SMALL AND MEDIUM ENTERPRISES: ENERGY EFFICIENCY KNOWLEDGE SHARING

VOLUME 14 | ISSUE 3 | SEPTEMBER 2023

# SAMEEEKSHA NEWSLETTER

www.sameeeksha.org

## Inside...

- Taking forward decarbonization of the secondary steel industry
- Deep dive studies on steel rerolling industries in Raipur cluster
- Profile of sponge iron/DRI industries in Raipur secondary steel cluster

Promoting Energy Efficiency in SMEs

SAMEEEKSHA

### VISION

SAMEEEKSHA envisages a robust and competitive SME sector built on strong foundations of knowledge and capabilities in the development, application, and promotion of energy-efficient and environment-friendly technologies.

Bureau of Energy Efficiency

SHAKTI SUSTAINABLE ENERGY FOUNDATION

teri THE ENERGY AND RESOURCES INSTITUTE Creating Innovative Solutions for a Sustainable Future

MSME

SED FUND

A PLATFORM FOR PROMOTING ENERGY EFFICIENCY IN SMEs

## IN THIS ISSUE. . .

This issue retains focus on the continuing efforts to achieve decarbonization of Indian industry, particularly in the 'hard-to-abate' industrial sectors such as cement, iron & steel, etc.  In order to bring about successful energy transition away from fossil fuels in these sectors, huge investments are required for research, development, demonstration and dissemination of new/innovative low carbon technologies (LCTs), backed by enabling policy and regulatory frameworks, innovative financing mechanisms and business models for technology delivery, and strengthening of awareness and technical capacities among stakeholders at all levels.

The theme article outlines a project supported by the Stichting SED Fund under which TERI is engaged in studies and actions aimed at the progressive decarbonization of the steel and cement sectors.  In the steel sector, apart from large plants the project also focuses on MSMEs, which make up a significant proportion of secondary steel producers in sub-sectors such as steel rerolling (SRR), direct reduced iron (DRI), electric arc furnace (EAF) and electric induction furnace (IF).  The project focuses on identifying and accelerating the adoption of energy-efficient technologies (EETs) and renewable energy (RE) options, best operating practices (BOP), electrification of fossil fuel-based processes, and promoting circularity in resource usage.  The project is also developing near/zero emission roadmaps and policy briefs for the cement and steel industries. As a part of this project, TERI is supporting efforts to spur the development, demonstration and adoption of 'deep decarbonization' options such as green hydrogen-based steelmaking; carbon capture, use, and storage (CCUS); and other innovative technological solutions.

The second article in this issue summarizes the results of deep-dive studies conducted on 10 secondary steel MSMEs in the Raipur secondary steel cluster. The last article summarizes the key findings of a study conducted on DRI industries in the Raipur cluster.

*SAMEEEKSHA Secretariat*

# TAKING FORWARD DECARBONIZATION OF THE SECONDARY STEEL INDUSTRY

## Backdrop

India continues to sharpen its focus on industrial decarbonization, as it addresses the twin challenges of remaining on the path of steady socio-economic development while reducing carbon emissions through large-scale transition away from fossil fuels towards low or zero-carbon energy. As explained in earlier issues,[1] the barriers to decarbonization are particularly difficult to overcome in the 'hard-to-abate' industrial sectors like cement, chemicals, iron & steel, etc., which on the one hand constitute the very foundations of economic development but on the other account for a significant share of overall energy consumption and carbon emissions. For instance, the steel and cement sectors together account for 38% of India's industrial energy consumption and 40% of the industry's $CO_2$ emissions.

In order to bring about successful energy transition in these hard-to-abate sectors, huge investments are required for research, development, demonstration and dissemination of new/innovative low carbon technologies (LCTs); and these investments must be backed by enabling policy and regulatory frameworks, innovative financing mechanisms and business models for technology delivery, and strengthening of awareness and technical capacities on the LCTs among industry stakeholders at all levels.

