सत्यमेव जयते

Ministry of Power
Government of India

Improving Energy Efficiency in

Iron & Steel Sector

(Achievements and Way Forward)

Perform Achieve & Trade

September 2018

BUREAU OF ENERGY EFFICIENCY

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Iron and Steel has become an essential part of our daily lives ever since its discovery and invention. India is third largest steel manufacturer in the world, which is expected to step up to second in near future. The sector contributes to 2% of the country's GDP. It has been identified as one of the most energy intensive sector. The complex process along with several utilities paves way for tremendous energy efficiency potential in the sector. The sector in spread across large to medium to small scale industries. The efficiency in some plants are at par with the world's best plants. However, a good number of plants still have significant reduction potential.

Germany has been playing a very active role in promoting energy efficiency in not only its own land, but also supporting the other countries to adopt the same. Germany has been supporting India in various fields since last 60 years, with an aim of promoting cooperation and involving public-private sectors of both sides in the areas of energy, environment and sustainable economic development. The Indo-German Energy Programme (IGEN), works as a partner of Bureau of Energy Efficiency (BEE) in supporting policies and programmes envisaged under the Energy Conservation Act, 2001.

It has been a privilege to work with BEE, the organization spearheading activities on energy efficiency in India. IGEN has been involved with BEE in the Perform Achieve and Trade since its inception, and hence it is blissful to know that the outcome of this scheme led to a huge savings in terms of CO_2 emission reduction and coal.

However, the real outcome of PAT scheme is not only the savings in terms of toe and CO¬2, but it is the change in behavior towards energy efficiency. It is astonishing to see the amount of resources and concepts the industries have put together in achieving the target. Some state-of-the-art projects implemented in PAT cycle-I are cross cutting and could have significant potential across the sectors. Some of the positive outcomes of this scheme were the utilization of waste heat in generation of steam and power, adoption of cogeneration, use of alternate fuel and raw material, etc. This report analyses the outcome of PAT scheme in Iron and Steel sector in multidimensional ways and forecasts the future savings along with innovative case studies having high replication potential. The estimate suggests the cumulative energy savings from the sector till 2030 to be 29.88 million TOE, which is quite impressive.

We are delighted to be a part of this historic journey where India has been a forerunner in implementing an exceptional scheme, customized to the benefit of the industries as well as the nation. I personally feel that the deepening of this scheme in Iron and Steel sectors including SME would prove a game changer in the times to come. This scheme has tremendous opportunities for regional synergies and its adaptation by other countries could lead to address the global climate issues.

Dr. Winfried Damm

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सत्यमेव जयते

ENERGY IS LIFE
CONSERVE IT

ऊर्जा दक्षता ब्यूरो
(भारत सरकार, विद्युत मंत्रालय)
BUREAU OF ENERGY EFFICIENCY
(Government of India, Ministry of Power)

FOREWORD

As we are embarking an ambitious path to provide electricity to all and raise the level of energy availability to the population across the country with limited resources at disposal; efficient use of primary energy resources is absolutely necessary.

Bureau of Energy Efficiency, under the Ministry of Power has been spearheading the promotion of energy efficiency in various aspects of the country's energy landscape, through programs such as Standards & Labelling for appliances, Energy Conservation Building Code (ECBC) for buildings and Demand Side Management (DSM) program for Agriculture and Municipality sectors.

One such flagship program for energy intensive industries namely Perform, Achieve and Trade (PAT) was launched under the National Mission for Enhanced Energy Efficiency (NMEEE). This scheme has demonstrated its value in its first cycle, in which 478 Designated Consumers have achieved 8.67 MTOE of energy savings against the target of 6.68 MTOE, exceeding by about 30 %.

With an objective to have further insight on the actions taken and other notable effects taken by these designated units in achieving the excellent results, a study has been taken up by BEE in partnership with GIZ. The report gives an in-depth analysis of the achievements, projections and success stories across various sectors covered in the first cycle of PAT scheme.

With the continued guidance of Ministry of Power, the Bureau of Energy Efficiency expresses its gratitude towards all the industries, associations and other stakeholders for their significant contribution to achieve the task of saving energy and adoption of energy efficiency measures. BEE intends to convey our congratulations to all who joined us on our collective endeavour of improving energy efficiency in the country.

Abhay Bakre.
(Abhay Bakre)

New Delhi: 19.09.2018

स्वहित एवं राष्ट्रहित में ऊर्जा बचाएँ   Save Energy for Benefit of Self and Nation

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1.0 Executive Summary

In a bid to combat increasing energy consumption and related carbon emissions, the Government of India released the National Action Plan on Climate Change (NAPCC) in 2008 to promote and enable sustainable development of the country by promoting a low carbon and high resilience development path. Under the NAPCC, eight national missions were framed to focus on various aspects related to water, solar energy, sustainable habitat, agricultural, energy efficiency, ecosystems, etc. Perform Achieve and Trade scheme (PAT) is a component of the National Mission for Enhanced Energy Efficiency (NMEEE) which is one of the eight missions under the NAPCC.

PAT is a regulatory instrument to reduce specific energy consumption (SEC) in energy intensive industries, with an associated market-based mechanism to enhance cost effectiveness through certification of excess energy savings, which could be traded. Energy Savings Certificate (ESCerts) are issued to the industries which reduce their SEC beyond their target. Those companies which fail to achieve their target are required to purchase ESCerts for compliance, or are liable to be penalised. Trading of ESCerts are conducted on existing power exchanges.

