

**Environmental Damages Cost Calculation for Solar Industries  
India Limited**

## INTRODUCTION

Solar Industries India Limited, at Chakdoh, near Bazargaon Amravati Road (about 37 km from Nagpur), District Nagpur, Maharashtra has evolved from a single-site manufacturing company to a globally recognized leader in industrial explosives since its inception in 1995. On Sunday, December 17, 2023, at around 9:30 am, a devastating explosion occurred during the packing of explosives at Solar Industries India Limited's factory, Maharashtra, resulting in the death of nine people and severely injuring three others. Solar Industries, known for manufacturing various items for defense establishments, faced this tragic incident in the Bazargaon region.

Quantifying the environmental damages in monetary terms proves to be a useful strategy for increasing awareness among local municipalities and governing bodies. This study focuses on appraising the monetary extent of environmental damages incurred by the explosion of hazardous materials, such as those witnessed in the tragic incident at Solar Industries India Limited's factory. By assessing the financial impact of such events, stakeholders can better understand the repercussions and allocate resources for mitigation and prevention efforts effectively.

For evaluation of the environmental damages due to above explosion, a committee was constituted by MPCB with office order MPCB/NRO/103/2024 dated 3/5/2024 based on Hon'ble NGT matter OA No. 28/2024 (WZ, Pune Bench). In order to evaluate the monetary costs of environmental damages, the committee visited the Solar Industries for site inspection and collection of data on 7<sup>th</sup> May 2024. Post meeting, a questionnaire was circulated to the industry for collection of data. Solar industries responded to the questionnaire with data via email on 9<sup>th</sup> May 2024, which has been used for computation of the environmental damages. During the site visit, the committee observed that multiple damaged equipments, vessels, collapsed structures, and concrete debris were still lying on the site which may be disposed off as per the regulation.

In order to evaluate the environmental damages cost, three components have been considered for assessment: environmental compensation considering the explosion and related violation; environmental liability due to production of additional load of hazardous waste in the



environment which should not have been generated and environmental damages cost due to release of pollutants. Each of these aspects have been evaluated separately in the report.

### **Environmental Compensation**

To calculate the Environmental Compensation (EC) for Solar Industries India Limited, the CPCB methodology has been followed. According to the classification by Central Pollution Control Board (CPCB), concerned Industries lies in the Red category based on their Pollution Index (PI), with Red category industries having a PI in the range of 60 to 100. To calculate EC, an average PI of 80 is used for red-category industries. The number of days (N) for which the violation occurred is 1, representing the period between the observed violation and compliance verification. The monetary value (R) is set at ₹250, a standard value for such cases. Given the large size of the industry, the scale of operation factor (S) is 1.5. Additionally, the location factor (LF) is determined by the population of the area; for Bazargaon area, district Nagpur, with a population of 1 to less than 5 million according to the Census of India (2011), the LF is 1.25.

The Environmental Compensation shall be based on the following formula:

$$EC = PI \times N \times R \times S \times LF$$

Where,

EC is Environmental Compensation in ₹

PI = Pollution Index of the industrial sector

N = Number of days of violation took place

R = A factor in Rupees (₹) for EC

S = Factor for scale of operation

LF = Location factor

#### **For Solar Industries India Limited**

PI = 80 (Red Category Industry)

N = 1

S = 1.5 (Solar Industries India Limited is classified as a large industry)

R = ₹250

LF = 1.25 (Population of Nagpur as per the latest Census of India 2011)

**EC = 37,500 ₹/day**

The Environmental Compensation (EC) for Solar Industries India Limited is calculated at ₹37,500 per day. The explosion happened in one day only, hence the compensation value is ₹37,500.

### **Liability Cost due to release of Hazardous Waste**

In this specific incident, the hazardous waste involved included 1832.9 kg of TNT-contaminated soil and 298 kg of stones and RCC material recovered as per the details obtained from the industry. Between 2 and 2.5 kiloliters of water was utilized for washing contaminated soil and debris, while 1.5 to 2 kiloliters was employed for cooling the site immediately following the explosion. These actions raise concerns about the potential contamination of both ground and subsurface water sources. The penalty cost is justified by several other critical factors as well such as this hazardous waste should not have released into the environment that is to CHWTSDF as well, the collection of waste required machinery and water, the processing of waste required lot of machinery which released pollution into the environment and so on. The detailed information related to these aspects is not available as they were not collected at that time.

