	11.2013	1
71	KMPCL (AKALTARA)	KSK MAHANADI POWER COMPANY LIMITED (Chhattisgarh)	1800.00	5.0131	32.00	1.6041	1.6339	101.86	0.0132	1.3172	0.0120				0.0031	0.2883			1.6339	Sept.2013	1
72	AMARKANTAK TPS (PATHADI TPP)	LANCO AMARKANTAK POWER LIMITED (Chhattisgarh)	600.00	2.8881	39.82	1.1500	0.5755	50.05	0.0023	0.2445	0.0004			0.0981	0.2302				0.5755	01.05.2009	1
73	LALITPUR	LALITPUR POWER GENERATION COMPANY LIMITED (UP)	1980.00	3.4053	33.28	1.1334	1.1334	100.00	0.0079	0.5867				-0.0461	0.5850				1.1334	08.01.2016	1
73A	ANPARA-C TPS	LANCO ANPARA POWER LIMITED (Uttar Pradesh)	1200.00	4.9300	24.75	1.2200	0.3600	29.51		0.3600									0.3600	10.12.2011	1
74	MAITHON RBTPP	MPL (Jharkhand)	1050.00	4.2906	40.42	1.7344	1.7738	102.27	0.0991	0.1735					0.0135	1.4877			1.7738	01.09.2011	1
75	SANJAY GANDHI	M.P.P.G.C.L. (M.P.)	1340.00	5.6985	35.45	2.0203	1.4539	71.96	0.0397	1.3662	0.0407				0.0072				1.4539	07 10.1993	1
76	SATPURA	M.P.P.G.C.L. (M.P.)	1330.00	5.7049	40.42	2.3059	0.7016	30.43	0.4528	0.2301		0.0009		0.0092		0.0006			0.7016	07.01.1979	1
77	AMARKANTAK	M.P.P.G.C.L. (M.P.)	210.00	0.8802	28.14	0.2477	0.1645	66.42	0.0370	0.1154	0.0112					0.0009			0.1645	10.09.2009	1
78	SHREE SINGAJI TPS	M.P.P.G.C.L. (M.P.)	2520.00	5.6979	37 91	2.1602	0.2899	13.42	0.0065	0.1444								0.1390	0.2899	01.02.2014	1
79	BHUSAWAL	M.S.P.G.C.L.(Maharashtra)	1210.00	4.9792	35.26	1.7556	1.6756	95.44	0.3088	0.5750				0.4761			0.0298	0.2861	1.6756	18.09.1982	1
80	CHANDRAPUR	M.S.P.G.C.L.(Maharashtra)	2920.00	11.5382	26.77	3.0892	1.0361	33.54	0.0371	0.9991									1.0361	03.05.1985	1
81	KHAPARKHEDA	M.S.P.G.C.L.(Maharashtra)	1340.00	6.4698	41.66	2.6952	0.3837	14.24	0.2678					0.1160					0.3837	26.03.1989	1
82	KORADI	M.S.P.G.C.L.(Maharashtra)	2600.00	6.4720	41.07	2.6580	0.7740	29.12	0.0070	0.0010	0.7660								0.7740	15.07.1978	1
83	NASHIK	M.S.P.G.C.L.(Maharashtra)	630.00	1.8643	37.67	0.7022	1.4340	204.20	1.0743	0.3597									1.4340	26.04.1979	1
84	PARLI	M.S.P.G.C.L.(Maharashtra)	750.00	2.0225	42.41	0.8578	2.5058	292.11	1.0639	0.1735		0.2040		0.9674			0.0339	0.0632	2.5058	01.11.2007	1
85	PARAS	M.S.P.G.C.L.(Maharashtra)	500.00	1.9320	34.57	0.6679	0.2274	34.05	0.2100	0.0174									0.2274	31.03.2008	1
86	MCCPL BANDHAKHAR	MARUTI CLEAN COAL AND POWER LIMITED (Chhattissgarh)	300.00	1.5890	45.88	0.7290	0.7290	100.00			0.0020				0.7270				0.7290	30.07.2015	1
87	THAMMINAPATNAM TPS	MEENAKSHI ENERGY PRIVATE LIMITED (Andhra Pradesh)	300.00	0.0275	4.97	0.0014	0.0085	622.26	0.0016					0.0069					0.0085	07.10.2012	1

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FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019)

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			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
88	JHABUA POWER LIMITED (SEIONI TPP)(AVANTHA BHANDAR TPP)	M/S JHABUA POWER LIMITED (MP)	600.00	1.7951	31.70	0.5691	0.3456	60.74	0.0311	0.2964	0.0134							0.0047	0.3456	03.05.2016	1
89	KWPCL TPP	M/s KORBA WEST POWER COMPANY LIMITED (Chhattisgarh)	600.00	0.0000	#DIV/0!	0.0000	0.0600	#DIV/0!	0.0000	0.0000				0.0460	0.0140				0.0600	31.03.2014	1
90	ANUPPUR TPS	MB POWER (MADHYA PRADESH) LIMITED (M.P.)	1200.00	4.7206	33.43	1.5779	1.6359	103.68	0.0111	0.7489	0.0011	0.0009		0.1349	0.7215			0.0175	1.6359	20.05.2015	1
90A	MEJA TPP	MEJA URJA NIGAM PRIVATE LIMITED(Uttar Pradesh)	660.00	0.1570	40.13	0.0630	0.0001	0.22		0.0001									0.0001	31.03.2019	1
91	NEYVELI - I	NLC LTD.(Tamil Nadu)	500.00	4.7390	4.06	0.1925	0.1277	66.33	0.0209	0.1037								0.0031	0.1277	1962	1
92	NEYVELI -I EXPN	NLC LTD.(Tamil Nadu)	420.00	3.0085	4.72	0.1421	0.1421	100.00	0.0169	0.0945		0.0000				0.0257	0.0046	0.0004	0.1421	21.10.2002	1
93	NEYVELI - II	NLC LTD.(Tamil Nadu)	1470.00	11.7642	5.66	0.6663	0.7520	112.86	0.1519	0.3577	0.0741					0.1568		0.0114	0.7520	20.03.1986	1
94	NEYVELI - II EXPN	NLC LTD. (Tamil Nadu)	500.00	1.9005	5.63	0.1070	0.1044	97.57	0.0834								0.0211		0.1044	22.04.2015	1
95	BARSINGSAR LIGNITE	NLC LTD. (Rajasthan)	250.00	1.2342	17.86	0.2205	1.0618	481.63	0.4809	0.1270							0.4539		1.0618	27.10.2009	1
96	NLC TAMILNADU POWER Ltd	NLC TAMIL NADU POWER LIMITED (Tamil Nadu)	1000.00	3.4076	30.36	1.0347	1.0343	99.96	0.0881	0.7821	0.0209							0.1432	1.0343	08.03.2015	1
97	BHILLAI TPS (BHILLAI PP-III)	NSPCL (Chhattisgarh)	500.00	2.2696	40.51	0.9195	1.0585	115.12	0.1138	0.6658				0.0740	0.0050				1.0585	05.01.2009	1
97A	BHILLAI TPS (BHILLAI PP-II)	NSPCL (Chhattisgarh)	74.00	0.3757	38.08	0.1431	0.1438	100.51	0.0077	0.0605				0.0620	0.0137				0.1438	25.08.1982	1
97B	DURGAPUR CPP	NSPCL (Odisha)	120.00	0.7091	29.04	0.2060	0.2602	126.34		0.1082	0.0055			0.0695	0.0770				0.2602	17.02.1987	1
97C	ROURKELA CPP	NSPCL (West Bengal)	120.00	0.8912	51.13	0.4557	0.1654	36.30	0.0364	0.0863				0.0428					0.1654	01.03.2001	1
98	VALLUR	NTPC TAMIL NADU ENERGY COMPANY LTD ((NTECL) (Tamil Nadu))	1500.00	5.6240	40.13	2.2570	1.5250	67.57	0.2530	0.1520		0.1520						0.9680	1.5250	09.03.2012	1
99	BADARPUR	NTPC LTD (Delhi).	705.00	0.9800	30.00	0.2940	0.2900	98.64	0.2570	0.0270	0.0060								0.2900	Jul-73	1
100	DADRI	NTPC LTD. (U.P.)	1820.00	6.6880	33.40	2.2340	2.2369	100.13	0.3799	1.3401	0.4618				0.0480			0.0070	2.2369	Oct,1991	1
101	SINGRAULI	NTPC LTD. (U.P.)	2000.00	9.1870	31.46	2.8900	1.0130	35.05	0.0000	0.0010				0.2100	0.8020				1.0130	Feb-82	1
102	RIHAND	NTPC LTD. (U.P.)	3000.00	13.1210	26.80	3.5160	1.3020	37.03	0.1250	0.0500				0.3390	0.7290			0.0590	1.3020	Mar-88	1
103	FEROZE GANDHI UNACHAR	NTPC LTD.(U.P.)	1050.00	4.6470	36.99	1.7190	2.0290	118.03	0.0390	0.9860	0.9650			0.0250			0.0140		2.0290	Nov-88	1
104	TANDA	NTPC LTD. (U.P.)	440.00	1.6150	33.62	0.5430	1.5590	287.11	0.0010	0.3450	0.8870				0.3260				1.5590	Jan-00	1
105	KORBA	NTPC (Chhattisgarh).	2600.00	13.6751	39.58	5.4123	2.7650	51.09	0.0569	0.0002				1.4630	0.1518	0.0765	0.0002	1.0165	2.7650	Mar-83	1
106	VINDHYACHAL	NTPC LTD.(M.P.)	4760.00	24.5260	33.67	8.2580	2.6760	32.40	0.1230	0.0690				1.6890	0.2140			0.5810	2.6760	Oct-87	1
107	SIPAT	NTPC LTD. (Chhattisgarh).	2980.00	14.0010	34.28	4.7993	2.3770	49.53	0.3210	0.5430	0.1110			0.5860	0.2500		0.1240	0.4420	2.3770	May-07	1
108	RAMAGUNDAM	NTPC LTD. (Andhra Pradesh).	2600.00	11.5860	36.90	4.2750	4.7160	110.29	1.8220	0.6720				0.5550	0.7500	0.8500		0.0660	4.7150	Nov-83	1
109	SIMHADRI	NTPC LTD. (Andhra Pradesh).	2000.00	8.8410	33.67	2.9770	2.9820	100.17	0.5370	0.5380	0.7850			0.8200	0.0160			0.2660	2.9820	Feb-02	1
110	FARAKKA	NTPC LTD. (W.B.)	2100.00	9.4410	33.21	3.1350	2.5110	80.10	0.0430	0.3520	0.0800			0.7560	0.9780			0.3020	2.5110	Jan-86	1
111	KAHALGAON	NTPC LTD.(Bihar)	2340.00	12.5920	34.31	4.3200	2.0890	48.36	0.2690	0.5910	0.0540			0.3140	0.3830			0.4780	2.0890	Mar-92	1

Annex-I (POWER UTILITY WISE)

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FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland puzzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture /waste land Development	Others	Total Utilization	Date Of Commission	Total filled up data
			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
112	BARH SUPER TPS	NTPC LTD (Bihar)	1320.00	5.7030	40.28	2.2970	1.1520	50.15	0.1410	0.2660	0.7450								1.1520	Nov-14	1
113	TALCHAR(TPS)	NTPC LTD(Odisha).	460.00	2.8950	39.00	1.1290	1.1323	100.29	0.0113					0.0050		1.1160			1.1323	03.06.1995	1
114	TALCHAR(KAN)	NTPC LTD.(Odisha).	3000.00	17.1400	44.25	7.5850	3.8080	50.20	0.0980	0.0230	0.2230			3.3780	0.0860				3.8080	Feb-95	1
115	MOUDA TPS	NTPC LTD. (Maharashtra)	2320.00	7.8410	33.77	2.6480	2.3880	90.18	0.9110	0.3030	0.6970			0.4420	0.0370				2.3880	Apr-12	1
116	BONGAIGAON	NTPC LTD. (Assam)	750.00	1.5670	29.80	0.4670	0.1410	30.19	0.0320	0.0000	0.1090								0.1410	June,2015	1
117	SOLAPUR	NTPC LTD. (Maharashtra)	1320.00	1.2560	33.96	0.4265	0.5400	126.61	0.1800	0.2990				0.0110				0.0500	0.5400	01.04.2017	1
118	KUDGI	NTPC LTD. (Karnataka)	2400.00	4.1300	33.18	1.3703	0.8830	64.44	0.0030	0.8800									0.8830	Dec-16	1
118B	GADARWARA	NTPC LTD. (Madhya Pradesh)	800.00	0.2080	42.31	0.0880	0.0000	0.00											0.0000	29.03.2019	1
118C	BARAUNI	NTPC Ltd-BSPGCL(JV) (Bihar)	220.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000	01.05.1993	1
119	RAJPURA TPS	NABHA POWER PROJECT (Punjab)	1400.00	4.7651	30.21	1.4395	1.3055	90.69	0.0499	1.0676	0.0000	0.1056					0.0824		1.3055	24.01.2014	1
119A	NALCO,CPP AUNGAL	NATIONAL ALUMINIUM COMPANY LIMITED (NALCO) (Odisha)	1200.00	5.5940	44.26	2.4760	1.8206	73.53	0.3420		0.1036			1.2240	0.1510				1.8206	29.09.1986	1
120	IB VALLEY	O.P.G.C.L.(Odisha)	420.00	2.5643	39.55	1.0141	0.3434	33.86	0.0153		0.0088				0.3031		0.0001	0.0161	0.3434	21.12.1994	1
120A	OPG POWER GENERATION PRIVATE LIMITED	OPG POWER GENERATION PRIVATE LIMITED (Tamil Nadu)	414.00	1.8158	4.87	0.0885	0.0961	108.55	0.0240	0.0721									0.0961	01.08.2010	1
121	BATHINDA	P.S.P.C.L. (Punjab)	460.00	0.0000	#DIV/0!	0.0000	0.7427	#DIV/0!	0.2980	0.4447									0.7427	22.09.1974	1
122	LEHRA MOHABAT	P.S.P.C.L. (Punjab)	920.00	1.6360	38.20	0.6249	0.5394	86.32	0.0097	0.4237	0.0621				0.0439				0.5394	25.05.1998	1
123	ROPAR	P.S.P.C.L. (Punjab)	840.00	1.1442	34.65	0.3965	1.2771	322.11	0.0219	0.6375	0.5198	0.0015			0.0930		0.0033		1.2771	31.03.1988	1
50A	GVK POWER(GOINDWALSAHIB)LTD.,GOINDWALSAHIB	PSPCL (Punjab)	540.00	1.6827	27.75	0.4669	0.4658	99.76		0.4647				0.0011					0.4658	2016	1
124	PRAYAGRAJ TPS	PRAYAGRAJ POWER GENERATION COMPANY LTD. (U.P.)	1980.00	4.7921	28.15	1.3490	1.2555	93.07	0.0663	1.1891									1.2555	29.02.2016	1
127	UCCHPINDA	R.K.M.POWERGEN PVT. LTD (PGCIL) (Chhattisgarh)	1440.00	1.4126	38.94	0.5501	0.5417	98.47	0.0007	0.4692	0.0578				0.0004			0.0137	0.5417	23.11.2015	1
128	CHHABRA	RRVUNL (Rajasthan)	1000.00	4.1256	33.22	1.3707	1.4274	104.14	0.3188	0.9160	0.0151				0.0132			0.1643	1.4274	11.06.2010	1
129	SURATGARH	RRVUNL (Rajasthan)	1500.00	4.3128	33.21	1.4324	1.5319	106.95	0.1373	0.7266								0.6680	1.5319	31.10.1998	1