PAT Cycle – I, which was operationalized in April 2012, included 478 units, known as "Designated Consumers" (DCs), from eight energy-intensive sectors viz. Aluminium, Cement, Chlor – Alkali, Fertilizer, Iron &Steel, Pulp & Paper, Thermal Power Plant and Textile were included. The annual energy consumption of these DCs in eight sectors was around 164 mMTOE. The overall SEC reduction target in the eight sectors was about 4.05% with an expected energy saving of 6.68 mMTOE by the end of 2014-15.

With the completion of the PAT Cycle – I in 2015, the reported overall achievement was 8.67 mMTOE, exceeding the target for cycle -I by almost 30%. The total energy saving of 8.67 mMTOE is equivalent to saving of about 20 million tonnes of coal and avoided emissions of about 31 million tonnes of CO_2. In terms of monetary value, saving in energy consumption corresponds to Rs. 95,000 million.

PAT Cycle - I has witnessed an exceptional performance from all the sectors in terms of reducing their energy consumption. The DCs have made commendable efforts to achieve energy efficiency targets by adopting various improvement measures in technology, operational and maintenance practices, and application of management techniques.

Parameter	Units	Values
Number of DCs in the sector	nos	67
Total energy consumption of DCs in the sector	million TOE	25.32
Total energy saving target for Iron and Steel sector in PAT Cycle - I	million TOE	1.486
Total energy savings achieved by Iron and Steel sector in PAT Cycle - I	million TOE	2.1
Energy savings achieved in excess of the target	million TOE	0.614
Reduction in GHG Emissions in Cycle – I	million T CO_2	6.51
Cumulative energy savings with impact of PAT till 2030 over BAU	million TOE	29.88

Table 1: Iron and Steel sectoral achievements in PAT Cycle – I and projections till 2030

1. Difference of energy consumption between PAT and Business as Usual scenario(BAU)

Iron and Steel sector in India contributes to 2% of India's GDP and is the second largest consumer of Energy with 25.32 mMTOE in PAT after power plants. A brief achievement by the Iron and Steel sector at a glance is mentioned in Table 1.

The key focus of Iron and steel sectoral report is the comparison of PAT to Business as Usual scenario (BAU).This involves comparison of PAT and BAU scenario projected till the year 2030 and gives PAT scheme's contribution in reducing sectoral energy consumption by the year 2030. The report also shows impact of PAT on GDP of the country, sector specific data analysis, process trends, sectoral benchmarking of specific energy consumption, success stories implemented in plants, and list of key technologies which can be implemented in the sector.

3. Ministry of steel Annual report 2017 – 18

2.0 Iron and Steel sector in India

Iron and Steel industry in India is one of the core Industries out of 8 core Industries and has a weighted index of 17.9 . India is the third largest steel producer in the world and is on the verge of becoming the second largest steel producer in the world in the coming years. India's crude steel output in 2017 was 101.4 million Tonne per annum contributing to 6% of the world's crude steel production. The per capita steel consumption of India is 61 kg as compared to the world average of 208 kg.

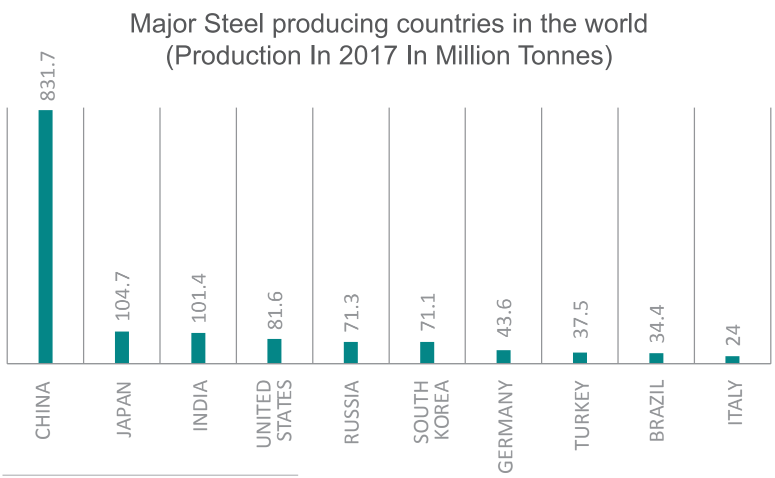

Figure 1: Major Steel producing countries in the world (2017)[5]

HIGHLIGHTS OF IRON AND STEEL SECTOR IN INDIA

- Iron and Steel sector contributes to 2% of India's GDP in 2015
- India is the third largest manufacturer of steel in the world
- Indian Steel Industry is expected to become the second largest steel manufacturer by 2018 (Ministry of steel)
- The annual production of Steel in India was 89 million Tonnes in the year 2014 – 15
- Per capita Steel consumption is 61 kg in India

The steel production in India is expected to reach 300 MT by the year 2030 – 31. The steel sector is expected to grow above 10% till 2030 to reach the target of 300 MT . Domestic crude steel production capacity in India has increased from 97.024 million tonnes in 2012 – 13 to 128.277 million tonnes in 2016 – 17. The actual production of crude steel in 2012 – 13 was 78.415 million tonnes and in 2016 – 17 has been 97.936 million tonnes with a CAGR of 4.6% annually.

