Reducing Air Pollution through Smart Energy Management in Industrial Clusters of India

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ABSTRACT

Smart energy management, along with clean technologies and advanced pollution control measures has proven to be an effective strategy for reducing air pollution in both developed and transitioning economies and holds significant potential to reduce emissions from industries and power plants—two of the major sources of air pollution in many of India's urban areas.

This manuscript presents the results from a project and provides a critical proof of concept to show that developing country cities can achieve significant, measurable reductions in air pollution, Volatile Organic Compound emissions and greenhouse gas emissions through investing in smart energy management and advance control technologies. Achieving this goal, however, requires addressing two key challenges: 1) lack of a demonstrated link between smart energy management and air quality improvements in India; and 2) the need to scale up development, financing, and implementation of smart energy solutions, including energy efficiency and clean technology measures that can help address air pollution in industrialized urban areas, critically polluted areas by offsetting fossil fuel use for diesel- and coal-fired electricity generation.

INTRODUCTION

India is a fast-developing economy, with high industrial and infrastructure growth. The growing construction of buildings, roads and highways, urban transport and industrial production has led to poor air quality in many cities and industrial clusters. India needs preventive measures to address air pollution. The sectors like energy, water, construction, industry, transport, agriculture are required to use effective measures to prevent the rising air pollution.

In India, there is an urgent need to address rapidly worsening effects of air pollution—on the climate as well as on human health. The situation is serious as out of the 100 most polluted cities in the world, 29 are in India[1]. In response to reduce the worsening effects of air quality, the International Institute for Energy Conservation (IIEC) with funding support from Climate and Clean Air Coalition (CCAC) has initiated a program to build air quality monitoring and tracking capacity among government, industry, and utility partners, and to demonstrate and deliver air pollution reduction strategies in two industrial Indian states—Gujarat and Odisha—through smart management of industrial energy use. These states were selected based on a need assessment as well as the demonstrated interest and commitment of their Pollution Control Boards. The project responded to a large body of evidence that points to industrial and power plant emissions as two of the major sources of air pollution in industrial areas[2]. It also builds on an increasing number of studies demonstrating the effectiveness of smart energy management as a strategy for reducing air pollution in industrialized urban areas.

[1] https://www.numbeo.com/pollution/rankings.jsp.

[2] Jaramillo, P., and N. Muller (2016), "Air Pollution Emissions and Damages from Energy Production in the US: 2002–2011", Energy Policy, Vol. 90, pp. 202-211.

Industrial Relevance

The outcomes of the study have great relevance to the industrial sector. The smart energy management measures suggested for the power plants, steel, aluminium, and chemical industries can save between 20-40% of air pollution.

- For integrated steel plants, installation of stationary land-based pushing emission control system in new and renovated (rebuilt) batteries, installation of sinter machines with larger surface area, installation of selective waste gas recycling technology in sinter plants shall be implemented. Oxyfuel combustion technology shall be used to eliminate heat loss. The Energy pulse super imposition/micro pulse discrimination technique shall be used in Electrostatic Precipitators at sinter plant to reduce dust emission. These measures can save around 30% of emissions from integrated steel plants.
- In steel rolling mills, upgradation of technical use of biomass gas as fuel, use of heat recovery technologies, and local exhaust ventilation and installation of bag filters for capturing fugitive dust emissions can reduce SO_2 and NOx emissions by 20%.
- In aluminum smelters, about 40% reduction in particulate matter emissions can be achieved with adoption of higher efficiency dust collection system and bag filter systems.
- In captive power plants and base load thermal power plants, optimizing the ratio of coal to air input, installation of fluidized bed combustion boilers, implementation of wet flue gas desulphurization and dry flue gas desulphurization, adopting low NOx combustion burners and proper selection of fuel can reduce the emissions significantly.
- For chemical plants, the adoption of greener chemistry and replacement of organic solvent-based process technologies with water-based process technologies will be useful.
- Replacement of manual solvent loading operations with automated loading operations and providing mechanical seals for solvent handling pumps to avoid leakages and spills along with the adoption of a solvent recovery system will be better.