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (POWER UTILITY WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Bricks/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture/waste land Development	Others	Total Utilization	Date Of Commission	Total filled up data
			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
129A	KALISINDH	RRVUNL (Rajasthan)	1200.00	2.9340	31.33	0.9191	1.0806	117.57	0,0765	0.6511	0.0531			0.0026	0,0011			0.2961	1.0806	07.05.2014	1
131	ROSA PHASE-1	RPSCL(U.P)	1200.00	2.5711	31.99	0.8224	0.9553	116.16	0.0548	0.5266		0.0008		0.2433	0.0964		0.0333		0.9553	12.03.2010	1
132	AMRAVATI TPS	RATTANINDIA POWER LTD. (Maharashtra)	1350.00	2.3515	30.68	0.7214	0.8329	115.46	0.4100			0.0237		0.1254	0.2738			0,000044	0.8329	03.06.2013	1
133	YERAMARUS TPS	RAICHUR POWER CORPORATION LIMITED (Karnataka)	1600.00	0.4736	25.66	0.1215	0.0400	32.91	0.0062	0.0338									0.0400	07.03.2017	1
133A	RINL CAPTIVE TPP, VISAKHAPATNAM	RASHTRIYA ISPAT NIGAM LIMITED (Andhra Pradesh)	315.00	1.7628	43.27	0.7628	0.2202	28.87		0.0417					0.1785				0.2202	12.03.1989	1
49	GMR Chhattisgarh	RAIPUR ENERGEN LIMITED(Formerly GMR CHHATTISGARH Energy Ltd) (Chhattisgarh)	1370.00	1.6707	29.71	0.4964	0.5173	104.21	0,0368	0.4805									0.5173	1.06.2015	1
138	SASAN UMPP	RELIANCE POWER LIMITED (Madhya Pradesh)	3960.00	18.0836	22.24	4.0222	1.4916	37.08	0,0014	0,1329		0.0026			1.3547				1.4916	16.08.2013	1
134	SIMHAPURI	SEPL(Andhra Pradesh)	600.00	0.0627	3.26	0.0020	0.0020	100,00	0.0020										0.0020	29.02.2012	1
135	RATIZA TPS	SPECTRUM COAL & POWER LTD.(Chhattisgarh)	100.00	1.1592	61.84	0.7169	0.5516	76.95	0.0160						0.5356				0.5516	27.02.2013	1
136	SAILILAGARH POWER GENERATION Ltd.	SAILILAGARH POWER GENERATION LIMITED (Chhattisgarh) (No Generation)	86.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000	00.00.2007	1
137	SEMBCORP ENERGY INDIA Ltd.(PAINAMPURAM TPP) (SGPL-TPP)	SEMBCORP ENERGY INDIA Ltd. (Formerly Thermal Powertech Corporation India Ltd) (Andhra Pradesh)	1320.00	4.8974	18.12	0.8874	0.7780	87.67	0.0063	0.7718									0.7780	Mar-15	1
137A	SWASTIK POWER & MINERALS RESOURCES PVT. LTD.	SWASTIK POWER & MINERALS RESOURCES PVT. LTD (Chhattisgarh) (No Generation)	25.00	0,0000	#DIV/0!	0.0000	0.0000	#DIV/0!	0.0000	0,0000	0.0000	0,0000	0.0000	0.0000	0,0000	0.0000	0.0000	0.0000	0.0000	02.05.2015	1
137C	SKS POWER GENERATION(CC)LTD (Binjkote TPP)	SKS POWER GENERATION(CHHATTISGARH) LIMITED (Chhattisgarh)	600.00	1.1700	47.36	0.5582	0.3961	70.96	0.0069	0.0869	0.0016				0.1553	0.1455			0.3961	06.10.2017	1
137B	SINGARENI TPP	THE SINGARENI COLLIERIES COMPANY LIMITED (Telengana)	1200.00	5.1945	35.12	1.8241	1.8736	102.71	0.1710	0.7489		0.1925			0.0166	0.7446			1.8736	25.09.2016	1
139	CUDDALORE	TAQA NEYVELLY POWER CO.PVT. LTD. (Tamil Nadu)	250.00	0.2034	52.47	0.1067	0.0803	75.22	0.0134	0.0646						0.0023			0.0803	15.12.2002	1
140	JOJOBERA	T.P.CO. (Jharkhnad)	547.50	0.2518	42.53	0.1071	0.0942	87.93	0.0002	0.0505		0.0069			0.0366				0.0942	September,1997	1
141	TROMBAY	T.P.CO.(Maharashtra)	750.00	2.2950	2.19	0.0502	0.0514	102.39	0.0066			0.0359				0.0081		0.0008	0.0514	1984	1
142	SABARMATI	TORRENT POWER LTD.(Gujarat)	422.00	1.5194	21.84	0.3339	0.3319	100.00		0.2595				0.0640			0.0084		0.3319	13.04.1997	1
143	TUTICORIN	T.N.G & D Corporation (Tamil Nadu)	1050.00	4.5497	22.39	1.0188	0.6922	67.94	0.1113	0.5806								0.00003	0.6922	09.07.1979	1

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FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (POWER UTILITY WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining Filling	In agriculture /waste land Development	Others	Total Utilization	Date Of Commission	Total filled up data
			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
144	METTUR-I	T.N.G & D Corporation (Tamil Nadu)	840.00	4.0680	28.20	1.1470	0.9373	81.72	0.1405	0.5094								0.2874	0.9373	07.01.1987	1
145	METTUR-II	T.N.G & D Corporation (Tamil Nadu)	600.00	2.0056	30.71	0.6159	0.4889	79.39	0.0870	0.3811								0.0208	0.4889	11.10.2012	1
146	NORTH CHENNAI-I	T.N.G & D Corporation (Tamil Nadu)	630.00	2.7914	36.43	1.0169	0.6727	66.16	0.0502	0.2696	0.3530								0.6727	23.10.1994	1
147	NORTH CHENNAI-II	T.N.G & D Corporation (Tamil Nadu)	1200.00	5.0088	28.60	1.4326	1.0624	74.16	0.2782	0.7842									1.0624	20.03.2014	1
147A	RAMAGUNDAM'B'	TSPGCL (Telangana)	62.50	0.2886	31.91	0.0921	0.1457	158.22		0.0107								0.1350	0.1457	17.10.1971	1
147B	KOTHAGUDEM-V	TSPGCL (Telengana)	500.00	3.1069	36.03	1.1195	0.2786	24.88		0.0631								0.2154	0.2786	27.03.1997	1
147C	KOTHAGUDEM-VI	TSPGCL (Telengana)	500.00	2.3499	28.96	0.6805	0.7168	105.34	0.0947	0.5689								0.0533	0.7168	20.10.2011	1
148	KOTHAGUDEM (Stage I to IV)	T.S.P.G.C.L (Telangana)	420.00	3.2963	54.15	1.7849	0.7393	41.42	0.4028	0.2465				0.0900				0.00004	0.7393	04.07.1966	1
149	KAKATIA (Stage-I)	T.S.G.E.N.C.O. (Telangana)	500.00	2.1826	37.06	0.8088	0.8209	101.49	0.1566	0.5562				0.1066	0.0013			0.0001	0.8209	31.03.2010	1
150	KAKATIA (Stage-II)	T.S.G.E.N.C.O. (Telangana)	600.00	2.0984	36.86	0.7735	0.7852	101.52	0.1401	0.5364				0.1069	0.0017				0.7852	24.03.2016	1
151	RAIGARH TPP (NAWAPARA TPP)	TRN ENERGY PRIVATE LIMITED (Chhattisgarh)	600.00	2.4469	43.46	1.0634	0.7895	74.25	0.0296						0.7599				0.7895	13.08.2016	1
152	TENUGHAT TPS	TENUGHAT VIDHYUT NIGAM LIMITED (Jharkhand)	420.00	1.2327	40.00	0.4931	0.6419	130.19							0.6399			0.0020	0.6419	14.04.1994	1
153	M/s TALWANDI SABO POWER LTD	TALWANDI SABO POWER LTD (Punjab)	1980.00	6.8800	33.14	2.2800	2.5100	110.09	0.1300	1.3000	0.3700				0.2600			0.4500	2.5100	05.07.2014	1
154	ANPARA 'A' & 'B'	U.P.R.V.U.N.L. (U.P.)	2630.00	12.7487	34.50	4.3989	0.2326	5.29	0.0031	0.2205					0.0089			0.0001	0.2326	01.01.1987	1
155	HARDUAGANJ	U.P.R.V.U.N.L. (U.P.)	610.00	1.9174	41.14	0.7889	0.7624	96.64	0.0382	0.3874					0.3368				0.7624	28.05.1978	1
156	OBRA	U.P.R.V.U.N.L. (U.P.)	1000.00	2.5631	30.44	0.7802	0.0904	11.58	0.0015	0.0715	0.0173								0.0904	28.01.1980	1
157	PANKI	U.P.R.V.U.N.L. (U.P.)(No Generation)	210.00	0.0000	#DIV/0!			#DIV/0!	0.0000	0.0000	0.0000								0.0000	10.11.1976, Shoutdown	1
158	PARICHHA	U.P.R.V.U.N.L. (U.P.)	1140.00	3.4020	39.30	1.3370	1.0942	81.84	0.0530	0.7680				0.2732					1.0942	31.03.1984	1
159	UDUPI	UDUPI POWER CORPORATION LIMITED (Karnatak)	1200.00	2.2190	5.68	0.1260	0.1261	100.08	0.0233	0.0740		0.0256						0.0032	0.1261	11.11.2010	1
160	BUTIBORI	VIDARBHA INDUSTRIES POWER LTD. (Maharashtra)	600.00	1.4377	32.73	0.4705	0.7488	159.16	0.0847	0.0851	0.4424	0.1366							0.7488	04.04.2013	1
161	VS LIGNITE POWER PRIVATE LTD	VS LIGNITE POWER PRIVATE LIMITED (Rajasthan)	135.00	0.3595	15.01	0.0540	0.0455	84.29	0.0020									0.0435	0.0455	2.2010	1
161A	VEDANTA LTD TPP	VEDANTA LIMITED (Odisha)	2400.00	7.8500	39.34	3.0881	3.7198	120.46	0.0137		0.0092			0.8329	2.2787			0.5852	3.7198	09.11.2010	1
161B	VEDANTA LTD CPP	VEDANTA LIMITED (Odisha)	1215.00	6.1600	39.99	2.4633	2.7713	112.50	0.0763	0.1980	0.0123			0.6555	1.8259			0.0033	2.7713	30.07.2008	1
162	KOLAGHAT	W.B.P.D.C.L(W.B.)	1260.00	3.8391	42.11	1.6165	2.1411	132.45	0.0916	0.5492					1.5004				2.1411	16.00.1990	1

Annex-I

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (POWER UTILITY WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Bricks/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture /waste land Development	Others	Total Utilization	Date Of Commission	Total used up data
			(MW)	(MT)	%age (7)/(5)x100	(MT)	(MT)	%age (8)/(7)x100	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT)	(MT) Σ(10) to		
163	SAGARDIGHI	W.B.P.D.C.L(W.B.)	1600.00	3.6005	34.12	1.2283	1.1470	93.38	0.0770	0.2548					0.8152				1.1470	07.09.2008	1
164	BANDEL	W.B.P.D.C.L (W.B.)	335.00	1.1539	42.13	0.4861	0.4337	89.23	0.0250	0.2328					0.1752				0.4337	04.09.1965	1
165	SANTALDIH	W.B.P.D.C.L (W.B.)	500.00	0.2374	45.90	0.1090	0.1103	101.25	0.0026	0.0352					0.0719			0.0005	0.1103	01.04.2009	1
166	BAKRESWAR	W.B.P.D.C.L(W.B.)	1050.00	4.1406	38.78	1.6057	1.8783	116.98	0.0440	0.8539					0.9804				1.8783	18.07.1999	1
167	SAI WARDHA POWER Ltd. ,WARORA	WPCL (Maharashtra)	540.00	0.7790	33.76	0.2630	0.3016	114.66	0.0320	0.1410	0.0126			0.0290		0.0070			0.3016	15.04.2010	1
		Grand Total	197966.50	667.4302	32.52	217.0381	168.3976	77.58	21.6097	59.3401	9.7244	1.7742	0.0000	21.5734	29.3177	10.1002	1.3769	14.5809	168.3975		195