A drop of capacity utilization from 89% to 74% has been observed between the period 2010 – 11 and 2015 -16. Despite the decrease in capacity utilization, it was observed in 2014 – 15 assessment year of PAT that several measures

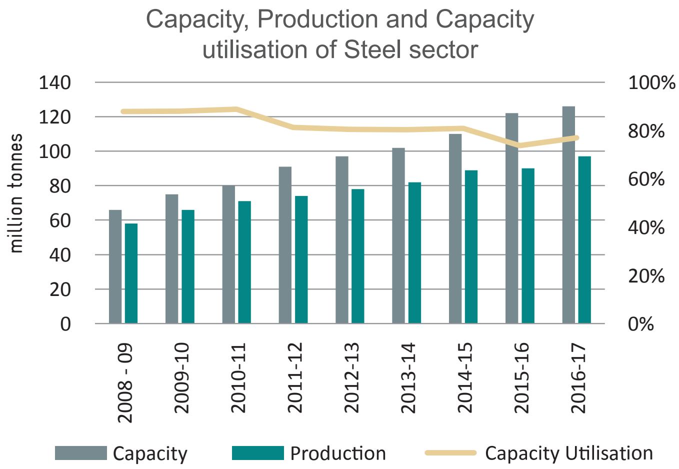

Figure 2: Steel Production in India from FY08 to FY17 (April to December)[6]

4. Annual report 2018; Department of Industrial Policy and Promotion, Ministry of Commerce and Industry http://dipp.nic.in/sites/default/files/annualReport_English_08March2018.pdf
5. World steel Association
6. National Steel Policy 2017/Ministry of steel annual report
7. Ministry of steel

were taken by the Iron and Steel Industry to exceed the energy conservation target allotted to the sector.

2.1 Sectoral Contribution to Country's Economic Value

Indian Steel Sector's contribution to overall Gross Domestic Product of the country is nearly 2% during 2015-16[8]. The Indian Iron and Steel sector has an ambitious target of becoming the second largest steel manufacturer in the world by 2018. The country's contribution has been significant in the infrastructure and automobile sector. India is aiming to produce 300 million Tonnes of steel by the financial year 2030 – 31.

Year	Crude Steel Production (million tonne)	Percentage growth (%)
FY12	78.4	
FY13	81.7	4.2%
FY14	89.0	8.9%
FY15	89.8	0.9%
FY16	98.0	9.1%
FY20	135.0	8.4%
FY25[9]	202.0	
FY30	300.0	

Table 2: Growth of Iron and Steel Industry[10]

Iron and Steel Industry is one of the 8 core Industries recognised by Ministry of Commerce and Industry. The weight given to Iron and Steel sector is 17.9(Overall 100). India's aim to achieve 300 million tonne at FY30 requires an annual growth rate of 8.4% as compared to 2016 growth rate of 9.1%. The compounded annual growth rate observed from FY12 to FY16 is 4.6%. During FY16 growth rate of around 9% is observed.

Financial Year	Total Energy Consumption of India[9]	Gross Domestic Product (GDP)	Energy Intensity
	mMTOE	Billion USD	toe/ million USD
2008	427	1,187	360
2009	453	1,324	342
2010	512	1,657	309
Average Baseline[12]	464	1,389	334
2015	659	2,102[14]	313
2020	1018[15]	3,018	337
2025	1211[16]	4,233	286
2030	1440[7]	5,937[18]	243

Table 3: India's energy intensity

8. http://pib.nic.in/newsite/PrintRelease.aspx?relid=153661
9. Estimates are based on CAGR to achieve 300 million Tonne of steel production by 2030
10. Ministry of Steel
11. Energy consumption values are taken from Energy Statistics 2017 report
12. Equivalent Production of Iron and Steel Industries in PAT
13. BP Statistical Review of World Energy 2016
14. GDP from World Bank GDP for India – Upto 2015
15. India Energy Outlook, Year 2015 - IEA
16. Estimated by calculating CAGR for 2020 and 2040 in India Energy Outlook, Year 2015 - IEA
18. GDP values calculated based on GDP growth rate of 7.5% till 2020 and 7% between 2020 and 2030. Same assumptions have been considered in India Energy Outlook, Year 2015 - IEA

The contribution of Iron and steel DC's to overall energy intensity of India is 5.46% for the baseline year (2007 – 08 to 2009 -10. Iron and Steel sector has achieved 2.1 mMTOE savings under PAT cycle – I. The contribution of this energy savings to overall energy intensity of India is 0.32% during the assessment year (2014-15).

Financial Year	Total Production	Total Energy Consumption	Gross Domestic Product (GDP)	Energy Intensity
	million tonnes	mMTOE	Billion USD	toe/ million USD
Average Baseline	47.272[19]	25.32	1,389	18.23
2015	62.227	31.39	2,102	14.93
2020	135	49.94	3,018	16.03
2025	202	123.878	4,233	18.22
2030	300	126.41	5,937	20.86

Table 4: Iron and Steel sectoral energy intensity

Iron and Steel sector Energy intensity contribution in baseline year and assessment year was **5.46%** and **4.76%** respectively.

19. Equivalent production of DCs under PAT

3.0 Process, Technologies and Energy consumption trend of the sector

The installed capacity of various segments in Iron and steel industry is listed in Table 5. The process path followed in Indian Iron and Steel industries are Blast furnace – Basic Oxygen Furnace, Smelt reduction – Basic oxygen furnace/Electric arc furnace and Direct reduced Iron – Electric arc furnace/Induction furnace.