## The project

Towards achieving these aims, the Stichting SED Fund is supporting TERI in a project aimed at the progressive decarbonization of the steel and cement sectors in India. In the steel sector, apart from large plants the project also focuses on MSMEs, which make up a significant proportion of secondary steel producers in sub-sectors such as steel rerolling (SRR), direct reduced iron (DRI, also known as sponge iron), electric arc furnace (EAF) and electric induction furnace (IF).[2]

These secondary steel producers face the same closely linked challenges that make it difficult to introduce and scale up LCTs throughout the Indian MSME sector: primarily, their continuing dependence on obsolete, low-efficiency technologies; low awareness levels regarding improved technologies and best operating practices (BOP); difficulties in accessing adequate, affordable and timely finance for upgrading technology even when LCT options are available off-the-shelf (which is usually not the case); inability to access clean fuels at affordable costs; and lack of avenues to upgrade the skills of operators, other plant personnel, and local service providers on the new/improved technologies.

The project is finding solutions to these challenges through studies and actions in the broad and overlapping domains of technology, policy, and finance.

**Steel rerolling mill in Raipur cluster**

The focus is on accelerating the adoption of proven, commercially available energy-efficient technologies (EETs), BOP, electrification of fossil fuel-based processes, promotion of renewable energy (RE) options wherever feasible, and improving resource efficiencies and reducing waste (i.e. promoting circularity). Collaborations and knowledge exchange are being further strengthened with government agencies, financial institutions, industrial associations and other stakeholders. The project is also developing near/zero emission roadmaps and policy briefs for the cement and steel industries. As a part of this project, TERI is supporting efforts to spur the development, demonstration and adoption of 'deep decarbonization' options such as green hydrogen-based steelmaking; carbon capture, use, and storage (CCUS); and other innovative technological solutions.

All in all, the SED Fund project is effectively building upon and taking forward the earlier activities by

---

1 SAMEEEKSHA issues 13(2), June 2022 and 14(1), March 2023

2 There are an estimated 8259 operational MSMEs in these six secondary steel sub-sectors, accounting for energy consumption of about 11.8 million tonnes of oil equivalent (Mtoe) and emissions of 58.2 million tonnes $CO_2$ annually. [SAMEEEKSHA 14(1), March 2023)]

**Green steel**

The Government of India launched the National Green Hydrogen Mission in January 2023 as a key strategy towards the goal of making India a net-zero economy by 2070. In parallel, the Ministry of Steel (MOST) has set up 13 Task Forces to drive the development and adoption of low/zero-carbon steelmaking technologies and practices in India. The task forces focus on: (1) developing taxonomy on green steel; (2) monitoring $CO_2$ emissions; (3) generation of demand for green steel; (4) energy efficiency; (5) renewable energy; (6) materials efficiency; (7) green hydrogen; (8) CCUS; (9) process transition; (10) research, development and demonstration (RD&D); (11) finance; (12) international focus; and (13) skill development. TERI plays the role of 'Knowledge Partner' on 6 Task Forces, and is also a 'Member' of the remaining 7 Task Forces.

[Details are available at https://www.psuconnect.in/news/steel-ministry-formed-task-forces-to-drive-production/37079/]

TERI related to decarbonizing the steel sector. The project also fits well with other ongoing initiatives of the Government of India in this field: notably, by the Ministry of Steel, Government of India (MOST) to spur the development and adoption of sustainable, low or zero-emission technologies and practices (i.e. LCTs) for manufacturing 'green' steel, in which TERI is playing a central role (see Box); and the schemes by the Bureau of Energy Efficiency (BEE), Ministry of Power (MoP).

Under the SED project, TERI is conducting in-depth studies in a number of secondary steel clusters with the focus on identifying EE and RE options offering attractive payback periods on investments, which will be promoted for adoption. The next article in this issue summarizes the results of deep-dive studies conducted on 10 secondary steel MSMEs in the Raipur secondary steel cluster. A few other current or proposed initiatives with which the project is synergizing are outlined below.