ANNEX-II

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (State WISE)

Sl no.	Name of TPS	Power utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Genaration	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture/ waste land Development	Others	Total Utilization
			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) Σ(10) to
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
	ANDHRA PRADESH																		
1	Dr. N.T.R (Vijawada)	APGENCO (Andhra Pradesh)	1760.00	8.9435	46.02	4.1149	4.2752	103.90	2.2977	1.3738	0.0224	0.1598	0.0000	0.0000	0.4945	0.0000	0.0000	0.1276	4.2752
2	RAYALSEEMA	APGENCO (Andhra Pradesh)	1650.00	4.8249	39.88	1.9240	1.6172	84.06	0.4403	1.1770	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.6172
3	SRI DAMODARAM SANJEEVAIAH	APPDCL(Andhra Pradesh)	1600.00	4.4150	27.45	1.2120	0.7926	65.40	0.1570	0.4990	0.0000	0.0000	0.0000	0.0000	0.1366	0.0000	0.0000	0.0000	0.7926
4	Vizag TPS	HINDUJA NATIONAL POWER CORPORATION LIMITED (Andhra Pradesh)	1040.00	0.6047	61.84	0.1991	0.5201	76.95	0.1626	0.1228	0.1637	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0709	0.5201
5	THAMMINAPATNAM TPS	MEENAKSHI ENERGY Pvt. Ltd.(Andhra Pradesh)	300.00	0.0275	4.97	0.0014	0.0085	622.20	0.0016	0.0000	0.0000	0.0000	0.0000	0.0069	0.0000	0.0000	0.0000	0.0000	0.0085
6	RAMAGUNDAM	N.T.P.C. (Andhra Pradesh).	2600.00	11.5860	36.90	4.2750	4.7150	110.29	1.8220	0.6770	0.0000	0.0000	0.0000	0.5550	0.7500	0.8500	0.0000	0.0660	4.7150
7	SIMHADRI	N.T.P.C. (Andhra Pradesh).	2000.00	8.8410	33.67	2.9770	2.9820	100.17	0.5370	0.5380	0.7850	0.0000	0.0000	0.8200	0.0160	0.0000	0.0000	0.2860	2.9820
8	RINL CAPTIVE TPP, VISAKHAPATNAM	RASHTRIYA ISPAT NIGAM LIMITED (Andhra Pradesh)	315.00	1.7628	43.27	0.7628	0.2202	28.87	0.0000	0.0417	0.0000	0.0000	0.0000	0.0000	0.1785	0.0000	0.0000	0.0000	0.2202
9	SIMHAPURI	SEPL(Andhra Pradesh)	600.00	0.0627	3.26	0.0020	0.0020	100.00	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020
10	SEMBCORP ENERGY INDIA Ltd.(PAINAMPURAM TPP) (SGPL-TPP)	SEMBCORP ENERGY INDIA Ltd. (Formerly Thermal Powertech Corporation India Ltd) (Andhra Pradesh)	1320.00	4.8974	18.12	0.8874	0.7780	87.67	0.0063	0.7718	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7780
		ASSAM																	
1	BONGAIGAON	NTPC LTD. (Assam)	750.00	1.5670	29.80	0.4670	0.1410	30.19	0.0320	0.0000	0.1090	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1410
		BIHAR																	
1	NABINAGAR	BHARATIYA RAIL BIJLEE COMPANY LIMITED (Bihar)	750.00	1.7080	35.72	0.6101	0.1744	28.59	0.0014	0.1730	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1744
2	MUZAFFARPUR TPS	KANTI BIJLEE UTPADAN NIGAM LIMITED (Bihar)	610.00	2.0444	39.71	0.8116	0.3022	37.22	0.0132	0.0000	0.0000	0.0000	0.0000	0.0000	0.2890	0.0000	0.0000	0.0000	0.3022
3	KAHALGAON	NTPC LTD.(Bihar)	2340.00	12.5920	34.31	4.3200	2.0890	48.36	0.2690	0.5910	0.0540	0.0000	0.0000	0.3140	0.3830	0.0000	0.0000	0.4780	2.0890
4	BARH SUPER TPS	NTPC LTD (Bihar)	1320.00	5.7030	40.28	2.2970	1.1520	50.15	0.1410	0.2660	0.7450	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.1520
5	BARAUNI	NTPC Ltd-BSPGCL(JV) (Bihar)	220.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
	CHHATTISGARH																		
1	KASAIPALI	ACB(INDIA)L (Chhattishgarh)	270.00	1.8834	57.29	1.0789	1.0789	100.00	0.0864	0.0000	0.0000	0.0000	0.0000	0.0000	0.9852	0.0000	0.0000	0.0074	1.0789
2	SVPPL Renki	ACB India Limited (Chhattisgarh)	60.00	0.0163	60.00	0.0098	0.0098	100.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0098	0.0000	0.0000	0.0000	0.0098
3	CHAKABURA TPP	ACB (INDIA) Ltd. (Chhattisgarh)	30.00	0.3249	55.00	0.1787	0.1787	100.00	0.0146	0.0000	0.0000	0.0000	0.0000	0.0000	0.1641	0.0000	0.0000	0.0000	0.1787
4	CHAKABURA TPP (EXTN)	ACB (INDIA) Ltd. (Chhattishgarh)	30.00	0.3044	54.98	0.1673	0.1673	100.00	0.0146	0.0000	0.0000	0.0000	0.0000	0.0000	0.1527	0.0000	0.0000	0.0000	0.1673
5	BALCO CPP-II	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	540.00	2.7172	38.28	1.0402	1.1076	106.48	0.0072	0.0013	0.0000	0.0000	0.0000	0.0000	0.4907	0.0023	0.0000	0.6060	1.1076

ANNEX-II

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (State WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture/ waste land Development	Others	Total Utilization
			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) Σ(10) to
6	BALCO CPP-III	BHARAT ALUMINIUM COMPANY LIMITED(BALCO) (Chhattisgarh)	1200.00	4.7820	36.76	1.7580	1.7579	99.99	0.0084	0.0017	0.0000	0.0000	0.0000	0.4267	0.5811	0.0000	0.0000	0.7400	1.7579
7	MARWA TENDUBHATA	C.S.P.G.C.L (Chhattisgarh)	1000.00	4.2014	41.08	1.7260	0.4313	24.99	0.0338	0.0872	0.0000	0.0000	0.0000	0.0000	0.3102	0.0000	0.0000	0.0000	0.4313
8	DSPM	C.S.P.G.C.L. (Chhattisgarh)	500.00	2.4645	39.44	0.9719	0.3144	32.35	0.0000	0.0000	0.0000	0.0000	0.0000	0.1461	0.1416	0.0247	0.0019	0.0000	0.3144
9	KORBA (WEST)	C.S.P.G.C.L Chhattisgarh	1340.00	6.6700	40.31	2.6890	1.3239	49.23	0.0740	0.0000	0.0000	0.0169	0.0000	0.2631	0.5409	0.0000	0.0000	0.4290	1.3239
10	KORBA (EAST)	C.S.P.G.C.L (Chhattisgarh)	440.00	1.5094	47.12	0.7112	0.7726	108.64	0.0011	0.0000	0.0000	0.0000	0.0000	0.0395	0.7321	0.0000	0.0000	0.0000	0.7726
11	O.P.Jindal Super TPP (Stage-I)	JPL (Chhattisgarh.)	1000.00	2.4770	42.63	1.0610	1.0870	102.45	0.0000	0.0000	0.0000	0.0000	0.0000	0.7530	0.2630	0.0710	0.0000	0.0000	1.0870
12	O.P.Jindal Super TPP(Stage-II)	JPL (Chhattisgarh.)	2400.00	5.3060	43.42	2.3040	2.3490	101.95	0.0540	0.0000	0.0000	0.0000	0.0000	1.7030	0.0000	0.5920	0.0000	0.0000	2.3490
13	DANGAMAHUA CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (CHHATTISGARH)	576.00	1.6499	46.96	0.7748	0.7754	100.08	0.0012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7742	0.0000	0.0000	0.7754
14	ANGUL CAPTIVE POWER PLANT	JINDAL STEEL AND POWER LIMITED (Chhattisgarh)	810.00	2.2474	46.41	1.0431	1.0167	97.47	0.0232	0.0000	0.0000	0.0000	0.0000	0.0000	0.4511	0.0000	0.0000	0.5423	1.0167
15	KMPCL (AKALTARA)	KSK MAHANADI POWER COMPANY LIMITED (Chhattisgarh)	1800.00	5.0131	32.00	1.6041	1.6339	101.86	0.0132	1.3172	0.0120	0.0000	0.0000	0.0000	0.0031	0.2883	0.0000	0.0000	1.6339
16	AMARKANTAK TPS (PATHADI TPP)	LANCO AMARKANTAK POWER LIMITED (Chhattisgarh)	600.00	2.8881	39.82	1.1500	0.5755	50.05	0.0023	0.2445	0.0004	0.0000	0.0000	0.0981	0.2302	0.0000	0.0000	0.0000	0.5755
17	MCCPL BANDHAKHAR	MARUTI CLEAN COAL AND POWER LIMITED (Chhattissgarh)	300.00	1.5890	45.88	0.7290	0.7290	100.00	0.0000	0.0000	0.0020	0.0000	0.0000	0.0000	0.7270	0.0000	0.0000	0.0000	0.7290
18	KWPCL TPP	M/s KORBA WEST POWER COMPANY LIMITED (Chhattisgarh)	600.00	0.0000	#DIV/0!	0.0000	0.0600	#DIV/0!	0.0000	0.0000	0.0000	0.0000	0.0000	0.0460	0.0140	0.0000	0.0000	0.0000	0.0600
19	BHILLAI TPS (BHILLAI PP-III)	NSPCL (Chhattisgarh)	500.00	2.2696	40.51	0.9195	1.0585	115.12	0.1138	0.8658	0.0000	0.0000	0.0000	0.0740	0.0050	0.0000	0.0000	0.0000	1.0585
20	BHILLAI TPS (BHILLAI PP-II)	NSPCL (Chhattisgarh)	74.00	0.3757	38.08	0.1431	0.1438	100.51	0.0077	0.0605	0.0000	0.0000	0.0000	0.0620	0.0137	0.0000	0.0000	0.0000	0.1438
21	KORBA	NTPC (Chhattisgarh).	2600.00	13.6751	39.58	5.4123	2.7650	51.09	0.0569	0.0002	0.0000	0.0000	0.0000	1.4630	0.1518	0.0765	0.0002	1.0165	2.7650
22	SIPAT	NTPC LTD. (Chhattisgarh).	2980.00	14.0010	34.28	4.7993	2.3770	49.53	0.3218	0.5430	0.1110	0.0000	0.0000	0.5860	0.2500	0.0000	0.1240	0.4420	2.3770
23	UCCHPINDA	R.K.M.POWERGEN PVT. LTD (PGCIL) (Chhattisgarh)	1440.00	1.4126	38.94	0.5501	0.5417	98.47	0.0007	0.4692	0.0578	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0137	0.5417
24	GMR Chhattisgarh	RAIPUR ENERGEN LIMITED(Formerly GMR CHHATTISGARH Energy Ltd) (Chhattisgarh)	1370.00	1.6707	33.22	0.4964	0.5173	104.14	0.0366	0.4805	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5173
25	RATIZA TPS	SPECTRUM COAL & POWER LTD.(Chhattisgarh)	100.00	1.1592	61.84	0.7169	0.5516	76.95	0.0160	0.0000	0.0000	0.0000	0.0000	0.0000	0.5356	0.0000	0.0000	0.0000	0.5516
26	SAILILAGARH POWER GENERATION Ltd.	SAILILAGARH POWER GENERATION LIMITED (Chhattisgarh) (No Generation)	86.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
27	SWASTIK POWER & MINERALS RESOURCES PVT. LTD.	SWASTIK POWER & MINERALS RESOURCES PVT. LTD (Chhattisgarh) (No Generation)	25.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
28	SKS POWER GENERATION(CC)LTD (Binjkote TPP)	SKS POWER GENERATION(CHHATTISGARH) LIMITED (Chhattisgarh)	600.00	1.1786	47.36	0.5582	0.3961	70.96	0.0069	0.0869	0.0016	0.0000	0.0000	0.0000	0.1553	0.1455	0.0000	0.0000	0.3961