Segment	Number of units	Capacity (million Tonnes)
Blast furnace	58	79.19
EAF	48	37.81
IF	1126	39.62
BOF	17	50.85
Sponge Iron	320	46.01
Re-Rolling	1166	61.99
Hot rolled flat products	28	55.82
Cold rolled flat products	70	25.76
GP/GC	24	7.15
Colour coated	16	2.76

Table 5 : Capacity of Iron and Steel Industry in 2016 – 17[20] (All India)

The process of an Iron and steel Industry can be split into various basic parts namely – Raw material preparation consisting of Sinter and Pellet plants, Iron making consisting of Blast furnace and Corex Units, Direct reduced Iron kilns DRI in rotary shaft with power generation, Midrex process and HYL process. Steel making consists of Open-hearth furnace, Basic oxygen furnace, Electric arc furnace and Induction arc furnaces. Also, there are small scale units based on DRI + Scrap and only Scrap recycle steel units using electric arc furnace or Induction arc furnace. Most of the steel are continuously cast barring very few that still uses ingot heating and rolling route. The final shape is provided in rolling mills either heating the continuously casted steel or directly charged for rolling. The modern steel making also incorporate cold rolling for grain orientation that improves the strength of steel.

In the raw material preparation section, ore is washed sized and agglomerated by Sinter or Pellet units. These agglomerates when charged in Blast furnace. Whereas DRI or Midrex or HYL process produces the required output in the form prereduced iron, Sponge Iron or Hot Briquetted Iron (If designed that way) and charged in BOF/EAF/IF. In the steelmaking process Basic oxygen furnace besides Hot Metal, utilizes scrap in certain proportion and blown with high pressure +99.9 % pure oxygen to reduce the carbon content from hot metal. Electric arc furnace (EAF) and Induction Furnace (IF) utilizes electricity to melt and required components are added to form the desired composition of steel. Then the steel is shaped in concast route or billet are casted. Rest follows the same route.

Raw material preparation

Raw material preparation consists of pelletisation and sinter plants. The raw material preparation section segregates the raw material and does blending. Larger sizes (+25 to 40mm) are used charge directly to Blast Furnace depending on burden mix. Small sizes are now a day universally used for Bedding and blending to attain uniformity of quality. DRI/MIDREX/IF takes sized iron ore where as bedded and blended materials are used in Sintering and pelletizing.

Sinter process

Sintering is described as incipient fusion of fine iron ores to convert it to course enough that can be

20. Ministry of Steel – Annual report 2017 - 18

directly charged to Blast Furnace. In sintering iron ore fines are also partially reduced that improves BF productivity. In sintering ore fines are mixed with coal/coke powder. This mixture is added with lime if basic sinter is to be produced, further with addition of water a moist mixture is formed This mixture is spread over a tunnel bed and ignited by series of burners along the width of material. Coal/Coke present act as a fuel as the tunnel bed travels and continuous suction subjected from bottom. The speed of tunnel bed and suction of air is so adjusted that the sintering process gets completed before tunnel bed discharges same to cooler. Sinter improves the permeability of blast furnace burden improving reduction process. A high quality of sinter material reduces intensity of blast furnace operation and reduces coke demand in the furnace.

The top of the blend is ignited by gas burners, fuelled by coke oven gas/blast furnace gas or natural gas.