- Proper implementation of Volatile Organic Compounds leak detection and repair and use of surface condensers can control reactor emissions. The use of liquid scrubbers and vapor incinerators and use of after-condensers, scrubbers, and carbon adsorbers can control emissions from distillation condensers.

PROJECT JUSTIFICATION

The project was designed to help speed and scale up clean energy implementation in two states of India by enhancing the value proposition for clean energy investment—demonstrating the clear link to meeting air pollution reduction goals—and by making the clean energy more affordable through integrating energy efficiency and demand response with integration of renewable energy. By establishing a clear connection between utility and industrial energy use and air quality and showing how highly polluted cities can attract bundled private finance for clean energy solutions to help address their air pollution.

PROJECT IMPACT

The project selected Jharsuguda[3] and Ankleshwar[4] Industrial Areas in Odisha and Gujarat States respectively to design the framework for implementation of Air Quality and Smart Energy Management (AQ-SEMP). The project addressed two key barriers to the adoption of energy

[3] Climate and Clean Air Coalition (CCAC) (2021): "Report on Reducing Air Pollution in India's Industrial Clusters through Smart Energy Management – A Case of Odisha State". https://www.ccacoalition.org/en/resources/reducing-air-pollution-indias-industrial-cluster-through-smart-energy-management-odisha.

[4] Climate and Clean Air Coalition (CCAC) (2021): "Report on Reducing Air Pollution in India's Industrial Clusters through Smart Energy Management – A Case of Gujarat State". https://www.ccacoalition.org/en/resources/reducing-air-pollution-indias-industrial-cluster-through-smart-energy-management-gujarat.

management as a solution to the deteriorating air quality in industrial areas[5]:

1. Lack of a demonstrated link between smart energy management and air quality improvement; and
2. The difficulty of financing smart energy solutions, that could help address air pollution in industrialized urban areas.

The project established a clear connection between industrial energy use and air quality and showing how highly polluted areas can address air pollution through adoption of energy efficiency measures and through deploying clean energy solutions.

METHODOLOGY

The project focused on improving understanding among government, industrial, and utility partners of the linkages between air quality and utility/industrial energy management, demonstrating the potential for reducing air pollution levels to achieve multiple health-related and economic benefits through smart management of industrial energy use and developing a methodology for clean energy solutions. To demonstrate

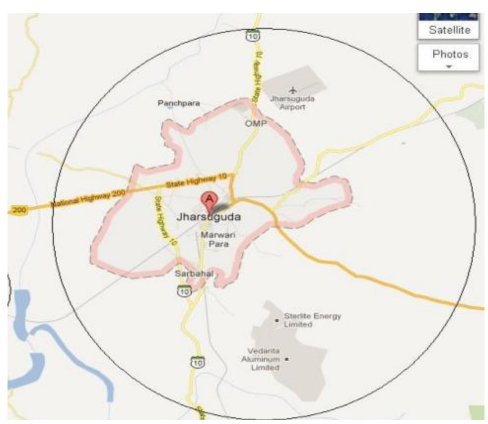

Figure 1: Study Area in Jharsuguda, Odisha

[5] Environment International Journal (2018): "The Impact on Air Quality of Energy Saving Measures in the Major Cities – Signatories of the Covenant of Mayors initiative: *Fabio Monforti-Ferrario, Albana Kona, Emanuela Peduzzi, Denise Pernigotti, Enrico Pisoni European Commission, Joint Research Centre.*

the AQ-SEMP Framework, the following methodology has been adopted. The case of Jharsuguda, Odisha is being discussed here.