ANNEX-II

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			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) Σ(10) to
29	RAIGARH TPP (NAWAPARA TPP)	TRN ENERGY PRIVATE LIMITED (Chhattisgarh)	600.00	2.4469	43.46	1.0634	0.7895	74.25	0.0296	0.0000	0.0000	0.0000	0.0000	0.0000	0.7599	0.0000	0.0000	0.0000	0.7895
		DELHI																	
1	RAJGHAT	IPGCL (Delhi)	135.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
2	BADARPUR	N.T.P.C.LTD (Delhi).	705.00	0.9800	30.00	0.2940	0.2900	98.64	0.2570	0.0270	0.0060	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2900
		GUJARAT																	
1	MUNDRA TPS	ADANI POWER (MUNDRA) LIMITED (Gujrat)	4620.00	13.2500	5.84	0.7740	0.7951	102.73	0.0000	0.3440	0.0000	0.0000	0.0000	0.0000	0.2180	0.0000	0.0000	0.2331	0.7951
2	BHADRESHWAR VIDYUT PRIVATE LTD TPS	BHADRESHWAR VIDYUT PRIVATE LIMITED (Gujarat)	300.00	1.2677	3.89	0.0493	0.0487	98.89	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0487	0.0487
3	MUNDRA UMPP	CGPL (Gujrat)	4150.00	11.5000	6.87	0.7900	0.7410	93.80	0.0090	0.4700	0.0000	0.0300	0.0000	0.0000	0.0800	0.0020	0.0000	0.1500	0.7410
4	SURAT LIGNITE	G.I.P.C.L. (Gujarat)	500.00	3.7073	16.27	0.6033	0.6033	100.00	0.4003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2030	0.6033
5	AKRIMOTA	G.M.D.C.L. (Gujarat)	250.00	1.1993	22.22	0.2665	0.3765	141.28	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3765	0.0000	0.0000	0.3765
6	GANDHINAGAR	G.S.E.C.L. (Gujarat)	630.00	0.2342	31.77	0.0744	0.1923	258.49	0.0325	0.0775	0.0611	0.0212	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1923
7	KUTCH LIGNITE	G.S.E.C.L. (Gujarat)	290.00	0.1640	26.71	0.0438	0.0439	100.23	0.0000	0.0055	0.0000	0.0000	0.0000	0.0000	0.0000	0.0384	0.0000	0.0000	0.0439
8	SIKKA	G.S.E.C.L. (Gujarat)	500.00	0.1358	7.36	0.0100	0.0339	339.00	0.0207	0.0132	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0239
9	UKAI	G.S.E.C.L. (Gujarat)	1110.00	0.4167	31.49	0.1312	0.1080	82.32	0.0521	0.0374	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0183	0.1080
10	WANAKBORI	G.S.E.C.L. (Gujarat)	1470.00	0.5223	32.26	0.1686	0.1570	93.09	0.0182	0.0937	0.0000	0.0000	0.0000	0.0195	0.0000	0.0000	0.0000	0.0256	0.1570
11	BHAVNAGAR LIGNITE	G.S.E.C.L. (Gujarat)	500.00	0.0625	10.88	0.0068	0.0059	86.76	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0039	0.0000	0.0000	0.0059
10	SABARMATI	TORRENT POWER LTD.(Gujarat)	422.00	1.5194	21.84	0.3319	0.3319	100.00	0.0000	0.2595	0.0000	0.0000	0.0000	0.0640	0.0000	0.0000	0.0084	0.0000	0.3319
		HARYANA																	
1	INDIRA GANDHI	APCPL (Haryana)	1500.00	4.7101	31.92	1.5034	1.5545	103.40	0.3434	1.2111	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.5545
2	RAJIV GANDHI (HISAR)	H.P.G.C.L.(Haryana)	1200.00	2.6974	39.47	1.0645	0.6482	60.89	0.1155	0.3944	0.0000	0.0041	0.0000	0.0000	0.1343	0.0000	0.0000	0.0000	0.6482
3	YAMUNANAGAR	H.P.G.C.L.(Haryana)	600.00	2.1322	40.29	0.8591	1.0741	125.02	0.0148	0.5223	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5370	1.0741
4	PANIPAT	H.P.G.C.L.(Haryana)	920.00	2.1695	38.00	0.8244	1.2384	150.21	0.0759	0.7271	0.2455	0.0000	0.0000	0.0000	0.1786	0.0000	0.0000	0.0113	1.2384
5	MAHATMA GANDHI	JHPL (Haryana)	1320.00	4.1306	39.90	1.6480	2.2565	136.92	0.0219	1.4766	0.7118	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0462	2.2565
		JHARKHAND																	
1	ADHUNIK PNR LTD.(MAHADEV PRASAD STPP)	ADHUNIK POWER & NATURAL RESOURCES LTD. (Jharkhand)	540.00	1.9972	37.47	0.7484	0.8805	117.65	0.0452	0.1484	0.0000	0.0040	0.0000	0.0810	0.4590	0.0000	0.0000	0.1321	0.8805

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			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) Σ(10) to
2	BOKARO 'B'	D.V.C.(Jharkhand)	710.00	2.0851	39.68	0.8274	0.2989	36.12	0.0000	0.0028	0.0000	0.0000	0.0000	0.0000	0.0000	0.2960	0.0000	0.0000	0.2989
3	CHANDRAPURA	D.V.C.(Jharkhand)	630.00	1.9458	44.81	0.8719	0.8495	97.43	0.0013	0.0781	0.0000	0.0000	0.0000	0.0000	0.0000	0.7700	0.0000	0.0000	0.8495
4	KODERMA	D.V.C. (Jharkhand)	1000.00	3.6054	44.85	1.6171	1.6061	99.32	0.0031	0.7534	0.0000	0.0000	0.0000	0.0150	0.3393	0.4953	0.0000	0.0000	1.6061
5	MAITHON RBTPP	MPL (Jharkhand)	1050.00	4.2906	40.42	1.7344	1.7738	102.27	0.0991	0.1735	0.0000	0.0000	0.0000	0.0000	0.0135	1.4877	0.0000	0.0000	1.7738
6	JOJOBERA	T.P.CO. (Jharkhnad)	547.50	0.2518	42.53	0.1071	0.0942	87.93	0.0002	0.0505	0.0000	0.0069	0.0000	0.0000	0.0366	0.0000	0.0000	0.0000	0.0942
7	TENUGHAT TPS	TENUGHAT VIDHYUT NIGAM LIMITED (Jharkhand)	420.00	1.2327	40.00	0.4931	0.6419	130.19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6399	0.0000	0.0000	0.0020	0.6419
		KARNATAKA																	
1	VIJAYANAGAR	JSW ENERGY LIMITED (Karnataka)	860.00	1.5269	15.58	0.2378	0.2679	112.65	0.0301	0.2083	0.0000	0.0000	0.0000	0.0157	0.0000	0.0000	0.0000	0.0138	0.2679
2	BALLARI	K.P.C.L (Karnataka)	1700.00	2.6201	30.30	0.7940	0.7317	92.15	0.0655	0.6662	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7317
3	RAICHUR	K.P.C.L.(Karnataka)	1720.00	6.2050	35.73	2.2160	1.5568	70.25	0.3340	1.0090	0.0068	0.0000	0.0000	0.2070	0.0000	0.0000	0.0000	0.0000	1.5568
4	KUDGI	NTPC LTD. (Karnataka)	2400.00	4.1300	33.18	1.3703	0.8830	64.44	0.0030	0.8800	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8830
5	YERAMARUS TPS	RAICHUR POWER CORPORATION LIMITED (Karnataka)	1600.00	0.4736	25.66	0.1215	0.0400	32.91	0.0062	0.0338	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0400
6	UDUPI	UDUPI POWER CORPORATION LIMITED (Karnatak)	1200.00	2.2190	5.68	0.1260	0.1261	100.08	0.0233	0.0740	0.0000	0.0256	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032	0.1261
		MADHYA PRADESH																	
1	MAHAN	ESSAR POWER MP LTD.(M.P.)	1200.00	2.0770	27.10	0.5629	0.4834	85.89	0.0027	0.1737	0.0000	0.0000	0.0000	0.2040	0.1030	0.0000	0.0000	0.0000	0.4834
2	JAYPEE BINA TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	500.00	1.6615	32.27	0.5362	0.5416	101.01	0.0474	0.4041	0.0000	0.0000	0.0000	0.0000	0.0900	0.0000	0.0000	0.0000	0.5416
3	JAYPEE NIGRIE SUPER TPP	JAIPRAKSH POWER VENTURES LIMITED (MP)	1320.00	4.0500	26.42	1.0700	1.0870	101.59	0.0270	1.0600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0870
4	SANJAY GANDHI	M.P.P.G.C.L. (M.P.)	1340.00	5.6985	35.45	2.0203	1.4539	71.96	0.0397	1.3662	0.0407	0.0000	0.0000	0.0000	0.0072	0.0000	0.0000	0.0000	1.4539
5	SATPURA	M.P.P.G.C.L. (M.P.)	1330.00	5.7049	40.42	2.3059	0.7016	30.43	0.4528	0.2381	0.0000	0.0009	0.0000	0.0092	0.0000	0.0006	0.0000	0.0000	0.7016
6	AMARKANTAK	M.P.P.G.C.L. (M.P.)	210.00	0.8802	28.14	0.2477	0.1645	66.42	0.0370	0.1154	0.0112	0.0000	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.1645
7	SHREE SINGAJI TPS	M.P.P.G.C.L. (M.P.)	2520.00	5.6979	37.91	2.1602	0.2899	13.42	0.0065	0.1444	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1390	0.2899
8	JHABUA POWER LIMITED (SEIONI TPP)(AVANTHA BHANDAR TPP)	M/S JHABUA POWER LIMITED (MP)	600.00	1.7951	31.70	0.5691	0.3456	60.74	0.0311	0.2964	0.0134	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0047	0.3456
9	ANUPPUR TPS	MB POWER (MADHYA PRADESH) LIMITED (M.P.)	1200.00	4.7206	33.43	1.5779	1.6359	103.68	0.0111	0.7489	0.0011	0.0009	0.0000	0.1349	0.7215	0.0000	0.0000	0.0175	1.6359
10	VINDHYACHAL	NTPC LTD.(M.P.)	4760.00	24.5260	33.67	8.2580	2.6760	32.40	0.1230	0.0690	0.0000	0.0000	0.0000	1.6890	0.2140	0.0000	0.0000	0.5810	2.6760
11	GADARWARA	NTPC LTD. (Madhya Pradesh)	800.00	0.2080	42.31	0.0880	0.0000	0.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
12	SASAN UMPP	RELIANCE POWER LIMITED (Madhya Pradesh)	3960.00	18.0836	22.24	4.0222	1.4916	37.08	0.0014	0.1329	0.0000	0.0026	0.0000	0.0000	1.3547	0.0000	0.0000	0.0000	1.4916

ANNEX-II

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (State WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick /Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Area	In Mining filling	In agriculture/ waste land Development	Others	Total Utilization
			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) Σ(10) to
		MAHARASHTRA																	
1	TIRODA	ADANI POWER MAHARASHTRA LTD (Maharastra)	3300.00	13.6870	31.88	4.3630	3.6847	84.45	0.0576	0.0156	0.0287	0.0000	0.0000	0.7525	0.5332	0.0000	0.0000	2.2971	3.6847
2	MIHAN	AMNEPL (Maharashtra) (No Generation)	246.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
3	ADANI DAHANU	ADANI ELECTRICITY MUMBAI LIMITED (Maharashtra)	500.00	2.1670	26.03	0.5640	0.7324	129.85	0.0004	0.0000	0.0000	0.3100	0.0000	0.0560	0.0000	0.0000	0.0000	0.3660	0.7324
4	DHARIWAL INFRASTRUCTURE Ltd.	DHARIWAL INFRASTRUCTURE LIMITED(Maharashtra)	600.00	2.1080	32.77	0.6910	0.7246	104.86	0.0883	0.0070	0.0293	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7246
5	GMR WARORA ENERGY Ltd.	GMR WARORA ENERGY LTD. (Maharashtra)	600.00	2.4976	30.32	0.7574	0.8280	109.32	0.0621	0.6181	0.0301	0.0000	0.0000	0.0000	0.0000	0.1177	0.0000	0.0000	0.8280
6	GEPL TPP	GUPTA ENERGY PRIVATE LIMITED(Maharashtra) (No Generation)	120.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
7	BELA TPS	IDEAL ENERGY PROJECTS LIMITED (Maharashtra)	270.00	0.1126	27.20	0.0306	0.0000	0.00											0.0000
8	RATNAGIRI	JSW ENERGY LIMITED (Maharashtra)	1200.00	3.3581	12.67	0.4254	0.4277	100.54	0.0563	0.0397	0.0000	0.3317	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4277
9	BHUSAWAL	M.S.P.G.C.L.(Maharashtra)	1210.00	4.9792	35.26	1.7556	1.6756	95.44	0.3088	0.5750	0.0000	0.0000	0.0000	0.4761	0.0000	0.0000	0.0296	0.2861	1.6756
10	CHANDRAPUR	M.S.P.G.C.L.(Maharashtra)	2920.00	11.5382	26.77	3.0892	1.0361	33.54	0.0371	0.9991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0361
11	KHAPARKHEDA	M.S.P.G.C.L.(Maharashtra)	1340.00	6.4698	41.66	2.6952	0.3837	14.24	0.2678	0.0000	0.0000	0.0000	0.0000	0.1160	0.0000	0.0000	0.0000	0.0000	0.3837
12	KORADI	M.S.P.G C.L.(Maharashtra)	2600.00	6.4720	41.07	2.6580	0.7740	29.12	0.0070	0.0010	0.7660	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7740
13	NASHIK	M.S.P.G.C.L.(Maharashtra)	630.00	1.8643	37.67	0.7022	1.4340	204.20	1.0743	0.3597	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.4340
14	PARLI	M.S.P.G.C.L.(Maharashtra)	750.00	2.0725	42.41	0.8578	2.5058	292.11	1.0639	0.1735	0.0000	0.2040	0.0000	0.9674	0.0000	0.0000	0.0339	0.0632	2.5058
15	PARAS	M.S.P.G.C.L.(Maharashtra)	500.00	1.9320	34.57	0.6679	0.2274	34.05	0.2100	0.0174	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2274
16	MOUDA TPS	NTPC LTD. (Maharashtra)	2320.00	7.8419	33.77	2.6480	2.3880	90.18	0.9110	0.3010	0.6970	0.0000	0.0000	0.4420	0.0376	0.0000	0.0000	0.0000	2.3880
17	SOLAPUR	NTPC LTD. (Maharashtra)	1320.00	1.2560	33.96	0.4265	0.5400	126.61	0.1800	0.2990	0.0000	0.0000	0.0000	0.0110	0.0000	0.0000	0.0000	0.0500	0.5400
18	AMRAVATI TPS	RATTANINDIA POWER LTD. (Maharashtra)	1350.00	2.3515	30.68	0.7214	0.8329	115.46	0.4100	0.0000	0.0000	0.0237	0.0000	0.1254	0.2738	0.0000	0.0000	0.0000	0.8329
19	TROMBAY	T.P.CO.(Maharashtra)	750.00	2.2950	2.19	0.0502	0.0514	102.39	0.0066	0.0000	0.0000	0.0359	0.0000	0.0000	0.0000	0.0081	0.0000	0.0008	0.0514
20	BUTIBORI	VIDARBHA INDUSTRIES POWER LTD. (Maharashtra)	600.00	1.4377	32.73	0.4705	0.7488	159.16	0.0847	0.0851	0.4424	0.1366	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7488
21	SAI WARDHA POWER Ltd. ,WARORA	WPCL (Maharashtra)	540.00	0.7790	33.76	0.2630	0.3016	114.66	0.0320	0.1410	0.0126	0.0000	0.0000	0.0290	0.0000	0.0870	0.0000	0.0000	0.3016
		ODISHA																	
1	GMR KAMALANGA TPP	GMR KAMALANGA ENERGY LTD (Odisha)	1050.00	4.8016	37.21	1.7867	1.7887	100.11	0.0207	0.1150	0.2938	0.0000	0.0000	0.0000	0.0000	0.0000	0.5597	0.0000	1.7887
2	INDIAN METALS & FERRO ALLOYS LTD.	INDIAN METALS & FERRO ALLOYS Ltd.(Odisha)	258.00	0.9330	46.81	0.4367	0.4368	100.02	0.2918	0.0396	0.0053	0.0000	0.0000	0.0000	0.0947	0.0000	0.0000	0.0053	0.4368