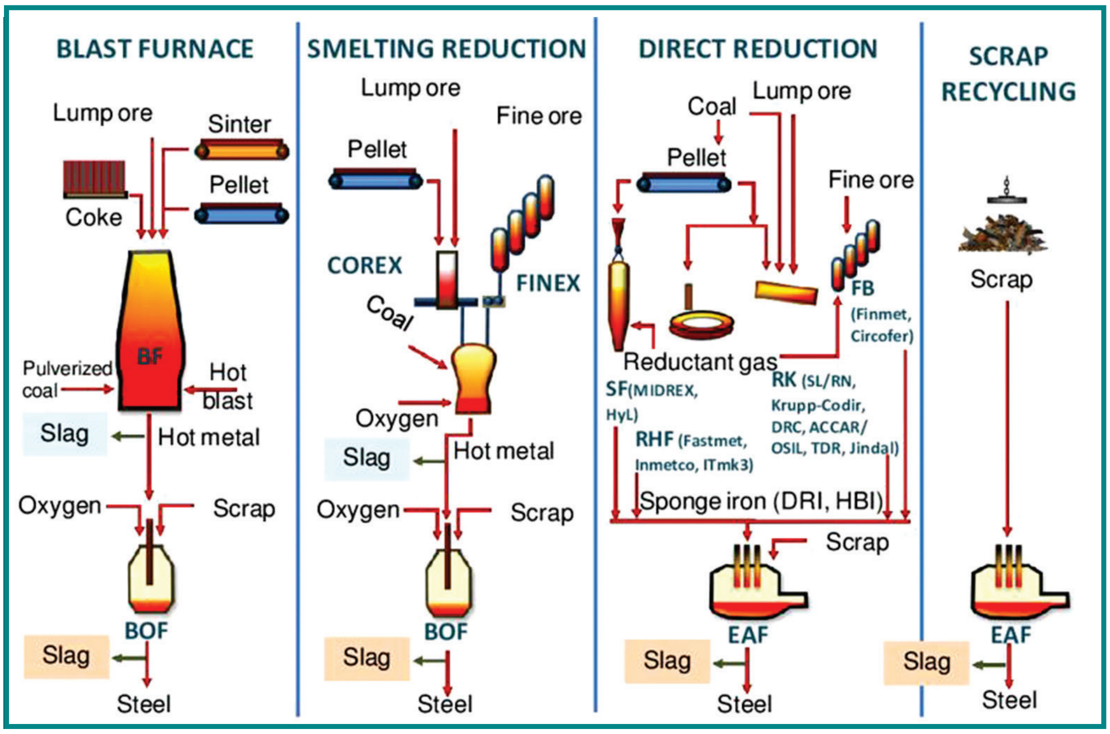

Figure 3: Steel Process flowchart

Pelletisation

Pelletisation is the process of converting iron ore fines to uniformly sized iron ore pellets that are 9-16 mm rounds. Pellets do not prereduced but with addition of glue in the form of Bentonite and moisture gives desired strength to Pellets to be directly charge to furnace. In this process the iron ore fines lesser than 200 mesh is added along with bentonite is poured on inclined rotor disc that moves slowly and forms the pellets. Theses pellets are charge in rotary kiln for drying. The kiln is again fired with BF/CO/NG to form iron ore pellets. Porosity in pellets is high and reducibility is faster in pellets.

Iron making

Iron making process can be done with a blast furnace or Corex Furnace. The output of the blast furnace system is Hot Metal and that of DRI/ MIDREX/HYL kilns are sponge iron. Corex process is considered smelt reduction as the necessity of producing coke is 75% eliminated. Midrex process is an alternate process of direct reduced iron and produces both cold & hot briquetted iron.

Steel making

Steel making is least energy consumer in iron making process. Basic oxygen furnace (BOF), takes hot metal as primary input. It also uses DRI and Scrap to certain percentage if available. Oxygen is blown at high pressure (16-18 bar) through a water-cooled lance from the bottom of BOF vessel carbon at 6% is reduced to less than 1%. The process is exothermic in nature and does not consume additional thermal energy. Electric Arc furnace (EAF), Induction furnace (IF) and Conarc (a combination of BOF and EAF) is also used. The steel thus produced is given shape of slab or billet in a concast. The latest technology is to use thin slab casting in which heating of slab is eliminated as the products are cast near to their final shape.

Rolling mills and Finishing

In rolling mills, hot rolling and cold rolling are practised in India. In the case of hot rolling steel is heated and passed through heavy rollers to reduce the thickness or providing desire shape. Hot rolled steels primarily for grain orientation and also reduces thickness and smoothen surface. Cold rolling mill consumes higher electrical energy and thermal energy is used for pickling followed by treatment in a tandem mill. Final process involves finishing of the product, where annealing and surface treatment are done for the mills.

4.0 Methodology adopted for the project

The activities were initiated with the collection of sector specific data from Bureau of Energy Efficiency (BEE). In addition, data was also collected through secondary research. Data analysis was conducted to assess the impact of PAT Cycle – I on energy intensity in the BAU v/s PAT scenario, GDP of the country, trend analysis for energy efficiency, quantification of energy saving in terms of TOE and coal saving. Feedback was also collected from DCs on benefits and the challenges experienced through the PAT scheme.

DATA COLLECTION

- Sector specific data from Bureau of Energy efficiency
- GDP of the country
- Benchmarking
- Miscelleneous data through Secondary research

DATA ANALYSIS

- Analysis of sector specific data and finding out specific energy consumption of individual processes based on PAT scheme
- Identifying GDP contribution of the sector
- Impact on energy intensity
- Assumptions considered for calculations for the sector

FEEDBACK FROM PAT STAKEHOLDERS

- Identifying key senior people from sectors
- Contacting Designated consumers and collecting feedback on PAT scheme

SUCCESS STORIES

- Shortlisting of case studies
- Visit to specific plants to obtain information on Case studies
- Preparation of case studies and sharing case studies with plant team

Figure 4: Methodology followed for Impact assessment of PAT Cycle – 1

The case studies were shortlisted based on higher savings, low cost implementation, innovative projects and high replication potential across the sector. With the assistance of BEE and GIZ, various plant visits were scheduled and conducted across various sectors to study the technical benefits and challenges faced by designated consumers in implementing their projects. Based on the feedback from the respective plants, success stories were developed on the same.

5.0 PAT Cycle – I and its impact on Iron and Steel Sector

PAT scheme's primary goal is to reduce energy consumption by assigning time bound targets to the designated consumers. Any gain or shortfall in meeting the target is traded by using ESCerts, where 1 ESCert is equivalent to 1 MTOE of energy saving. This scheme is regulated by Bureau of Energy Efficiency (BEE). The existing power exchanges facilitate trading of ESCerts among DCs.

PAT Cycle – I started in 2012 and the baseline was considered from financial years 2007 – 08 to 2009-10. The average value of specific energy consumed by the plant was taken for three years. The minimum threshold considered for becoming a designated consumer of PAT varies based on sectors. A threshold limit of 30000 TOE has been taken for a plant in Iron and Steel sector, to be declared as a designated consumer.

The total reported energy consumption of these designated consumers was about 25.32 mMTOE. These DCs were given a target of 1.486 mMTOE energy consumption reduction, which was around 22.22% of the total energy saved under PAT Cycle - I. In PAT Cycle - I and II 45% and 72%[21] of total energy consumed by the iron and steel sector was under the PAT scheme. The number of designated consumers in PAT Cycle - I and II for Iron and Steel sector are 67 and 71 respectively. In PAT Cycle - III 29 new DCs were notified in the Iron and Steel sector.