- **Step 1: Defining the Study Area:** The study area in Jharsuguda covers an area of 1961 sq. km. (25 km radius of study area) (Figure 1). The area falls under "Northwestern highland" agro-climatic zone having hot and moist sub-humid environmental conditions (Figure 2). The area experiences extremely high temperatures and moderate humidity conditions during summer conditions and low temperature and normal humidity conditions during winter season. Moderate to high wind speeds in the region enable effective dispersion of pollutants during summer season and due to lower mixing heights, the ventilation coefficient during winter season is generally lower than that of other seasons.

- **Step 2: Review of Published Baseline Air Quality in the Study Area –** As a part of the study, published secondary air quality data has been collected from online ambient air quality stations installed by Odisha State Pollution Control Board (OSPCB) at the Brajrajnagar location, and from published EIA reports at following locations such as Lapanga, Bomaloi, Gumkarama, Sripura, Brundamal, Tarikela and Thelkoloi villages. Continuous air quality monitoring data of PM_{10}, $PM_{2.5}$, SO_2 and NO_2 levels are considered for the study.

- **Step 3: Developing Emission Inventories**: An attempt was made to develop baseline emission inventory for all the large to medium scale industrial facilities in the study area[6]. The continuous emission monitoring data available with Odisha State Pollution Control Board

[6] Amann, M., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Höglund-Isaksson, L., Klimont, Z., Nguyen, B., Posch, M., Rafaj, P., Sandler, R., Schöpp, W., Wagner, F., Winiwarter, W., 2011. "Cost-Effective Control of Air Quality and Greenhouse Gases in Europe: Modeling and Policy Applications". Environ. Model. Softw. 26, 1489–1501. http://dx.doi.org/10.1016/j.envsoft.2011.07.012

(OSPCB) and published emission factors data for respective industrial clusters was used for the analysis. Various industries such as integrated steel plants, aluminum smelter, steel re-rolling mills, sponge iron units, thermal power plants and captive power plants are covered under this emission inventory study [7]. The energy conservation measures (ENCON) are proposed for these industries. While the industries are required to meet emission standards for particulate matter, these emissions are less significant compared with SO_2 and NOx. Although thermal power plants are required to meet the new thermal power plant emission norms notified by the Ministry of Environment, Forests & Climate Change under Environment Protection Act 1986 in 2015, all the Captive Power Plants and power plants in the study area are in the process of implementing the SO_2 and NO_X control technologies as per the directions of Central Pollution Control Board (CPCB) and OSPCB. It is assumed that respective industries are meeting the industry specific emission norms issued by CPCB/OSPCB as per the consent conditions. Details of the emission inventory in the study area is discussed in the subsequent sections of this report.

- **Step 4: Predicting Ground Level Concentrations (GLCs) for the Baseline Emission Scenario Case**: To establish the possible GLCs due to release of emissions from current industries, the baseline emission inventory data is adopted[8]. The modelled GLCs are plotted as isopleths to establish the spread and distribution of possible GLC in the study area. The 2^{nd} height GLC's as provided in Table-1 represent the worst-case emission release scenario in the study. Since all the stacks in the study area are like floating clouds, unstable conditions (Stability Class A and B as per Pasqual classification) represent the worst-case

[7] Ministry of Environment, Forest, and Climate Change (MOEF&CC), Government of India Order No. 22-24/2018-IA.III (2019): "Exemption of Environment Clearance for Thermal Power Plant using Waste Heat recovery Boilers (WHRB) without any Auxiliary Fuel etc."
[8] Government of India: Ministry of Environment and Forests (2014), "National Air Quality Index Launched by the Environment Minister: AQI is a huge initiative under 'Swachh Bharat', Press release". www.pib.nic.in/newsite/PrintRelease.aspx?relid=110654

meteorological scenario. Since highest mixing heights with maximum number of unstable meteorological conditions will be experienced in hot and dry climatic conditions, summer season has been considered as a worst-case scenario for air quality modelling.