ANNEX-II

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (State WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick/Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Arae	In Mining filling	In agriculture/ waste land Development	Others	Total Utilization
			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) Σ(10) to
3	DERANG TPP	JINDAL INDIA THERMAL POWER LIMITED (Odisha)	1200.00	3.3520	40.99	1.3740	0.9460	68.85	0.0970	0.0000	0.0000	0.0000	0.0000	0.4840	0.3620	0.0000	0.0030	0.0000	0.9460
4	DURGAPUR CPP	NSPCL (Odisha)	120.00	0.7091	29.04	0.2060	0.2602	126.34	0.0000	0.1082	0.0055	0.0000	0.0000	0.0695	0.0770	0.0000	0.0000	0.0000	0.2602
5	TALCHAR(TPS)	NTPC LTD(Odisha).	460.00	2.8950	39.00	1.1290	1.1323	100.29	0.0113	0.0000	0.0000	0.0000	0.0000	0.0050	0.0000	1.1160	0.0000	0.0000	1.1323
6	TALCHAR(KAN)	NTPC LTD.(Odisha).	3000.00	17.1400	44.25	7.5850	3.8080	50.20	0.0980	0.0230	0.2230	0.0000	0.0000	3.3780	0.0860	0.0000	0.0000	0.0000	3.8080
7	NALCO,CPP AUNGAL	NATIONAL ALUMENIUM COMPANY LIMITED (NALCO) (Odisha)	1200.00	5.5940	44.26	2.4760	1.8206	73.53	0.3420	0.0000	0.1036	0.0000	0.0000	1.2240	0.1510	0.0000	0.0000	0.0000	1.8206
8	IB VALLEY	O.P.G.C.L.(Odisha)	420.00	2.5643	39.55	1.0141	0.3434	33.86	0.0151	0.0000	0.0088	0.0000	0.0000	0.0000	0.3031	0.0000	0.0001	0.0161	0.3434
9	VEDANTA LTD TPP	VEDANTA LIMITED (Odisha)	2400.00	7.8500	39.34	3.0881	3.7198	120.46	0.0137	0.0000	0.0092	0.0000	0.0000	0.8329	2.2787	0.0000	0.0000	0.5852	3.7198
10	VEDANTA LTD CPP	VEDANTA LIMITED (Odisha)	1215.00	6.1600	39.99	2.4633	2.7713	112.50	0.0763	0.1980	0.0123	0.0000	0.0000	0.6555	1.8259	0.0000	0.0000	0.0033	2.7713
		PUNJAB																	
1	RAJPURA TPS	NABHA POWER PROJECT (Punjab)	1400.00	4.7651	30.21	1.4395	1.3055	90.69	0.0499	1.0676	0.0000	0.1056	0.0000	0.0000	0.0000	0.0000	0.0824	0.0000	1.3055
2	BATHINDA	P.S.P.C.L. (Punjab)	460.00	0.0000	#DIV/0!	0.0000	0.7427	#DIV/0!	0.2980	0.4447	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7427
3	LEHRA MOHABAT	P.S.P.C.L. (Punjab)	920.00	1.6360	38.20	0.6249	0.5394	86.32	0.0097	0.4237	0.0621	0.0000	0.0000	0.0000	0.0439	0.0000	0.0000	0.0000	0.5394
4	ROPAR	P.S.P.C.L. (Punjab)	840.00	1.1442	34.65	0.3965	1.2771	322.11	0.0219	0.6375	0.5198	0.0015	0.0000	0.0000	0.0930	0.0000	0.0033	0.0000	1.2771
5	GVK POWER(GOINDWALSAHIB)LTD.,GOINDWALSAHIB	PSPCL (Punjab)	540.00	1.6827	27.75	0.4669	0.4658	99.76	0.0000	0.4647	0.0000	0.0000	0.0000	0.0011	0.0000	0.0000	0.0000	0.0000	0.4658
6	M/s TALWANDI SABO POWER LTD	TALWANDI SABO POWER LTD (Punjab)	1980.00	6.8000	33.14	2.2800	2.5100	110.09	0.1300	1.3000	0.3700	0.0000	0.0000	0.0000	0.2600	0.0000	0.0000	0.4500	2.5100
		RAJANTHAN																	
1	KAWAI	ADANI POWER RAJASTHAN LTD. (Rajasthan)	1320.00	4.3280	29.57	1.2800	1.5198	118.74	0.1401	0.9988	0.0000	0.0000	0.0000	0.0000	0.3560	0.0000	0.0000	0.0250	1.5198
2	JALIPA KAPURDI	JSW ENERGY (BARMER) LIMITED (Formerly Raj Westpower Ltd.) (Rajasthan)	1080.00	0.6110	14.40	0.0880	0.1090	123.86	0.0130	0.0830	0.0000	0.0000	0.0000	0.0000	0.0130	0.0000	0.0000	0.0000	0.1090
3	BARSINGSAR LIGNITE	NLC LTD. (Rajasthan)	250.00	1.2342	17.86	0.2205	1.0618	481.63	0.4809	0.1270	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4539	0.0000	1.0618
4	CHHABRA	RRVUNL (Rajasthan)	1000.00	4.1256	33.22	1.3707	1.4274	104.14	0.3188	0.9160	0.0151	0.0000	0.0000	0.0000	0.0132	0.0000	0.0000	0.1643	1.4274
5	SURATGARH	RRVUNL (Rajasthan)	1500.00	4.3128	33.21	1.4324	1.5319	106.95	0.1373	0.7266	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6680	1.5319
6	KALISINDH	RRVUNL (Rajasthan)	1200.00	2.9340	31.33	0.9191	1.0806	117.57	0.0765	0.6511	0.0531	0.0000	0.0000	0.0026	0.0011	0.0000	0.0000	0.2961	1.0806
7	VS LIGNITE POWER PRIVATE LTD	VS LIGNITE POWER PRIVATE LIMITED (Rajasthan)	135.00	0.3595	15.01	0.0540	0.0455	84.29	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0435	0.0455
		TAMIL NADU																	
1	NUTIARA	COASTAL ENERGEN PVT. LTD (Tamil Nadu)	1200.00	2.0116	3.49	0.0703	0.0705	100.23	0.0212	0.0492	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0705

ANNEX-II

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			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) $\Sigma(10)$ to
2	CHEMPLAST LIMITED TPS	CHEMPLAST SANMAR LIMITED(Tamil Nadu)	48.50	0.2708	6.75	0.0183	0.0184	100.44	0.0184	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0184
3	IL&FS TAMIL NADU POWER COMPANY Ltd.	IL&FS TAMIL NADU POWER COMPANY LIMITED (Tamil Nadu)	1200.00	3.1050	4.19	0.1300	0.1280	98.46	0.0000	0.1280	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1280
4	JSW STEEL LIMITED CPP-II	JSW STEEL LIMITED (Tamil Nadu)	60.00	0.1197	10.61	0.0127	0.0127	100.11	0.0127	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0127
5	NEYVELI - I	NLC LTD.(Tamil Nadu)	500.00	4.7390	4.06	0.1925	0.1277	66.33	0.0209	0.1037	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0031	0.1277
6	NEYVELI -I EXPN	NLC LTD.(Tamil Nadu)	420.00	3.0085	4.72	0.1421	0.1421	100.00	0.0169	0.0945	0.0000	0.0000	0.0000	0.0000	0.0000	0.0257	0.0046	0.0004	0.1421
7	NEYVELI - II	NLC LTD.(Tamil Nadu)	1470.00	11.7642	5.66	0.6663	0.7520	112.86	0.1519	0.3577	0.0741	0.0000	0.0000	0.0000	0.0000	0.1568	0.0000	0.0114	0.7520
8	NEYVELI - II EXPN	NLC LTD. (Tamil Nadu)	500.00	1.9005	5.63	0.1070	0.1044	97.57	0.0834	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0211	0.0000	0.1044
9	NLC TAMILNADU POWER Ltd	NLC TAMIL NADU POWER LIMITED (Tamil Nadu)	1000.00	3.4076	30.36	1.0347	1.0343	99.96	0.0881	0.7821	0.0209	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1437	1.0343
10	VALLUR	NTPC TAMIL NADU ENERGY COMPANY LTD {(NTECL) (Tamil Nadu)}	1500.00	5.6248	40.13	2.2570	1.5250	67.57	0.2530	0.1520	0.0000	0.1520	0.0000	0.0000	0.0000	0.0000	0.0000	0.9680	1.5250
11	OPG POWER GENERATION PRIVATE LIMITED	OPG POWER GENERATION PRIVATE LIMITED (Tamil Nadu)	414.00	1.8156	4.87	0.0885	0.0961	108.55	0.0240	0.0721	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0961
12	CUDDALORE	TAQA NEYVELLY POWER CO.PVT. LTD. (Tamil Nadu)	250.00	0.2034	52.47	0.1067	0.0803	75.22	0.0134	0.0646	0.0000	0.0000	0.0000	0.0000	0.0000	0.0023	0.0000	0.0000	0.0803
13	TUTICORIN	T.N.G & D Corporation (Tamil Nadu)	1050.00	4.5497	22.39	1.0188	0.6922	67.94	0.1113	0.5808	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6922
14	METTUR-I	T.N.G & D Corporation (Tamil Nadu)	840.00	4.0680	28.20	1.1470	0.9373	81.72	0.1405	0.5094	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2874	0.9373
15	METTUR-II	T.N.G & D Corporation (Tamil Nadu)	600.00	2.0056	30.71	0.6159	0.4889	79.39	0.0870	0.3811	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0208	0.4889
16	NORTH CHENNAI-I	T.N.G & D Corporation (Tamil Nadu)	630.00	2.7914	36.43	1.0169	0.6727	66.16	0.0502	0.2696	0.3530	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6727
17	NORTH CHENNAI-II	T.N.G & D Corporation (Tamil Nadu)	1200.00	5.0088	28.60	1.4326	1.0624	74.16	0.2782	0.7642	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0624
		TELENGANA																	
1	SINGARENI TPP	THE SINGARENI COLLIERIES COMPANY LIMITED (Telengana)	1200.00	5.1945	35.12	1.8241	1.8736	102.71	0.1710	0.7489	0.0000	0.1925	0.0000	0.0000	0.0166	0.7446	0.0000	0.0000	1.8736
2	RAMAGUNDAM'B'	TSPGCL (Telengana)	62.50	0.2886	31.91	0.0921	0.1457	158.22	0.0000	0.0107	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1350	0.1457
3	KOTHAGUDEM-V	TSPGCL (Telengana)	500.00	3.1069	36.03	1.1195	0.2786	24.88	0.0000	0.0631	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2154	0.2786
4	KOTHAGUDEM-VI	TSPGCL (Telengana)	500.00	2.3499	28.96	0.6805	0.7168	105.34	0.0947	0.5689	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0533	0.7168
5	KOTHAGUDEM (Stage I to IV)	T.S.P.G.C.L (Telangana)	420.00	3.2963	54.15	1.7849	0.7393	41.42	0.4028	0.2465	0.0000	0.0000	0.0000	0.0900	0.0000	0.0000	0.0000	0.0000	0.7393
6	KAKATIA (Stage-I)	T.S.G.E.N.C.O. (Telangana)	500.00	2.1826	37.06	0.8088	0.8209	101.49	0.1566	0.5562	0.0000	0.0000	0.0000	0.1066	0.0013	0.0000	0.0000	0.0001	0.8209
7	KAKATIA (Stage-II)	T.S.G.E.N.C.O. (Telangana)	600.00	2.0984	36.86	0.7735	0.7852	101.52	0.1401	0.5364	0.0000	0.0000	0.0000	0.1069	0.0017	0.0000	0.0000	0.0000	0.7852
		UTTAR PRADESH																	

ANNEX-II

FLY ASH GENERATION AND ITS UTILIZATION AT COAL/LIGNITE BASED THERMAL POWER STATIONS IN THE COUNTRY FOR THE YEAR 2018-19 (APRIL-2018 TO MARCH-2019) (State WISE)

Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick /Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Arae	In Mining filling	In agriculture/ waste land Development	Others	Total utilization
			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) ∑(10) to
1	BARKHERA	BEPL (UP)	90.00	0.1146	41.02	0.0470	0.0471	100.18	0.0025	0.0086	0.0000	0.0000	0.0000	0.0000	0.0359	0.0000	0.0000	0.0000	0.0471
2	KHAMBER KHERA	BEPL (UP)	90.00	0.1089	42.06	0.0458	0.0458	100.00	0.0049	0.0349	0.0000	0.0000	0.0000	0.0000	0.0061	0.0000	0.0000	0.0000	0.0458
3	KUNDARKI	BEPL (UP)	90.00	0.1527	40.50	0.0618	0.0618	100.00	0.0067	0.0446	0.0000	0.0000	0.0000	0.0000	0.0106	0.0000	0.0000	0.0000	0.0618
4	MAQSOODAPUR	BEPL (UP)	90.00	0.1065	40.57	0.0432	0.0432	100.00	0.0001	0.0051	0.0000	0.0000	0.0000	0.0000	0.0345	0.0000	0.0036	0.0000	0.0432
5	UTRAULA	BEPL (UP)	90.00	0.1464	39.78	0.0582	0.0582	100.00	0.0095	0.0334	0.0000	0.0000	0.0000	0.0000	0.0154	0.0000	0.0000	0.0000	0.0582
6	LALITPUR	LALITPUR POWER GENERATION COMPANY LIMITED (UP)	1980.00	3.4053	33.28	1.1334	1.1334	100.00	0.0079	0.5867	0.0000	0.0000	0.0000	-0.0461	0.5850	0.0000	0.0000	0.0000	1.1334
7	ANPARA-C TPS	LANCO ANPARA POWER LIMITED (Uttar Pradesh)	1200.00	4.9300	24.75	1.2200	0.3600	29.51	0.0000	0.3600	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.3600
8	MEJA TPP	MEJA URJA NIGAM PRIVATE LIMITED(Uttar Pradesh)	660.00	0.1570	40.13	0.0630	0.0001	0.22	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
9	DADRI	NTPC LTD. (U.P.)	1820.00	6.6880	33.40	2.2340	2.2369	100.13	0.3799	1.3401	0.4618	0.0000	0.0000	0.0000	0.0480	0.0000	0.0000	0.0070	2.2369
10	SINGRAULI	NTPC LTD. (U.P.)	2000.00	9.1870	31.46	2.8900	1.0130	35.05	0.0000	0.0010	0.0000	0.0000	0.0000	0.2100	0.8020	0.0000	0.0000	0.0000	1.0130
11	RIHAND	NTPC LTD. (U.P.)	3000.00	13.1210	26.80	3.5160	1.3020	37.03	0.1250	0.0500	0.0000	0.0000	0.0000	0.3390	0.7290	0.0000	0.0000	0.0590	1.3020
12	FEROZE GANDHI UNACHAR	NTPC LTD.(U.P.)	1050.00	4.6470	36.99	1.7190	2.0290	118.03	0.0390	0.9860	0.9650	0.0000	0.0000	0.0250	0.0000	0.0000	0.0140	0.0000	2.0290
13	TANDA	NTPC LTD. (U.P.)	440.00	1.6150	33.62	0.5430	1.5590	287.11	0.0010	0.3450	0.8870	0.0000	0.0000	0.0000	0.3260	0.0000	0.0000	0.0000	1.5590
14	PRAYAGRAJ TPS	PRAYAGRAJ POWER GENERATION COMPANY LTD. (U.P.)	1980.00	4.7921	28.15	1.3490	1.2555	93.07	0.0663	1.1891	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.2555
15	ROSA PHASE-I	RPSCL(U.P)	1200.00	2.5711	31.99	0.8224	0.9553	116.16	0.0548	0.5266	0.0000	0.0008	0.0000	0.2433	0.0964	0.0000	0.0333	0.0000	0.9553
16	ANPARA 'A' & 'B'	U.P.R.V.U.N.L. (U.P.)	2630.00	12.7487	34.50	4.3989	0.2326	5.29	0.0031	0.2205	0.0000	0.0000	0.0000	0.0000	0.0089	0.0000	0.0000	0.0001	0.2326
17	HARDUAGANJ	U.P.R.V.U.N.L. (U.P.)	610.00	1.9174	41.14	0.7889	0.7624	96.64	0.0382	0.3874	0.0000	0.0000	0.0000	0.0000	0.3368	0.0000	0.0000	0.0000	0.7624
18	OBRA	U.P.R.V.U.N.L. (U.P.)	1000.00	2.5631	30.44	0.7802	0.0904	11.58	0.0015	0.0715	0.0173	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0904
19	PANKI	U.P.R.V.U.N.L. (U.P.)(No Generation)	210.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
20	PARICHHA	U.P.R.V.U.N.L. (U.P.)	1140.00	3.4020	39.30	1.3370	1.0942	81.84	0.0530	0.7680	0.0000	0.0000	0.0000	0.2732	0.0000	0.0000	0.0000	0.0000	1.0942
		WEST BENGAL																	
1	B.B.G.S.	C.E.S.C. (West Bengal)	750.00	3.5600	34.16	1.2160	1.2160	100.00	0.0530	0.9950	0.0090	0.0010	0.0000	0.0030	0.1550	0.0000	0.0000	0.0000	1.2160
2	S.G.S.	C.E.S.C. (West Bengal)	135.00	0.1980	27.27	0.0540	0.0540	100.00	0.0140	0.0280	0.0070	0.0050	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0540
3	T.G.S.	C.E.S.C. (West Bengal) No Generation	240.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
4	DURGAPUR	D.V.C.(West Bengal)	210.00	0.7356	45.50	0.3347	0.0257	7.66	0.0000	0.0257	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0257
5	MEJIA	D.V.C.(West Bengal)	2340.00	8.2692	46.67	3.8591	2.8519	73.90	0.0736	1.2494	0.0000	0.0000	0.0000	0.0000	0.0000	1.5290	0.0000	0.0000	2.8519

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Sl no.	Name of TPS	Power Utility & state	Installed Capacity	Coal Consumed	Ash Content of coal	Fly Ash Generation	Fly Ash Utilization	%age utilization	In making of Fly Ash based/Brick /Blocks/Tiles etc.	In manufacture of portland pozzolana cement	In construction of Highways & Roads including flyovers	Part replacement of cement in concrete	In Hydro power sector in RCC Dam construction	In Ash Dyke raising	In reclamation of low lying Arae	In Mining filling	In agriculture/ waste land Development	Others	Total Utilization
			(MW)	MT	%age (7)/(5)x100	MT	MT	%age (8)/(7)x100	MT	MT	MT	MT	MT	MT	MT	MT	MT	MT	(MT) Σ(10) to
6	DURGAPUR STEEL	D.V.C. (West Bengal)	1000.00	3.9377	40.93	1.6118	1.2234	75.91	0.0545	0.9881	0.0000	0.0000	0.0000	0.0000	0.1808	0.0000	0.0000	0.0000	1.2234
7	RAGHUNATHPUR	D.V.C. (West Bengal)	1200.00	1.9047	42.13	0.8024	0.0783	9.76	0.0062	0.0721	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0783
8	D.P.P.S.	D.P.L (West Bengal).	550.00	1.6204	40.35	0.6539	0.5707	87.29	0.0181	0.4732	0.0000	0.0000	0.0000	0.0000	0.0794	0.0000	0.0000	0.0000	0.5707
9	CHINAKURI	EASTERN COALFIELDS LIMITED (West Bengal)(No Genearation)	30.00	0.0000	#DIV/0!	0.0000	0.0000	#DIV/0!											0.0000
10	HALDIA ENERGY LIMITED	HALDIA ENERGY LIMITED (W.B)	600.00	3.1024	33.81	1.0488	1.0488	100.00	0.0787	0.8990	0.0000	0.0000	0.0000	0.0000	0.0088	0.0000	0.0000	0.0623	1.0488
11	DISHERGARH POWER STATION	INDIA POWER CORPORATION Ltd. (W.B)	12.00	0.0336	50.88	0.0171	0.0171	100.00	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0171	0.0000	0.0000	0.0171
12	ROURKELA CPP	NSPCL (West Bengal)	120.00	0.8912	51.13	0.4557	0.1654	36.30	0.0364	0.0863	0.0000	0.0000	0.0000	0.0428	0.0000	0.0000	0.0000	0.0000	0.1654
13	FARAKKA	NTPC LTD. (W.B.)	2100.00	9.4410	33.21	3.1350	2.5110	80 10	0.0430	0.3520	0.0600	0.0000	0.0000	0 7560	0.9780	0.0000	0.0000	0.3020	2.5110
14	KOLAGHAT	W.B.P.D.C.L(W.B.)	1260.00	3.8391	42.11	1.6165	2.1411	132.45	0.0916	0.5492	0.0000	0.0000	0.0000	0.0000	1.5004	0.0000	0.0000	0.0000	2.1411
15	SAGARDIGHI	W.B.P.D.C.L(W.B.)	1600.00	3.6005	34.12	1.2283	1.1470	93.38	0.0770	0.2548	0.0000	0.0000	0.0000	0.0000	0.8152	0.0000	0.0000	0.0000	1.1470
16	BANDEL	W.B.P.D.C.L (W.B.)	335.00	1.1539	42.13	0.4861	0.4337	89.23	0.0258	0.2328	0.0000	0.0000	0.0000	0.0000	0 1752	0.0000	0.0000	0.0000	0.4337
17	SANTALDIH	W.B.P.D.C.L (W.B.)	500.00	0.2374	45.90	0.1090	0.1103	101.25	0.0026	0.0352	0.0000	0.0000	0.0000	0.0000	0.0719	0.0000	0.0000	0.0005	0.1103
18	BAKRESWAR	W.B.P.D.C.L(W.B.)	1050.00	4.1406	38.78	1.6057	1.8783	116.98	0.0440	0.8539	0.0000	0.0000	0.0000	0.0000	0.9804	0.0000	0.0000	0.0000	1.8783
		Grand Total	197960.50	667.4302	32.52	217.0381	168.3976	77.59	21.6097	58.3401	9.7244	1.7742	0.0000	21.6734	29.9177	10.1002	1.3769	14.5809	168.3975

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ANNEXURE-A-9

Report No 92
Special report on NCR Air Pollution: status of implementation of Hon'ble Supreme Court orders and further directions needed given the severity of the problem in winter
October 25, 2018
Environment Pollution (Prevention and Control) Authority for NCR (EPCA)

EPCA is submitting this special report for the consideration of the Hon'ble Supreme Court to do the following:

a. To take stock of directions given till date for different sources of pollution and to see what further needs to be done to ensure implementation
b. To recommend further actions that need to be taken, keeping in mind the need for strengthened enforcement and to ensure that actions to combat pollution can match the scale and severity of the problem.

It is well understood today that people in Delhi and NCR (and in many other parts of the country) face a public health emergency because of extremely toxic air. This pollution is worse in winter, when the weather conditions lead to inversion (because of cold); moisture (that traps the pollutants) and poor wind (that does not allow for dispersion). This is why even though the sources of pollution remain constant through the year, the level of pollution peaks in winter. This is also why pollution is high in north Indian cities as against south or coastal India.

The Hon'ble Supreme Court has issued a number of extremely important directions to help combat this deadly pollution. Many of these directions, though aimed for Delhi and NCR, have countrywide impacts. The key objective is to ensure that there is implementation of the directions so that pollution is reduced – drastically and brings the necessary health benefits.

1. Re-checking sources of pollution to ensure actions are on track

The Union Ministry of Earth Sciences (MoES) has just released its *Emission Inventory of Delhi for 2018.* The report provides information on the sources of pollution in Delhi. It has been done using high-resolution inventory of all major air pollutants (400 metres x 400 metres resolution) for Delhi and its adjoining areas, which is then combined with ground-level information on each source of pollution. This inventory provides this city with the most recent information on each source and how much it contributes to pollution in the city.

According to this inventory (see table below) the following are key sources in 2018:

1. There has been a 40% increase in vehicular pollution between 2010 and 2018 in the region.

2. Vehicles are the key contributor to air pollution – in terms of all pollutants. **Vehicles contribute as much as 41% of the pollution in the city of Delhi.** The suggests the need to clean up vehicles through fuel/technology and to reduce and restrain growth of individual vehicles through massively augmented public transport systems.

3. In the vehicle segment, heavy commercial vehicles (trucks) and commercial/personal vehicles like taxi are the major polluting source. The report finds that CO and NOx emissions from vehicles are very high, pointing to the fact that taxis (Ula, Uber etc) travel 400 km/day, as against personal cars (55 km/day). And so, even if these vehicles use CNG, the net contribution is high. This requires restrain on the trucks entering Delhi and on ensuring that there is reduction in overall personal vehicle and that even taxi use is controlled through augmented bus and metro services. It also means that para-transit (like taxi and autorickshaw) must use the cleanest fuel and technology as the miles travelled are the highest and so is their pollution potential.

4. Other state registered 4-wheel vehicles (cars and taxis) was found to be between 40-50% in major roads of Delhi. The inventory shows that 1.1 million vehicles enter Delhi every day at just 8 entry points. This includes trucks and taxis and personal vehicles. Clearly, this requires public transport connectivity for NCR region.

5. **Industrial pollution has increased by a whopping 48 per cent between 2010 and 2018**. Industry now contributes 18% of the air pollution in the city.

6. Most importantly, industry contributes as much as 65% of the SO2 emissions. This is because burning of pet coke earlier and now coal is rampant and it requires enforcement of the SO2 standards issued under directions of the Hon'ble Supreme Court.

7. **Brick kilns** have been identified as a major source of pollution in the region, mainly because of poor technology and the extremely poor quality of fuel that is used.

8. The residential emissions have reduced by half in this period – from 2010 to 2018. This is because of the increased penetration of LPG even in the poorer areas of the city.

9. The report cautions that emissions from **burning of municipal solid waste** (MSW) and MSW treatment plants (waste to energy plants) is now emerging as the new challenge in Delhi.

10. Interestingly the report finds that there is a **26% reduction in wind-blown dust** emissions in the region; Dust contributes some 22 per cent of emissions; but this is in the form of PM 10 – as much as 50% of the total PM 10 emissions are wind-blown dust.

Emission Inventory 2018: Ministry of Earth Sciences, Government of India

SECTORS	Relative Share 2018 Delhi only (%)	Relative Share 2018 Delhi + Surrounding Area (70km x 65km) (%)	Change with respect to 2010 in a full area of 70km x 65km (%)
Transport	41	32.1%	+40
Industry	18.6	17.3	+48
Power	4.9	3.0	+16
Residential	3.0	18.5	-64
Wind Blown Dust	21.5	27.8	-26
Rest Others	11.0	13.0	Additional
			Overall Change = +15%

2. Status of implementation of directions of the Hon'ble Supreme Court and further directions sought

The Hon'ble Supreme Court has passed directions on all sources of pollution. In addition, under the directions of the Hon'ble Court, the Ministry of Environment, Forests and Climate Change (MoEF&CC) has finalised the Comprehensive Action Plan for Air Pollution Control (CAP). This plan has been notified under Section 3 and Section 5 of the EP Act and includes actions on all the key sources of pollution. MoEF&CC has now been charged with the responsibility to ensure implementation of this plan. It is critical that this implementation is done in a timebound manner.