**Wire-drawing unit in Raipur cluster**

### *Feasibility study for a pilot green hydrogen-based DRI plant*

India's steel sector is unique, in that the major portion of crude steel production (55%) comes from industries using EAF and/or IF, for which the primary raw material is DRI. About 80% of India's total DRI is produced by DRI plants using coal-based processes; and hence, there is significant scope to decarbonize the overall steel sector by developing and deploying innovative, low/zero-carbon technologies for DRI production. As a step in this direction, TERI in collaboration with Global Efficiency Intelligence LLC is developing a proposal to conduct a site-specific feasibility study for setting up a pilot, commercial-scale DRI plant that will use green hydrogen.

### *Roadmap for industrial decarbonization in India*

Under a project supported by BEE and the World Bank, TERI in partnership with IDRIC (U.K.) and Rocky Mountain Institute (USA) is leading a consortium of expert organizations in drawing up a roadmap titled 'India industrial decarbonization roadmap to 2070'. This roadmap will help provide technological solutions, enabling policy and regulatory frameworks, business models, financing, and support for research, development and demonstration (RD&D) to help Indian industries slash emissions and achieve net zero by 2070. The six emissions-intensive industrial sectors that are being analysed are iron & steel, cement, aluminium, pulp & paper, chemicals, and fertilisers. The sectoral profiles of the six sectors and relevant technology roadmaps are currently under preparation.

### *Study on beneficiation and pellet manufacturing industry*

Iron ore is the main raw material used in the production of iron and steel. The iron ore is purified by removing extraneous matter (a process known as 'beneficiation') and then processed into different forms like finely ground powder, lumps (nuggets), or spherical balls known as 'pellets' for use by steelmaking plants. At the request of the Pellet Manufacturing Association of India (PMAI), TERI will shortly commence a study on various aspects of the pellet manufacturing industry in India. The aim is to study the options available for reducing the emissions from pellet manufacturing and assess the energy, environmental, quality, and resource benefits of using pellets rather than other forms of iron ore like powder, nuggets, etc.

# DEEP DIVE STUDIES ON STEEL REROLLING INDUSTRIES IN RAIPUR CLUSTER

Under the SED project, TERI conducted deep-dive studies on 10 steel rerolling mills (SRRMs) in the Raipur secondary steel cluster—one of the largest such clusters in India.[1] There are 316 individual secondary steel industrial units currently operating in the Raipur cluster, in the broad categories of DRI (sponge iron), electric induction furnace (EIF), steel rerolling mills (SRRMs), ferro-alloy, wire drawing (WI), and others including foundry and forging. Coal and electricity are the main sources of energy. The cluster-level annual energy consumption is 3.65 million tonnes of oil equivalent (Mtoe), with DRI accounting for the largest share (3.0 Mtoe or 82%) followed by SRRMs (0.2 Mtoe or 5.5%).

The deep-dive studies aimed at identifying energy efficiency (EE) and renewable energy (RE) options for the SRRMs, thereby laying the groundwork for implementing and scaling up these options among all SRRMs in the cluster. The 10 SRRMs covered by the study produce around 240,000 tonnes of structured steel products each year, consuming 24,900 tonnes of coal and 32,300 MWh of electrical power in the process. This is equivalent to annual energy consumption of nearly 15,900 tonnes of oil equivalent (toe), of which coal accounts for about 13,040 toe (82%) and electricity the remaining 2860 toe (18%). The total annual emissions are about 72,000 $tCO_2$ (table 1).

[1] See SAMEEEKSHA 13(2), June 2022 for an overview of the Raipur secondary steel cluster.

Inside steel rerolling mill

**Table 1.** Profile of 10 SRRMs studied

| SRRM No. | Products | Annual rolled production (t/y) | Energy consumption (toe/y) | Emissions ($tCO_2/y$) |
|---|---|---|---|---|
| 1 | TMT bars | 13200 | 791 | 3290 |
| 2 | Hot rolled strips | 31680 | 2469 | 10999 |
| 3 | Angles, channels, rounds | 24900 | 1400 | 6100 |
| 4 | Binding wire | 5069 | 252 | 2077 |
| 5 | Angles, channels | 4469 | 360 | 1585 |
| 6 | TMT bars | 92400 | 5527 | 24670 |
| 7 | Strips, pipes | 33060 | 2563 | 12388 |
| 8 | TMT bars | 19200 | 1414 | 6350 |
| 9 | Round bars | 11250 | 763 | 3145 |
| 10 | Flats, squares, round bars | 5000 | 325 | 1422 |
| | **Total** | **240228** | **15864** | **72026** |