- **Step 5: Evaluating the Reduction of Emissions due to Proposed Energy Conservation (ENCON) Measures**: Based on the discussion with technical experts revised inventory levels in the study area has been estimated to depict the reduced emission levels due to proposed ENCON measures and cleaner production opportunities. These inputs formed the basis for predicting the post project GLCs.
- **Step 6: Predicting Post ENCON GLCs in the Study Area and Evaluating the Benefits:** The revised estimated emission inventories are adopted to model the GLC to depict the possible reduction in the pollutant GLCs in the study area. Based on the results, an attempt was made to assess the possible benefits due to reduced ambient air pollutant concentration in the study area.

The flow diagram of the model depicting the methodology is presented in Figure-3.

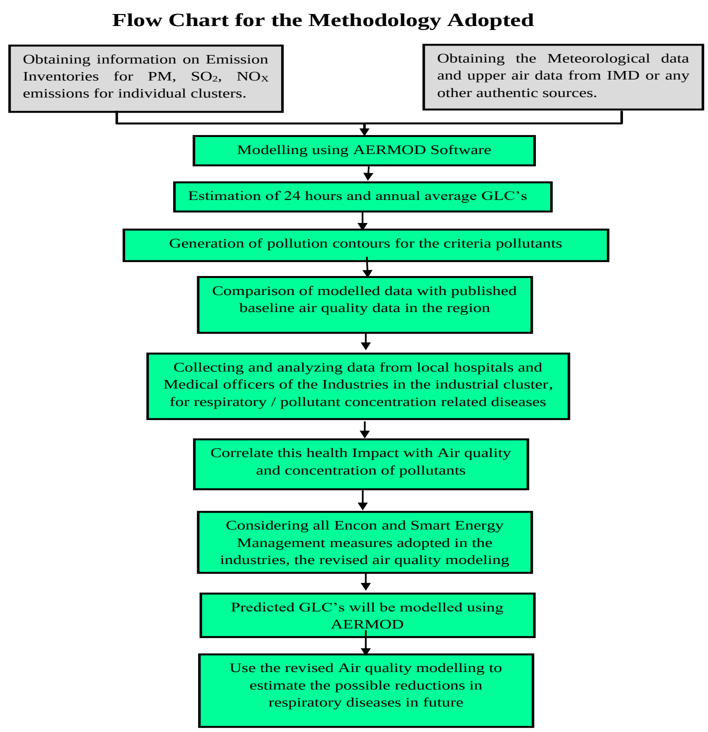

Figure 2: AQ-SEMP Framework Model and Methodology

RESULTS

Based on the envisaged reduced emission loads, the air quality modelling exercise was undertaken to compare the GLC's of $PM_{2.5}$, PM_{10}, NOx and SO_2 due to reduced emission levels as against the uncontrolled emission scenario in Jharsuguda Industrial Area. The summary of model results before and after implementation of ENCON measures and clean technology options are presented in Table 1.

Table 1: Predicted GLC for Baseline Emission Scenario V/S Post ENCON Scenario

Pollutant	Uncontrolled Emission Scenario		Post ENCON Scenario		Maximum Reported Baseline Air Quality Data ($\mu g/m^3$)[9]
	Pollutant load (t/h)	2nd Height Predicted 24Hrs Avg GLC ($\mu g/m^3$)	Revised pollutant load (t/h)	2nd Height Predicted 24 h Avg GLC ($\mu g/m^3$)	
SO_2	50.3	254	4.4	20.2	24
NOx	24.5	123	4.3	26.9	31
PM_{10}	6.1	22.9	2.7	14.1	81.4

Predicted GLC of SO_2: Predicted 2nd height GLC is reported to be in the order of 20.2 $\mu g/m^3$ as against the uncontrolled emission scenario of 254 $\mu g/m^3$. A significant reduction in GLCs can be achieved due to implementing various ENCON measures and clean technology options in thermal power plants, integrated iron and steel plants, aluminium smelters, and steel rolling industries. The predicted SO_2 concentrations were compared with that of the authentic published data and presented in Table 2.