5.1 Impact of PAT Cycle-I

Iron and Steel sector has achieved 2.1 mMTOE in comparison to the target of 1.486 mMTOE. This achievement has estimated GHG emission reduction of 6.51 million tonnes of CO_2 equivalent exceeding the targeted emission reduction by 2.69 million tonnes of CO_2 equivalent. The results of PAT Cycle – I is summarised in Figure 5.

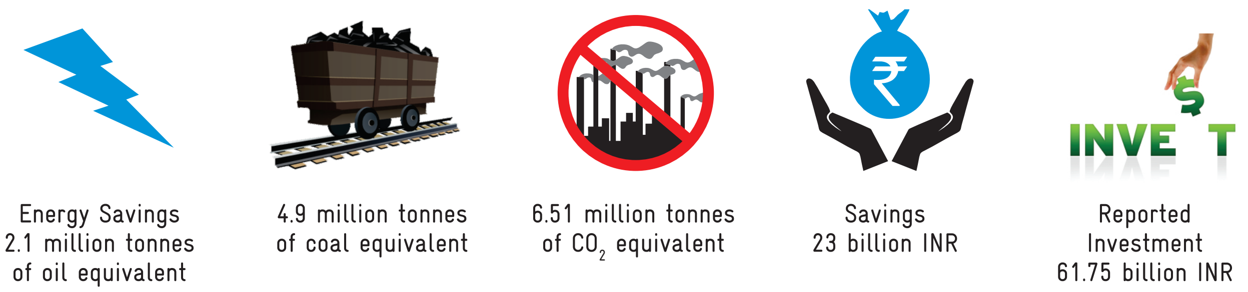

Figure 5: Savings achieved by Iron and Steel sector in PAT

The savings are attributed to a number of measures adopted by the DCs. Some of the DCs have implemented short term measures with minimal investment, others have opted for medium and long-term measures requiring considerable investment. Investment was reported by 55% of DCs in the sector against implementation of energy conservation. The emissions reduction due to PAT Cycle – I and contribution of these emissions are mentioned in Table 6. The emission reduction considers the emissions of fossil fuels only and is based on the fuel mix in the sector.

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Parameter	Value
Reduction of CO_2 emission due to implementation of PAT Cycle –I(All sectors)	31 million Tonnes of CO_2 equivalent
Reduction of CO_2 emission due to implementation of PAT Cycle-I in iron and steel sector	6.51 million Tonnes of CO_2 equivalent
Contribution to CO_2 emission reduction in overall PAT Cycle-I	21%

Table 6: Reduction in CO_2 emissions from PAT cycle - I

5.2 Energy Scenario at Business as usual (BAU) Vs PAT

The section describes the impact of PAT and comparison with BAU scenario. A summary of the performance of the sector and its projection for 2030 is mentioned in Table 7. The calculation of GHG emissions for PAT Cycle – I has been done based on the fuel mix of the Iron and Steel sector under PAT.

Particulars	Unit	Value
Number of plants in the sector	Nos.	67
Baseline Energy Consumption in PAT Cycle – I	million TOE	25.32
Energy reduction target for the sector	million TOE	1.486
Energy Savings achieved in PAT Cycle – I	million TOE	2.100
Energy savings achieved in excess of target	million TOE	0.614
Reduction in GHG Emissions in Cycle – I	million T CO_2	6.51
Cumulative energy savings with impact of PAT till 2030 over BAU[22]	million TOE	29.88

Table 7: Achievements of Iron and Steel sector in PAT Cycle – I and Projections till 2030

The energy saving of 8.67 mMTOE declared for PAT Cycle - I has been calculated based on notified production for the baseline period, whereas the actual energy saving obtained will be higher while considering the subsequent production of individual sectors for subsequent years. The methodology of calculation involves SEC consumption of individual years and the achieved energy savings till 2030.

The reduction in specific energy consumption in the baseline year from 2007 – 08, 2008 – 09 and 2009 – 10, has been calculated and considered as Business as Usual scenario (BAU). This reduction in specific energy consumption is used to project the reduction by the sector till 2030. The average specific energy reduction for the baseline period was 1.19% for integrated steel plants. This reduction has been considered for the entire sector of Iron and Steel.

The graphs in this section show specific energy consumption and energy consumption for Business as usual and impact of PAT, projected to 2030. The reduction from baseline to assessment year of PAT is the reduction in specific energy consumption for PAT Cycle - I. Since the achievement of specific energy consumption targets is considered to be

22. Difference of energy consumption between PAT and Business as Usual scenario(BAU)

achieved after PAT Cycle – II, the specific energy reduction is lesser than PAT Cycle – I. Figure 6 & 7 shows the projection till 2030 for specific energy consumption and energy consumption for Iron and steel sector.