Detailed energy audits (DEAs) were conducted in each of the 10 SRRMs, involving intensive observations, measurements and analyses of different energy-consuming equipment/systems and processes accompanied by discussions with plant personnel from management to shop-floor levels. Based on these studies, a number of energy conservation measures (ECMs) were identified for each SRRM that offer significant energy and cost savings as well as emissions reductions, with attractive simple payback period (SPP) on investments. A few of these ECMs are implementable by several of the SRRMs studied, as summarized in the next section.

## Energy conservation measures

*Energy efficiency*

**Install recuperator in reheating furnace; improve insulation**

The SRRMs use coal-fired reheating furnaces to heat steel billets/ingots prior to rolling. It was found that in most of these furnaces, hot flue gases were carrying away significant amounts of useful heat in the absence of suitable waste heat recovery systems (i.e. recuperators). The studies recommend (1) installation of compatible recuperators in the reheating furnace for recovery and reuse of waste heat from the flue gases; and (2) insulation of combustion air pipelines to reduce heat losses. This ECM is implementable by eight of the 10 SRRMs studied (table 2). The payback period on investment ranges between 6–18 months.

**Table 2.** Install recuperator in reheating furnace; improve pipeline insulation

| SRRM no. | Annual coal saving (t) | Annual cost saving (Rs lakh/y) | Investment (Rs in lakhs) | SPP@ (y) |
|---|---|---|---|---|
| 1 | 110 | 11.0 | 15.0 | 1.4 |
| 2 | 294 | 29.3 | 23.0 | 0.8 |
| 3 | 87 | 12.2 | 17.0 | 1.4 |
| 5 | 53 | 5.3 | 7.0 | 1.3 |
| 6 | 642 | 96.3 | 46.0 | 0.5 |
| 8 | 124 | 19.9 | 21.0 | 1.1 |
| 9 | 87 | 14.0 | 21.0 | 1.5 |
| 10 | 46 | 7.4 | 8.0 | 1.1 |
| **Total** | **1443** | **195.4** | **158.0** | **0.8** |

@ SPP—simple payback period

**Automation of reheating furnace**

Automation of the reheating furnace (by installation of swirl burner, online FGA, VFD for fans, and PLC instrumentation) will bring significant EE improvements. This ECM is implementable by seven of the 10 SRRMs studied (table 3). The average payback period on investment is just over a year.

**Recuperator for waste heat recovery and reuse**

**Reheating furnace**

**Table 3.** Automation of reheating furnace

| SRRM no. | Annual coal saving (t) | Annual cost saving (Rs lakh/y) | Investment (Rs lakh) | SPP (y) |
|---|---|---|---|---|
| 1 | 72 | 7.2 | 15.0 | 2.0 |
| 2 | 209 | 20.9 | 20.0 | 1.0 |
| 3 | 120 | 16.8 | 25.0 | 1.5 |
| 6 | 416 | 62.4 | 48.0 | 0.8 |
| 7 | 174 | 26.0 | 20.0 | 0.8 |
| 8 | 106 | 16.9 | 20.0 | 1.2 |
| 9 | 63 | 10.0 | 20.0 | 2.0 |
| **Total** | **1160** | **160.2** | **168.0** | **1.1** |

*Installation of power factor correction system*

The installation of an automatic power factor control (APFC) panel will improve the power factor and lower the demand charge, thereby reducing the electricity bill. Improvement of power factor also helps in avoiding penalty that may be otherwise levied by the electricity utility. This ECM is implementable in six of the SRRMs studied (table 4). The average payback period on investment is barely five months.