The explosion and handling of hazardous waste resulted in significant environmental damage, including soil and water contamination, necessitating extensive and costly remediation efforts. The potential contamination of groundwater requires comprehensive testing and treatment which cannot be determined or computed now. This incident places a high load on the environment and underscores that such events should not occur.

The committee feels that the scenario falls under the category of a landfill breach and release of hazardous waste into the environment, as mentioned in the "Guidelines on Implementing Liabilities for Environmental Damages due to Handling & Disposal of Hazardous Waste and Penalty" by the Central Pollution Control Board (CPCB) since the additional load of hazardous waste was released into the environment although after treatment and to the CHWTSDF. Care has been taken to only consider the assessment cost related liability and not the remediation costs related to such releases since they cannot be ascertained post facto of such a disaster where monitoring could not be done during the time of collection and processing of waste.

The cost of liability for such cases varies significantly, ranging from 20 lakhs to 1 crore 50 lakhs. This variation in cost can be attributed to several factors, including the volume of the waste, whether the waste is above ground surface or below ground surface, and whether



groundwater resources have been contaminated. Additional considerations include the quantity of waste released and the type of hazardous waste involved. Each of these factors can influence the overall financial impact, emphasizing the need for a detailed assessment to accurately determine the cost of environmental damages in each specific case.

The committee feels that the liability cost of 50 lakhs for landfill breaches and hazardous waste release into the environment reflects the severity of the incident and emphasizes adherence to environmental regulations since the actual data of the water contamination, if any, pollution load during processing and long term impacts of such hazardous waste is not quantifiable. Through effective penalties, authorities aim to mitigate environmental damage and foster responsible waste-handling practices.

### Valuation for Emission

Here, evaluation has been done on the basis of theoretical estimates of the production of possible products based on the explosion of TNT. Table 1 provides the detonation related products while Table 2 provides products based on theoretical complete combustion.

**Table 1:** Products of Detonation of TNT 200 Kg TNT (0.880548723 Kmol of TNT)

Components	Component %	Weight of Material Produced (Kg)
Carbon monoxide	70.5	141
Carbon Dioxide	3.7	7.4
Hydrogen	1.7	3.4
Nitrogen	19.9	39.8
Carbon	4.2	8.4
<b>Total</b>	<b>100</b>	<b>200</b>

**Table 2:** Weight of material produced, both in kilomoles and kilograms, considering the complete conversion of TNT

Component	Weight of Material Produced (Kmol)	Weight of Material Produced (Kg)
Carbon Dioxide	6.16	271.21
Water	2.20	39.62
Nitrogen	1.32	36.98
Total	9.69	347.82
Oxygen Consumed	4.62	147.93

*(Handwritten signatures and initials in blue ink)*

For economic valuation, Table 1 products have been considered since that provides a better estimate in case of explosion than complete combustion since complete combustion is highly unlikely in the case of explosion. The Value Transfer Method (VTM) has been used for economic valuation. In VTM, the valuation of the extent of damages produced by the same pollutants at one geographic place can be transferred to another place using economic checks and balances. The base methodology, using the VTM, used for the current valuation has been taken from CSIR-NEERI's framework and publications<sup>1,2</sup>. The framework defines the use of VTM and the approach in detail. The base formula used in the analysis includes:

*Damage Cost in India (I) (₹)*

$$= \text{Damage Cost at Location } x * \text{PPP Adjustment Factor (I vs x)} * \text{IR}$$

Suitable econometric conversions including purchasing power parity (PPP) and inflation rate (IR) have been used to convert foreign currency values to Indian values. The Indian values per tonne of emission hence arrived are used for the valuation of damages.

For Carbon dioxide, since it is GHG and can have a long-term impact on the environment, the social cost of carbon median values have been used as estimated by USEPA. Similar econometric factors including PPP and IR have been used to get the Indian values. For HCl, externalities estimates done for the utility sector calculated by Fraunhofer Institute, Germany, and Pace University, USA referred due to the limited availability of literature with suitable econometric adjustments as stated above. Using the above equation and the given literature, the damage value per tonne for all the pollutants has been calculated in Indian Rupees for the base year of 2024 and is given in **Table 3**. The consolidated table for environmental damages is given below:

### Calculation

Based on literature review on emissions from waste incineration, it's been established that incinerating 1 metric ton (MT) of waste typically results in the release of 0.7 to 1.2 MT of carbon dioxide (CO<sub>2</sub>)<sup>3</sup>. We'll use the upper value of 1.2 MT for our calculation. With 1335 kilograms (kg) of soil waste, which is considered to fall under the MSW category and is free