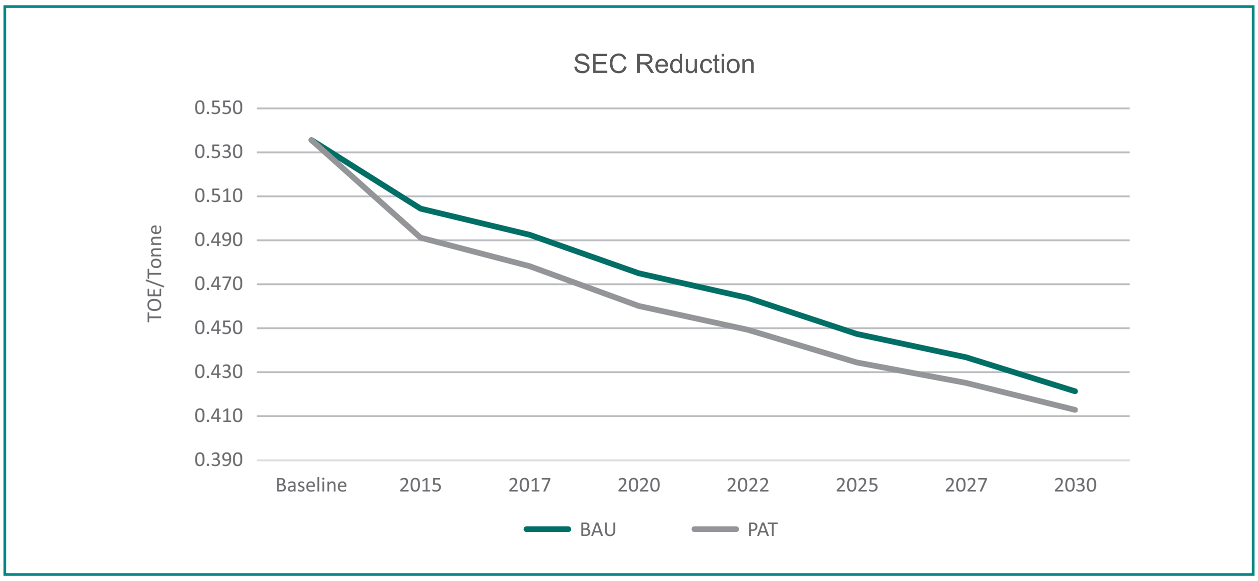


Figure 6: SEC reduction for Iron and steel sector BAU vs PAT

The mix of different sub sectors in Iron and steel has been considered in the specific energy consumption graph. The sub sectors included consists of integrated steel plants and plants less than 1 MTPA. Plants less than 1 MTPA consists of sponge Iron kilns, mini blast furnaces, steel melting shops and rolling mill. The average specific energy consumption of integrated steel plant was 7.261 GCal/tcs for baseline period.

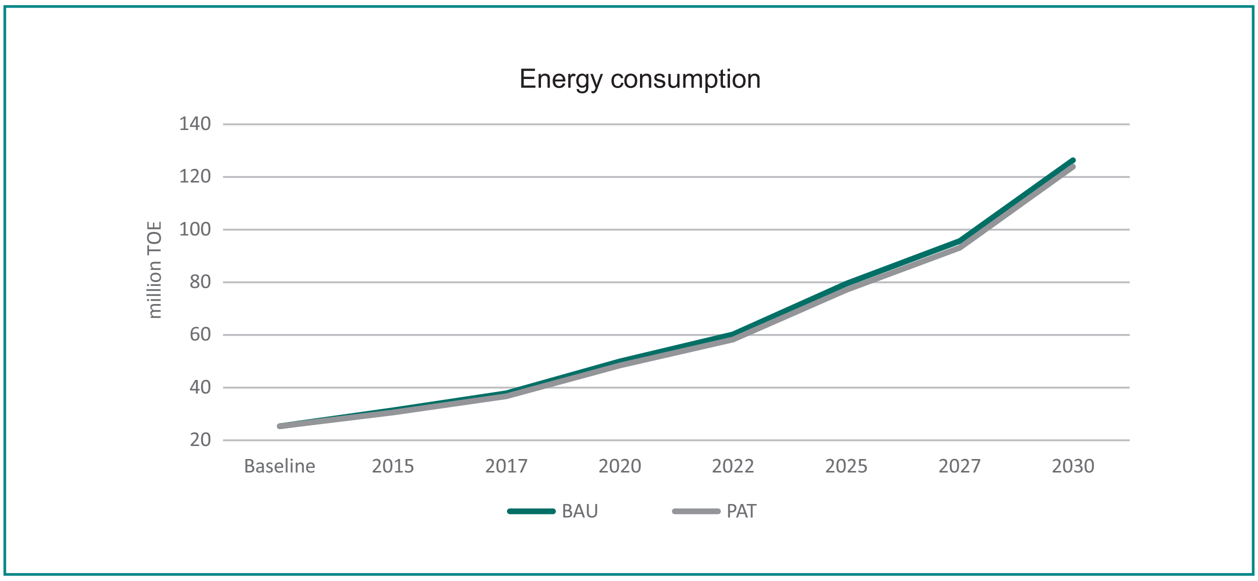


Figure 7: Energy consumption of Iron and steel plants BAU vs PAT

Figure 7 indicates that the PAT scheme would have positive benefit on the sector and would help in reducing the energy consumption additionally by 2.53 mMTOE over the BAU in 2030 and collective energy benefits for all years (2015-2030) would be 29.88 mMTOE.

24. Different steel production units (Sponge Iron to rolling mills)

The total energy consumption for Iron and Steel sector in the year 2030 without the impact of PAT is estimated to be 126.4 million TOE, which may reduce to 123.9 million TOE considering the impact of PAT.