**Table 4.** Installation of power factor correction system

| SRRM no. | Annual cost saving (Rs lakh /y) | Investment (Rs lakh) | SPP (y) |
|---|---|---|---|
| 1 | 1.1 | 1.8 | 1.7 |
| 2 | 6.5 | 4.1 | 0.6 |
| 3 | 4.9 | 3.0 | 0.6 |
| 4 | 4.7 | 0.8 | 0.2 |
| 5 | 3.7 | 2.0 | 0.6 |
| 7 | 36.0 | 10.0 | 0.3 |
| **Total** | **56.9** | **21.7** | **0.4** |

*Other EE options*

The other unit-specific EE options identified by the studies include the following:

- Using EE water pumps in rolling mill cooling system
- Replacing the existing low-efficiency combustion air blower with a new EE blower system
- Relining insulation at the heating and soaking zones of reheating furnaces

Rolling section

- Replacing the existing inefficient air compressor with a new EE air compressor
- Installing VFD in air compressor
- Arresting leakages in compressed air network
- Installing limit switch to eliminate idle operation of conveyor motors
- Installing online flue gas analyser in reheating furnace
- Revising contract demand and installing demand controller to reduce electricity bill and avoid penalties

Water pumping system in SRRM

*Renewable energy*

The studies found that there is significant potential for the SRRMs to install rooftop solar photovoltaic (SPV) systems to generate captive power and thereby reduce their grid electricity consumption and costs. Of the 10 SRRMs studied, one unit has already installed a ground-mounted SPV system with installed capacity of 400 kW. Table 5 summarizes the SPV systems recommended for implementation by the remaining nine SRRMs. The average payback period on investments is 3.5 years.

**Table 5**. Installation of rooftop solar PV systems

| SRRM no. | SPV system capacity (kWp) | RE generation potential (kWh) | Annual cost saving (Rs lakh /y) | Investment (Rs lakh) | SPP@ (y) |
|---|---|---|---|---|---|
| 2 | 160 | 240000 | 20.6 | 68.5 | 3.3 |
| 3 | 60 | 90000 | 9.2 | 25.7 | 2.8 |
| 4 | 160 | 168750 | 13.0 | 72.0 | 5.5 |
| 5 | 50 | 75000 | 7.5 | 21.4 | 2.9 |
| 6 | 125 | 187500 | 12.4 | 53.5 | 4.3 |
| 7 | 160 | 234000 | 22.4 | 66.1 | 3.0 |
| 8 | 40 | 60000 | 5.4 | 18.0 | 3.3 |
| 9 | 60 | 90000 | 8.7 | 25.7 | 3.0 |
| 10 | 60 | 67500 | 6.4 | 19.3 | 3.0 |
| **Total** | | **1212750** | **105.6** | **370.2** | **3.5** |

Ground-mounted solar PV system already installed at one SRRM unit

## Looking ahead

TERI is currently providing technical assistance to the 10 SRRMs for implementing the recommended ECMs. Implementation of all the ECMs will result in the following benefits:

- Annual coal consumption will be reduced by 2768 tonnes from the present level of 24,900 tonnes (i.e. by about 11%)
- Annual electricity consumption will be reduced by about 1102 MWh from the present level of 32,300 MWh (i.e. by about 3%) through implementation of EE options. In addition, implementation of the RE measures (SPV systems) will reduce consumption of grid power by another 1212 MWh (about 4%).
- The EE measures will reduce $CO_2$ emissions by 6371 tonnes annually (i.e. by about 9%). In addition, the SPV systems will help avoid another 886 tonnes of $CO_2$ emissions annually (about 1%).

# PROFILE OF SPONGE IRON/DRI INDUSTRIES IN RAIPUR SECONDARY STEEL CLUSTER

Under the SED project, TERI conducted an in-depth study of sponge iron/DRI industries in the Raipur secondary steel cluster. There are 45 DRI industries currently operating in the cluster, of which 20 plants are of capacity less than 250 tpd and the remaining 25 are large plants having capacity more than 250 tpd. The total annual sponge iron production is about 5.34 million tonnes per year (Mt/y), of which large-scale plants account for about 80% (4.26 Mtoe) and small & medium plants the remaining 20% (1.08) Mtoe (table 1).