Predicted GLC of NOx: Predicted 2nd height GLC is reported to be in the order of 26.9 $\mu g/m^3$ as against the uncontrolled emission scenario of 123 $\mu g/m^3$. A significant reduction in GLCs can be achieved due to implementing various ENCON measures and clean technology options. The predicted NOx concentrations were compared with that of the authentic published data and presented in Table 3.

Predicted GLCs of PM: Predicted 2nd height GLC is reported to be in the order of 14.1 $\mu g/m^3$ as against the uncontrolled emission scenario of 22.9 $\mu g/m^3$. The predicted GLC's is compared with reported baseline concentration which is presented in below Table 4.

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[9] Odisha State Pollution Control Board (OSPCB) data, 2018-19.

Table 2: Predicted GLCs of SO_2 – Post ENCON Measures and Clean Technology Options

Location	Coordinates	Predicted concentration of SO2 (µg/m3)		Published Baseline Concentration of SO2 (µg/m3)[10]
		Uncontrolled Emission Scenario	Post ENCON Scenario	
Brajrajnagar	182079.74 m E 2416375.25 m N	62.3	2.3	7.2
Lapanga Village	191233.77 m E 2405217.10 m N	52.6	2.0	8.2
Bomaloi Village	192953.47 m E 2402128.17 m N	43.4	1.6	8.0
Gumkarama Village	195297.80 m E 2408625.96 m N	67.1	2.9	8.5
Sripura Village	193955.96 m E 2410889.85 m N	74.4	3.9	8.0
Brundamal village	192154.54 m E 2414605.36 m N	248.7	6.2	8.0
Tarikela village	189041.00 m E 2410328.63 m N	72.8	3.1	7.5
Thelkoloi village	190844.32 m E 409845.99 m N	78.6	3.6	8.2

[10] Odisha State Pollution Control Board (OSPCB) data, 2018-19.

Table 3: Predicted GLCs of NO_x– Post ENCON Measures and Clean Technology Options

Location	Coordinates	Predicted concentration of NOx (µg/m³)		Published baseline concentration of NOx (µg/m³)[11]
		Uncontrolled Scenario	Reduction on emission scenario	
Brajrajnagar	182079.74 m E 2416375.25 m N	35.7	2.3	24.1
Lapanga Village	191233.77 m E 2405217.10 m N	24.8	2.0	29.8
Bomaloi Village	192953.47 m E 2402128.17 m N	23.1	1.8	29.1
Gumkarama Village	195297.80 m E 2408625.96 m N	34.9	2.7	25.2
Sripura Village	193955.96 m E 2410889.85 m N	38.4	3.4	28.8
Brundamal village	192154.54 m E 2414605.36	122.5	4.4	26.3

[11] Odisha State Pollution Control Board (OSPCB) data, 2018-19.

	m N			
Tarikela village	189041.00 m E 2410328.63 m N	41.7	3.1	24.9
Thelkoloi village	190844.32 m E 2409845.99 m N	44.5	3.3	29.8

Table 4: Predicted GLCs of PM. – Post ENCON Measures and Clean Technology Option

Location	Coordinates	Predicted Concentration of PM (μg/m³)		Published Baseline Concentration of PM (μg/m³)[12]
		Uncontrolled Scenario	Reduction Emission Scenario	
Brajrajnagar	182079.74 m E 2416375.25 m N	3.1	1.4	141
Lapanga Village	191233.77 m E 2405217.10 m N	2.4	1.5	86.6
Bomaloi Village	192953.47 m E 2402128.17 m N	2.0	0.8	81.7
Gumkarama Village	195297.80 m E 2408625.96 m N	3.6	1.8	80.4

[12] Odisha State Pollution Control Board (OSPCB) data, 2018-19.

Sripura Village	193955.96 m E 2410889.85 m N	4.5	2.0	84
Brundamal village	192154.54 m E 2414605.36 m N	6.5	3.5	83.4
Tarikela village	189041.00 m E 2410328.63 m N	4.7	2.2	75.4
Thelkoloi village	190844.32 m E 2409845.99 m N	4.6	2.7	78.8

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