	Action/sector	Status of orders/implementation	**Further directions needed for consideration of Hon'ble Court**
1	CAP: comprehensive action plan for air pollution control with timelines and agency responsible, based on report 71 and 78 of EPCA	Order passed on 16.7.2018 directed MOEF&CC to file quarterly reports on the implementation of the plan and deadlines fixed. On 10.10.2018, the learned ASG has asked for time to file the status report. Matter listed on 15.11.2018	**In light of the findings of the Emission Inventory 2018, MoEF&CC may be directed to expedite and ensure implementation of CAP measures on augmentation of public transport; non-motorised transport and inter- and intra-NCR connectivity.**
2.	**Vehicles**		
2.1	To introduce substantially cleaner fuel/emission standards through BS 6 and to register only BS 6 vehicles as of April 1, 2020 based on EPCA report no 71 and 78	MOPNG has introduced BS6 fuel in Delhi; rest of the country will get fuel by April 2020. Order passed on 24.10.2018 that no extension will be given to vehicles; only BS6 to be sold and registered as of April 1, 2020.	
2.2	Strengthened PUC for keeping emissions from on-road vehicles under control based on EPCA report no 73 and 75 and report no 85. Implementation	Order passed on 10.8.2017 and again on 5.2.208 that all acceptable recommendations to be implemented speedily. Annexure 1 provides update on implementation of PUC	**MoRTH may be directed to provide detailed status report on the implementation of orders on PUC dated 10.5.2018**

	will ensure improvement in system and also set up system for testing BS6 vehicles on road	On 10.5.2018, order passed on improvement in diesel vehicle testing and remote sensing. On 2.8.2018, order passed on use of remote sensing technology for pollution checks and centralised testing centers for diesel vehicles. Report of ICAT to check on the efficacy of this technology submitted to Hon'ble Court.	
2.3	Stickers on vehicles to identify age and fuel usage. Implementation of this will allow for vehicles to be restricted based on age/fuel during peak pollution days	Order of 13.8.2018 directed that hologram based sticker of light blue (petrol/CNG) and orange (diesel) should be implemented in NCR by October 2, 2018. Matter has been listed for 28.11.2018. MoRTH has to provide clarity on procedure for existing vehicles and status and timeframe for implementation	
2.4	Restriction on truck entry into Delhi as major contributor within vehicle segment: ban on entry of non-destined trucks; imposition of ECC on all Delhi-bound commercial vehicles; pre-2005 vehicles not allowed entry and setting up RFID for enforcement based	Orders of 9.10.2015, 16.12.2015 and 22.8.2016 are being implemented. To strengthen enforcement, SDMC is setting up RFID system for entry of commercial goods vehicles into Delhi on 13 points. This system will be operational by November 15 on 11 points and will ensure only post 2005 vehicles are pre-registered and that there is no cash collection of ECC.	**SDMC may be directed that only pre-registered goods vehicles will be allowed entry into Delhi after commissioning of RFID system and that diesel commercial vehicles over 10 year will not be pre-registered and given entry.**

	on EPCA reports of October 2015, August 2016 and Report no 83	Annexure 2 for status	
2.4	Eastern and Western Expressway (EPE and WPE) and for diversion of trucks	EPE has been commissioned and is in use. The remaining part of the WPE is expected to be commissioned by November 1st week 2018. On 10.5.2018, Hon'ble Court directed that the State of Haryana should ensure that the concessionaire sticks to the assurance made, the date of June 30, 2018 for completion of WPE.	**Government of Haryana may be directed to file commissioning schedule for WPE**
2.5	Hydrogen-CNG for buses: this trial will ensure that emissions from CNG fuelled buses will be reduced, based on EPCA report 86 and 88	Order of 13.8.2018 sanctions Rs 15 crore from ECC funds to the Indian Oil Corporation for carrying out study and pilot project. Matter listed on 28.11. 2018	
3.	**Industries**		
3.1	Ban on pet coke and furnace oil ban in NCR states based on EPCA reports 72, 76 and 80. This ensures that the most polluting fuel is eliminated.	Order of 24.10.2017 placed ban on use of FO and pet coke in the states of UP, Haryana and Rajasthan, as of November 1, 2017. Order of 5.2.2018 directed CPCB to compile data on all permitted industries for regulation; namely, cement, calcium carbide and lime-kiln. This data is available on the website of CPCB. However, it is difficult to monitor enforcement and to ensure	

		that industries are not misusing their permission to use petcoke as explained in EPCA report 91.	
3.2	Ban on import of pet coke into India based on EPCA reports 79, 80, 87; this ensures that across the country pet coke use is restricted only to industries that use it as feedstock.	Order of 26.7.2018 noted that consensus had been reached that imported pet coke would only be permitted in the following industries; cement, lime-kiln, calcium carbide and gasification. Hon'ble Court directed that the decision should be notified and implemented with immediate effect. On 24.8.2018, DGFT has issued notification to ban import of pet coke and its use permitted only in specified industries. On 6.9.2018, Hon'ble Court had allowed graphite electrode industry to use pet coke. On 9.10.2018 Aluminium and Calciner industry has been permitted to use pet coke. The matter of steel industry is pending and is listed on 14.11.2018	**Directions may be issued based on EPCA report 91, with regards regulation and enforcement of industries that are permitted to use pet coke (domestic and imported).**
3.3	Setting up of standards for SO2, NOX for 23 industries. This ensures that emissions from combustion are monitored and	Based on directions issued by Hon'ble Supreme Court MoEF&CC has notified standards for NOx and Sox for all industries. But the challenge is enforcement. EPCA in its report 87 had pointed out that	**MoEF&CC may be directed to provide status report on implementation of Sox and NOx standards in NCR.**

	controlled. It is expected that industry will move to coal or low-sulphur oil, which has lower emissions than pet coke. These standards also provide for incentives to move to natural gas, which has no emission limits.	enforcement is lacking and that this problem is fundamental and fatal.	**The Pollution Control Boards of Delhi, Haryana, UP and Rajasthan may be directed to inspect all factories in their NCR districts as per the Air Act and to report on compliance with standards for Sox and NOx.**
3.4	Natural gas for industries. Given the problems in enforcement of emission standards, it is critical that industries move to cleaner fuel, namely gas or electricity.	MoPNG has issued tenders for supply of natural gas in the districts of NCR. In the order of 16.7.2018, the Hon'ble Supreme Court notes that no further action is required to be taken in this regard and the issue is closed. However, the availability and supply of gas is not leading to the desired results because of higher price of this fuel as compared to more polluting fuels like coals or low sulphur oil. EPCA will file a report for the consideration of the Hon'ble Court so that further actions can be taken on this crucial matter.	
3.5	Measures to strengthen electricity supply in NCR to ensure that there is restricted use of generators and that	On 5.2.2018, the learned ASG had informed the Hon'ble Court that communication had been sent to the 3 states in NCR; namely Haryana, Rajasthan	**UP, Haryana and Rajasthan may be directed to file responses on steps taken to strengthen electricity supply**

	cleaner electricity can be used to power industry and over time vehicles	and UP. On 10.5.2018, the Hon'ble Court had issued notice to the 3 states of UP, Haryana and Rajasthan on this matter.	
4.	**Power Plants**		
4.1	Closure of Badarpur thermal power plant as per measures listed in CAP	Implemented as of October 2018	
4.2	Bawana gas plant to be made operational so that instead of coal, the city uses power from cleaner natural gas	Order of 5.2.2018 Implemented as of July 2018	
4.3	Expeditious implementation of thermal power plant 2015 emission standards implementation, based on EPCA reports 81 and 84. This would ensure that coal based power plants would be far less polluting. The standards were to be implemented in December 2017, but Ministry of Power and industry has argued that implementation would be delayed and could not be done before 2022	Based on intervention by Hon'ble Supreme Court the deadline for implementation of emission standards has been expedited. Order of 7.9.2018 directs that 57 units, which are under central government will meet emission standard for Sox and PM by December 31, 2021 and NOx by December 2022. Private Power Plants and state power generating companies are now required to expedite schedules. Ministry of Power has to revert on EPCA's suggestion on use of merit order dispatch to incentivise implementation. Matter is listed on 27.11.2018	
5.	**Others**		

5.1	Brick kiln to convert to cleaner zigzag technology and to use better quality fuel for combustion	EPCA has taken up this matter directly with brick kilns in the region in coordination with the Central and state pollution control boards. As of the beginning of the 2018 season (October 2018), 35-40% brick kilns had converted to cleaner technology. As per CAP, only zigzag brick kilns will be allowed to operate in NCR districts. The state boards have to ensure enforcement of these directions of the Central government. Annexure 3 for update on brick kiln	
5.2	Biomass burning from neighbouring states of Punjab and Haryana	The Union government has taken up the matter with the state governments and has allocated funds for machinery that help farmers plough back the straw. There is high level attention on this issue and it is expected that there will be reduction in paddy straw burning incidences this season.	
5.3	MSW burning and emissions from waste-to-energy plants, has emerged as a new challenge and requires concerted efforts to contain both fires at landfills and other point sources	The Hon'ble Supreme Court is monitoring this matter	

Annexure 1/EPCA Report 92

PUC improvement: what is needed to be done

The Hon'ble Supreme Court has passed important directions for the improvement of the pollution under control (PUC) system, which is key for checking emissions of vehicles on the road. The Hon'ble Supreme Court had on August 10, 2017 considered EPCA report no 73 and 75 and issued directions, which once implemented would strengthen the enforcement system for on-road vehicles. The Hon'ble Court had issued directions on May 10, 2018 regarding trials for remote sensing equipment to be used to monitor pollution from on-road vehicles.

EPCA has reviewed the status and while there is movement on the measures, there is a need for timebound implementation of the directions of the Hon'ble Supreme Court so that PUC/on-road emissions of vehicles are kept in check.

Sno	Direction	Status	Comments of EPCA
1.	**Limit the number of PUC centres, upgrade them and bring them under strong supervision and quality control.** • Ascertain the number of petrol stations in the NCR region and how many of them are equipped with PUC centres. • Ascertain how many authorized service centres of OEMs are in the NCR region. • Issue advisory to all the State Transport Departments all over the country for mandating PUC centres at every fuel station.	In Affidavit filed on 20.9.2017, MoRTH has informed the Hon'ble SC as follows: No of stations in NCR: 3020 Number of stations with PUC in NCR: 1083 Number of authorised service stations of OEMs in NCR: 1054 Number of authorised service stations of OEMs in NCR: 160	The upgradation and supervision for quality control will happen once the MoRTH has linked all the stations and provided protocols for quality control (item 2)
2.	All empanelled and authorized PUC centres having Type Approved Machines will be uploaded on the website of the Ministry of Road, Transport and Highways with their names, addresses and authorized personnel. In the first stage, the needful will be done within a month in	MoRTH has issued a notification (GSR 527 (E) on June 6, 2018 as an amendment to the Central Motor Vehicles Rules, 1989 to allow for the following: The emission results obtained during testing as per clause (i) or clause (ii) above shall be electronically uploaded through online	In its meeting on July 27, 2018, EPCA has discussed the status of this online system with MoRTH and National Informatic Centre (NIC), which is developing the software. The system is expected to be commissioned by end-

	so far as the NCR region is concerned and thereafter for the rest of the country.	process to the state register of Motor Vehicles of the Central Register of Motor Vehicles as the case may be." The schedule for implementation of this is as follows: NCT Delhi: June 1, 2018 Haryana, Rajasthan, UP: October 1, 2018 Rest of the country: April 1, 2018	August and Delhi PUC data will be linked to it. ARAI has been asked to submit information on the type-approval provided for such equipment so that the system can be designed and all data transferred.
3.	**Introduce automatic online network for transmission of PUC data to the central server to minimize manual interference and allow proper analysis of data for remote auditing of PUC centres.**	As above	The software being designed by NIC for MoRTH in compliance with the directions of the Hon'ble court will go a long way to improve the current system. State governments would upload information on the authorised and registered PUC centres allow registration of all authorised with the details of the equipment available. All PUC test data would be recorded and transmitted real-time from PUC centres to the central server, which would be linked to the VAAHAN database. It is important that this project is completed as soon as possible. Schedule for completion is needed.
4.	**Mandate pre-payment of PUC fees before the tests are conducted**	Done. As per information it is being implemented	
5.	**Ensure 100 percent compliance by linking annual vehicle insurance with PUC certificates**	MoRTH has taken up this matter with all insurance companies and after much follow-up and effort, the insurance companies have issued directions that it is mandatory to check for PUC certificate before issuance of the insurance policy. A list of 15 insurance companies that	MoRTH must continue to follow up to ensure that there is full compliance with these directions. To improve compliance and enforcement, EPCA has asked for the following to be done: Currently all insurance companies have to upload information

		have complied with the directions was sent to EPCA through email.	about the policy in the VAAHAN database. It was agreed that an additional column/field would be created requiring insurance companies to fill that they had complied with the mandatory direction at the time of issuing the policy. This would ensure compliance.
6.	**Make Lambda test for petrol cars mandatory across NCR**	Done. Being implemented	The effectiveness will be known once there is a system to check on the working of the authorised PUC station
7.	**Introduction of roadside remote sensing screening of emissions in Delhi and NCR to complement the current PUC system**	The International Centre for Automotive Technology at Manesar (ICAT) is conducting study.	ICAT report to be submitted to Hon'ble Court

Annexure 2/EPCA report 92
Implementation of RFID for improving enforcement of orders of Hon'ble Supreme Court barring entry of pre-2005 commercial vehicles into Delhi and ensuring that vehicles pay the Environment Compensation Charge, which would act as a disincentive for commercial vehicles to traverse through Delhi

The 2015 orders of the Hon'ble Supreme Court were given in order to reduce commercial vehicle entry into Delhi and by doing this, to reduce air pollution. On 22.8.2016, the Hon'ble Supreme Court had directed that the South Delhi Municipal Corporation (SDMC) would install a Radio Frequency Identification (RFID) system into entry points to Delhi to make the system effective and credible and to reduce the chances of corruption and leakages in this cash-based system.