Table 1. Profile of DRI industries in Raipur cluster

| Category | No. of plants | Capacity (tpd) | Production (Mt/y) |
|---|---|---|---|
| Small | 10 | <200 | 0.26 |
| Medium | 10 | 200–250 | 0.82 |
| Large | 25 | >250 | 4.26 |
| **Total** | **45** | | **5.34** |

## Technology and energy use

Sponge iron is manufactured by the reduction of iron ore in solid state at a temperature below the melting point of iron. The reduction process is carried out in a horizontal rotary kiln, which uses coal for thermal energy requirements as well as for the reduction reactions that transform the iron ore into sponge iron. The charge materials—comprising crushed iron ore and coal—are supplied to the kiln from its feed end, while pulverized coal is injected into the kiln from the discharge end. The temperature of the kiln is maintained at 900–1050 °C. As the charge moves through the kiln from the pre-heating zone to the reduction zone, the carbon in the charge and from the injected coal combines with the oxygen in the iron ore to form carbon monoxide gas, leaving metallic iron in the form of a honeycomb structure that gives sponge iron its name. The mixture of sponge iron and residual charge from the kiln is transferred by belt conveyor to a rotary cooling system, where it is cooled down to about 100 °C. Thereafter, the sponge iron is separated from other materials by an electromagnetic (EM) separator, and screened to yield the final product in the form of lumps and fines.

The main process equipment used in a DRI plant is the coal-fired horizontal rotary kiln. Other process equipment and machinery include electrical crushers, blowers, belt conveyors, rotary coolers, EM separators, and screening systems.


**Horizontal rotary kilns in DRI plant**

The total annual energy consumption in the Raipur DRI cluster is estimated at 3 million tonnes of oil equivalent (Mtoe), of which thermal energy from coal accounts for 95–98% (2.82 Mtoe) and electricity the remaining 0.18 Mtoe. The corresponding annual emissions are about 13.3 Mt CO2.

## Energy saving options

A few of the energy saving options identified under the study are summarized below.

### *Waste heat recovery*

The study revealed that over 60% of input energy in the rotary kiln is lost as waste heat, of which off-gas losses alone account for over 40%. Hence, there is significant potential for energy saving through the installation of a suitable waste heat recovery (WHR) system. The recovered heat can be used for:

View of DRI plant

- power generation, using a WHR boiler connected to a turbo-generator system.
- pre-heating of input iron ore to about 650 °C, thereby reducing coal consumption and overall energy costs.

### *Coal gasifier system*

The overall efficiency of the rotary kiln can be improved by installing a coal gasifier system to convert the coal injected at the discharge end to producer gas (a flammable mixture consisting mainly of carbon monoxide and hydrogen). Apart from energy savings, the benefits of this measure include:

- Better control and monitoring of kiln operating parameters
- Increased kiln capacity (by 20%)
- Increased metallization, and hence better recovery of metal
- Longer campaign life of kiln

### *Switchover to iron ore pellets*

DRI plants use iron ore in the form of 5–10 mm lumps, known as calibrated lump ore (CLO). In order to increase the yield of iron metal, the iron ore can be used in the form of uniform-sized pellets (less than 0.074 mm). Other advantages of using pellets instead of CLO are:

- No loss on ignition, resulting in better yield
- Uniform metallization
- Reduces thermal load for reduction reactions
- Less 'fines' generation
- Reduced slag quantity (and related handling requirements)
- Eliminates the need for magnetic separators

## ABOUT **SAMEEEKSHA**

SAMEEEKSHA is a collaborative platform aimed at pooling the knowledge and synergizing the efforts of various organizations and institutions—Indian and international, public and private—that are working towards the common goal of facilitating the development of the Small and Medium Enterprise (SME) sector in India, through the promotion and adoption of clean, energy-efficient technologies and practices.

SAMEEEKSHA provides a unique forum where industry may interface with funding agencies, research and development (R&D) institutions, technology development specialists, government bodies, training institutes, and academia to facilitate this process.

**For more details, please contact**

**Secretary – SAMEEEKSHA**
Industrial Energy Efficiency Division
TERI, Darbari Seth Block
IHC Complex, Lodhi Road,
New Delhi - 110 003, India
Tel: (+91 11) 2468 2100
Fax: (+91 11) 2468 2144, 2468 2145
Email: sameeeksha@teri.res.in
Website: http://sameeeksha.org