<sup>1</sup>[https://www.neeri.res.in/file\\_homes/41441989\\_EDCA\\_Final\\_Soft.pdf](https://www.neeri.res.in/file_homes/41441989_EDCA_Final_Soft.pdf)

<sup>2</sup><https://link.springer.com/article/10.1007/s11869-020-00845-3>

<sup>3</sup>[https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5\\_3\\_Waste\\_Incineration.pdf](https://www.ipcc-nggip.iges.or.jp/public/gp/bgp/5_3_Waste_Incineration.pdf)

of hazardous contaminants, we can estimate the CO<sub>2</sub> emissions. Converting the waste amount to MT gives us 1.335 MT. Multiplying this by the CO<sub>2</sub> emission factor of 1.2 MT per MT of waste incinerated, we find that the CO<sub>2</sub> emissions from incinerating 1335 kg of soil waste are approximately 1.602 MT. This estimates the CO<sub>2</sub> emissions from incinerating the given quantity of soil waste in an incinerator. The total CO<sub>2</sub> emissions can be calculated by summing the emissions from both sources: the incineration of 1335 kg of soil waste and the emissions from TNT. CO<sub>2</sub> emissions from TNT 0.27121 MT. Therefore, the total CO<sub>2</sub> emissions from incinerating 1335 kg of soil waste and the emissions from TNT are approximately 1.87321 metric tons.

The emission of CO was 0.141 metric tons in the incident as given in Table 1. According to a literature study, the damage cost due to CO emissions was 7.2 Hong Kong Dollars in 1997. Using appropriate econometric conversions, including purchasing power parity (PPP) and inflation rate (IR), these foreign currency values have been converted to Indian values. The resulting Indian value per tonne of emissions has been used to assess the valuation of damages. The damage cost per tonne for the year 2024 is ₹167,930.

**Table 3: Calculated damage cost (₹) for air pollution due to explosion & fire.**

Pollutant	CO <sub>2</sub>	CO
Pollutant Load (MT) (a)	1.873	0.141
Damage Value per tonne in ₹ (b)	2,940	167,930
Damage Value in ₹ (c=a*b)	5,507	23,678

## Conclusion

In conclusion, the environmental and financial repercussions of the explosion at Solar Industries India Limited's factory are substantial. The calculated penalties, liability costs due to hazardous waste release, and valuation for emissions emphasize the significant impact of such incidents and are mentioned in Table 4.

**Table 4: Calculated damage cost (₹) for different aspects**

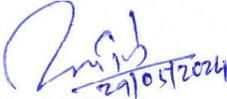
Sr. No.	Aspect	Cost (in INR)
1.	Environmental Compensation (EC)	₹ 37,500
2.	Liability Cost	₹ 50 lakhs

3.	Valuation for Emissions	₹ 29,185
	<b>TOTAL</b>	<b>₹ 5,066, 685</b>

The Environmental Compensation (EC) for Solar Industries India Limited, calculated at ₹37,500 per day, underscores the seriousness of environmental violations. Additionally, the liability cost of ₹50 lakhs for landfill breaches and hazardous waste release underscores the need for strict adherence to environmental regulations and responsible waste handling practices.

The valuation for emissions of CO<sub>2</sub> and CO amounts to ₹29,185. Furthermore, the valuation for emissions highlights the monetary value of environmental damage caused by the release of pollutants such as carbon dioxide (CO<sub>2</sub>) and Carbon monoxide (CO). The total damage cost is ₹5,066,685. It becomes evident that the pollution load resulting from such incidents carries a significant financial burden.

The high penalty costs, liability expenses, and environmental damage valuation underscore the urgency of implementing robust strategies to prevent similar disasters in the future. These strategies may include enhancing safety protocols, implementing stricter environmental regulations, investing in advanced monitoring and control systems, and promoting sustainable practices throughout the industry. By proactively addressing these issues, stakeholders can mitigate environmental risks, protect public health, and safeguard valuable ecosystems from further harm. The committee also feels that given the sensitive nature of such industries, cameras should be installed at suitable places so that cause and impact of such explosions can be recorded and necessary comprehensive impact assessment can be done, should the need arise.

  
27/06/2024  
Prof. Dilip H. Lataye  
VNIT, Nagpur

  
Prof. Bharat Bhanvase  
LITU, Nagpur

  
27/6/24  
Dr. Hemant Bherwani  
Sr. Scientist, CSIR-  
NEERI

  
27/6/24  
Dr. Arjun M Jadhav  
SRO, MPCB, Nagpur-2

Place - Nagpur

Date - 27.06.2024