EPCA report 82 had pointed out that collection of ECC was greatly flawed and that the directions of the Hon'ble Supreme Court are in effect being flouted and all efforts to mitigate pollution derailed. It had reiterated the need for expeditious implementation of RFID system for 13 key entry points into Delhi.

The South Delhi Municipal Corporation (SDMC) has since expedited the implementation of the RFID system on 13 entry points into Delhi. Roughly 80 per cent of the commercial vehicles enter the city from these 13 points.

The following is the schedule for implementation:
November 1, 2018:

1. Kapasera
2. Aya Nagar
3. Tigri
4. Shahdra Main
5. Shahdra Flyover

November 15

6. Kundli
7. Rajokri
8. Ghazipur (old)
9. Ghazipur (main)
10. DND

November 30

11. Kalindi kunj (may be delayed further as road is inoperative)
12. Badarpur
13. Badarpur (flyover)

EPCA has worked with SDMC to make rules for pre-registration of vehicles to ensure that there is compliance with the orders of the Hon'ble Supreme Court on exemptions to certain goods and vehicles. The objective of these rules is to ensure that leakage and corruption at the time of collection of ECC is reduced, which is rampant because of manual checks at the border.

The rules are as follows:
The following **vehicles types**, which are exempt, under the Hon'ble SC order will get exemption at the time of pre-registration:

1. CNG vehicle (with RC showing that they are CNG vehicle)
2. Milk tanker
3. Oil tankers carrying petroleum products

4. Water tanker
5. Ambulance
6. Fire fighting vehicles

The following **goods are exempt from paying ECC** and currently the system to check this is manual, which is leading to huge transaction costs and corruption:

1. Eggs
2. Salt
3. Ice
4. Foodgrains
5. Vegetable
6. Packed milk

The rules will be as follows:

1. All vehicles will be required to pay ECC at the time of entry.
2. The vehicle owner will be required to show proof that the exempt goods are being carried in the form of Bilti/challan and that the goods are destined for Delhi. This Bilti/challan will be scanned at the time of entry.
3. In the case of vegetables and open grains, where the bilti/challan is not available a photograph of the goods will be taken and used as proof
4. The exempt vehicles, carrying the necessary documentation, after audit, will get a recharge in their ECC account.
5. The process of audit and refund will take up to 1 week
6. All toll plazas have cameras to record the transaction, number plate and the nature of goods being carried, which will be used at the time of audit
7. There will be a penalty for wrong claim of reimbursement, which could lead to blacklisting.

Rules for empty vehicles bound for Delhi

As per the Hon'ble Supreme Court order of 16.12.2015, vehicles that are bound for Delhi can enter on payment of ECC of Rs 700 and Rs 1300 per vehicle depending on the category to which the vehicle belongs. The system for these vehicles, to avail, this half rate of ECC, will be as follows:

1. All vehicles will be required to pay full ECC at the time of entry.
2. The vehicle owner will be required to show proof that the vehicles is bound for Delhi in the form of: Bilti/challan, which will be scanned at the time of entry
3. In addition, cameras will take photographs of the vehicle to show that it is empty
4. The reimbursement to the empty vehicle, carrying the necessary documentation, after audit, will be given in the form of recharge in their ECC account.
5. The process of audit and refund will take up to 1 week
6. All toll plazas have cameras to record the transaction, number plate and the nature of goods being carried and also to record if the vehicle is empty, which will be used at the time of audit.
7. There will be a penalty for wrong claim of reimbursement, which could lead to blacklisting.

Annexure 3/EPCA report 92

Brick Kilns in NCR: Status of pollution control to reduce emissions

The brick kiln sector has been long considered to be extremely polluting and a major contributor to pollution in the airshed. The technology used in NCR brick kilns, known as fixed chimney bull trench (FCBT), is rudimentary and requires continues combustion and is known to be high in emissions. The conversion of the existing brick kilns to an alternative technology, called as zigzag technology, is widely understood as the most cost-effective and feasible method to reduce pollution in this sector.

EPCA has been working with the Central and state pollution control boards to ensure that the existing brick kilns convert from FCBT to zigzag technology to reduce pollution.

Background

The Hon'ble Supreme Court in its order dated September 11, 1996 directed that "...brick kilns cannot be permitted to operate and function in the Union Territory of Delhi. These brick kilns may relocate/shift themselves to any other industrial estate in the NCR".

Following this, in 2016-17, the Hon'ble Court took up the matter of an emergency plan for Delhi and NCR, as well as the comprehensive action plan to deal with all sources of air pollution in the region. Both these plans have provisions to combat emissions from brick kilns.

The Graded Response Action Plan for Delhi & NCR (GRAP), which has been notified as per the by the MoEF&CC on January 12, 2017, deals with emissions from brick kilns by reiterating stringent enforcement of existing pollution control regulations in the "moderate to poor" category of actions. During "severe" pollution episodes, GRAP mandates the EPCA to direct authorities to shut down operations of all brick kilns in the region.

The Hon'ble Court directed the notification of the Comprehensive Action Plan for Delhi & NCR (CAP). The CPCB issued directions under Sections 3 & 5 of the Environment (Protection) Act, 1986 regarding the CAP in Delhi & NCR on June 22, 2018.

The CAP directs all NCR state pollution control boards to ensure that brick kilns are converted to "zigzag technology". It says "Only brick kilns which have converted to zig-zag technology and have been certified by the SPCB will be allowed to operate during winter 2017-2018. By July 1, 2018, only brick kilns with zigzag technology will be allowed to operate in NCR."

The need for control of pollution in brick kilns

The brick industry is one of the five largest industrial consumers of coal and there are serious environmental concerns associated with the production of fired clay bricks. Emissions from brick kilns have been identified as one of the major sources of air pollution in Delhi-NCR.

The 2015 IIT Kanpur Study on Air Pollution in Delhi has identified the various sources of air pollution within the NCT of Delhi. Although the state of Delhi does not permit the operation of brick kilns within its territory, the emissions from the nearby regions affect air quality within Delhi. The study explores the contribution of fly-ash from brick kilns operating outside Delhi and identifies these kilns as a definite factor that affects air quality.

Over the past two decades, there has been a rapid increase in the brick production capacity in the NCR region. Following the closure in Delhi brick kilns have moved to areas bordering Delhi such as Ghaziabad, Noida, Baghpat, Muzaffarnagar, Bulandshahar, Hapur, Meerut (UP), Palwal, Sonepat, Faridabad, Jhajjar, Jind, Bhiwani, Nuh (Haryana) and Alwar and Bharatpur in Rajasthan. In this period, the total brick production capacity has increased by six-ten times. This corresponds with the increased rate of urbanization and resultant construction in the region. This has increased the pollution impact from brick kilns in this common airshed of NCR.

Strategy for pollution reduction through technology conversion

In NCR region, almost all brick kilns are based on the rudimentary FCBT technology with chimneys emitting pollutants continuously during the peak manufacturing season from mid-October to June every year.

The more advanced technologies, namely, Vertical Shaft Brick Kilns (VSBK), Hybrid Hoffman Kilns (HHKs) need high initial investment. Therefore, the most appropriate option found suitable for this sector, is the zigzag kiln. Zigzag kilns are better than FCBT kilns when it comes to the amount of coal being consumed and also reduction in pollution.

The infrastructure of zigzag kilns is similar to FCBT kilns, the only difference being that the former is always rectangular. Hot air leaves the kiln travels in a zigzag path through the stacks of green bricks, thus pre-heating them for a longer period. This makes zigzag kilns more energy efficient. The draught in these kilns can either be natural or forced. This technology also reduces the consumption of coal by 20–30 per cent and also decreases emissions, including black carbon-containing particulate matter. The SPM and black carbon emissions are reduced drastically by about 75 per cent, and the number of good quality bricks goes up by around 25 per cent.

This technology was introduced in India by Central Building Research Institute (CBRI), Roorkee, in the early 1970s but gained popularity in the mid-nineties (around 1993-1994) only in eastern India, especially West Bengal. However, other parts of the world (including Bangladesh) have rapidly moved to zigzag technology as it reduces pollution.

The pay-back period of this conversion is small – one to two years – as the quality of bricks is improved and the cost of fuel is reduced.

Table: Advantages of zigzag kiln over the FCBT Kilns

S. No.	Fixed Chimney Bull Trench (FCBT) kilns	Zigzag kilns
1.	Specific energy consumption is in the range of 1.1–1.5 MJ/kg of fired bricks	Specific energy consumption in comparison to the FCBT kilns is 20 per cent less
2.	Percentage of Class I bricks produced is between 50–60 per cent	Percentage of Class I bricks is much higher and is more than 80 per cent
3.	Range of particulate emission from FCBT kilns is from 250–1,250 mg/Nm3	Range of particulate emission from the kiln is less than 250 mg/Nm3.
4.	Black carbon emission ranges from 0.07–0.27 g/kg of fired bricks	Black carbon emission is less than 0.05 g/kg of fired bricks

CPCB directions on zig zag conversion

Since 2015, the Central Pollution Control Board has issued directions to brick kilns to convert to zigzag technology in the Delhi-NCR region.

Timeline of CPCB orders:

- On December 29, 2015, CPCB issued directions under Section 18 (1) (b) of the Air (Prevention and Control of Pollution) Act directing all brick kilns in NCR to convert from natural draft to induced draft within 90 days.

- In a subsequent order in November 2016, CPCB clarified that all brick kilns must convert to a kiln design that has zig-zag brick settings and redesigned chimneys along with transition from natural to induced draught. CPCB directed that all kilns not complying with these conditions must shut down for the winter till March 31, 2017.
- On June 27, 2017, the CPCB directed all SPCBs in the NCR states to provide status on conversion of brick kilns from natural draft to induced draft (with rectangular kiln shape and zig-zag brick setting).
- On October 24, 2017, the CPCB directed the State Governments of the NCR states to close down all brick kilns operating without consent. It also reiterated that kilns that have not converted to zigzag kilns by September 30, 2017, should not be allowed to operate.
- On February 13, 2018, CPCB issued directions to all NCR district governments that they should ensure compliance of its directions, which are as follows:
  a. Operation of brick kiln, not converted to zigzag technology (natural/induced draft with rectangular shape) should be allowed for the period March 1, 2018 to June 30, 2018 provided they have valid consents from the respective SPCB's and ensure stack monitoring facilities.
  b. **All brick kilns that had not converted to zigzag technology would cease to operate beyond June 30, 2018.**

EPCA's interventions and current status of brick kilns

EPCA has been closely monitoring the situation of brick kiln conversion since February 2017. It has held a series of meetings to reiterate the directions of the CPCB in this matter and to ensure that there is compliance.

In October 2017, EPCA directed that FCBT brick kilns would be allowed to operate for one last season – from March 1, 2018 to June 30, 2018 – provided that they had given a signed undertaking that they would convert to zigzag.

This direction was reiterated on January 11, 2018 and made clear to all NCR state pollution control boards that from July 1, 2018 only zig-zag technology (natural/induced draft with rectangular shape) would be allowed to operate in NCR.

As of today, the status of conversion is as follows;

Table: Status of conversion of brick kilns in NCR to zigzag kilns

State	**Total Brick Kilns**	**Zigzag kilns**	**Non-Zigzag Kilns**
Delhi	0	0	0
Haryana	2887	1286	1601
Rajasthan	246	82	164
Uttar Pradesh*	2107	403+64 (in process)	1640
Total	**5240**	**1835 (35%)**	**3405 (65%)**

Source: Data provided to EPCA by SPCB's in its meeting dated September 14, 2018
*Data for Uttar Pradesh excludes the district of Shamli

At its recent meeting on September 14, 2018 convened specifically to discuss the conversion of the brick kilns before the onset of the coming season in October 2018, EPCA noted the following:

a. Some 1835 brick kilns had converted to zigzag, which would now be allowed to operate from the coming season – October 2018. All other brick kilns, not converted to zigzag, and certified by the state pollution control board, would not be allowed to operate.

b. It was noted that the state pollution control boards must ensure the quality of technology conversion is good and that it does not negate the efforts to control emissions. EPCA therefore, asked for quality checks and rigorous audits to ensure compliance.

c. It was directed that all state governments must ensure all brick kilns that have not converted to zigzag must be shut down.

d. It was also directed that all state governments must ensure that brick kilns do not use highly toxic fuel like used rubber, old rubber slippers, plastic wastes and other toxic substances are being used to fire the brick kilns. The advantage with good quality zigzag converted kilns is that the quality of combustion material is better – including the use of crushed or briquettes of agricultural residues – and this reduces pollution substantially.

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Gmail

Rounak Nayak <rounaknayak@gmail.com>

O.A. NO. 1016 OF 2019 - REPLY ON BEHALF OF THE SONEPAT BRICK KILN OWNERS' ASSOCIATION.

1 message

Rounak Nayak <rounaknayak@gmail.com> Fri, Sep 11, 2020 at 1:35 PM
To: poojadhar@gmail.com, shlokchandra@chandralawchambers.com

Dear Sir/Madam,

I am writing to you from the Office of Mr.Rohit Sharma, Advocate, to serve upon you a copy of the Reply filed by us on behalf of the Sonepat Brick Kiln Owners' Association to the CPCB Report dated 06.07.2020 in OA No. 1016 of 2019. Please find attached a copy of the Reply along with this email. Thank you.

FINAL - VOL-I Scanned Reply to CPCB in O.A No.1...

FINAL - VOL-II - Scanned Reply to CPCB in O.A N...

Regards,

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