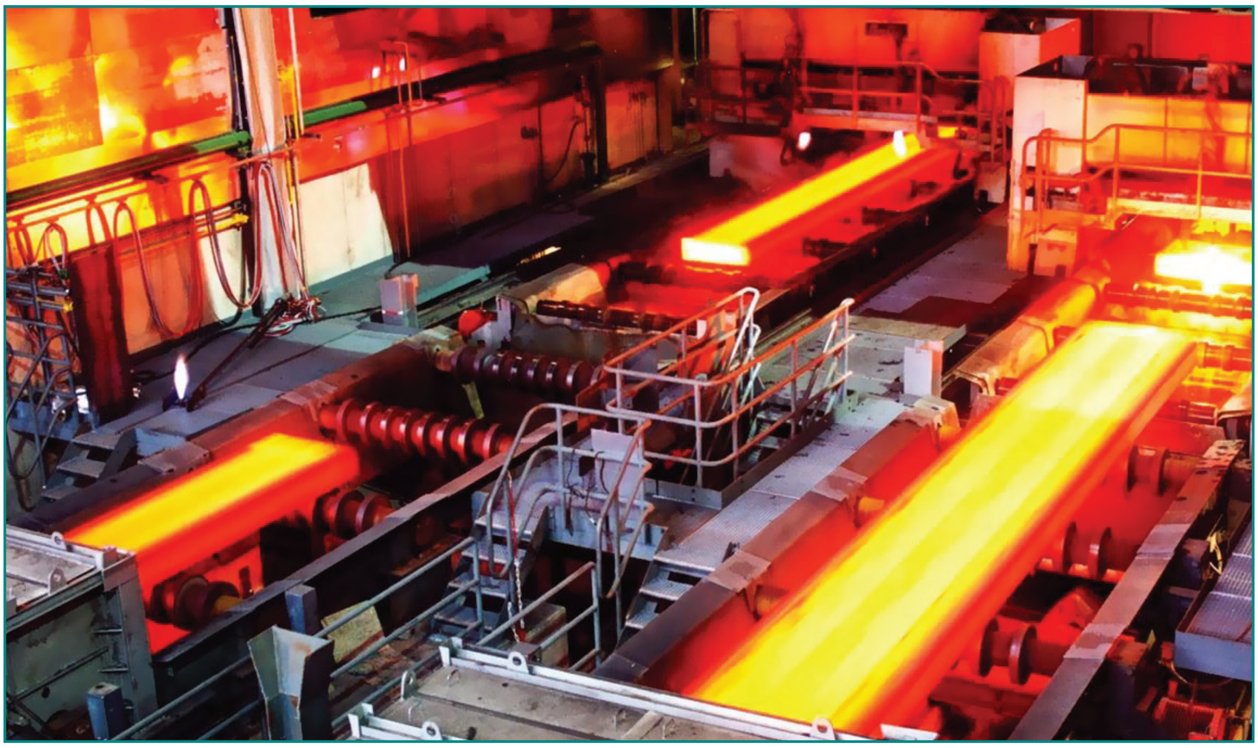


Figure 8: A view of Iron & Steel plant

Year	GDP	Business as usual	With PAT
	Billion USD	Energy Intensity	Energy Intensity
		Toe/million USD	Toe/million USD
Baseline	1,389	18.23	18.23
2015	2,102	14.93	14.54
2020	3,018	16.55	16.03
2025	4,233	18.77	18.22
2030	5,937	21.29	20.86

Table 8: Energy intensity with PAT and BAU for Iron and Steel

The energy intensity of Iron and Steel sector is mentioned in Table 8. The energy intensity is observed to be decreasing till 2020 and is found to be increasing from 2020 to 2030. This increase in energy intensity between 2020 and 2030 is due to the following reasons

- Decrease in GDP growth rate between 2020 and 2030
- Reduction in PAT targets for subsequent cycles
- High increase in production in comparison to GDP growth rate

Assumptions considered for BAU Vs PAT calculation till 2030

Specific Energy Consumption

- The SEC of the sector has been calculated by taking into account the total production of the sector and the total energy consumption in the sector, and hence may not represent the actual SEC of any particular sub-sector/ product/ process.

Business as usual scenario:

- The plant would have undertaken activities on energy efficiency on its own, even without the intervention of PAT scheme.
- The production for Iron and Steel sector is taken as 300 MTPA by the end of FY30
- The reduction in specific energy consumption in the baseline year from 2007 – 08, 2008 – 09 and 2009 – 10, has been calculated and the same reduction is projected till the year 2030 to get the BAU scenario.

With PAT scenario:

- The actual energy saving achieved in the PAT Cycle – I is taken for the assessment year 2014 – 15.
- It has been assumed that the plants meet the target allotted to them till the years 2030.
- The target for the subsequent PAT cycles are calculated based on the current trend of reduction in target between PAT Cycle – I and II.
- It has been considered that the target will go on decreasing in the subsequent cycles owing to the diminishing potential in the plant as they go on implementing projects on energy efficiency.
- It has also been considered that some breakthrough technological advancement might provide further reduction potential in the sector.
- It has been considered that 90% of the energy intensive plants will come under PAT directly, whereas small production units which comes under SMEs may be covered under voluntary PAT

5.3 Iron and steel sector specific data analysis of PAT Cycle – 1

The major Iron and steel production in the country is from integrated steel plants. The capacity utilization of the DCs from integrated steel plants and various section of sponge Iron plant is mentioned in Table 9. The capacity utilization is marginally varied in the case of integrated steel plants and was higher in the baseline period in comparison to assessment period, whereas the Sponge Iron and mini blast furnace steel plants can be improved in the near future for enhancing energy efficiency.

S No	Sections of Steel plants	Capacity Utilization Baseline period	Capacity Utilization Assessment period
1	Integrated Steel Plant	89.88	77.27
2	Sponge Iron	67.86	69.22
3	Steel Melting Shop	13.47	15.89
4	Ferro Chrome	67.14	73.56
5	Ferro Manganese	15.90	36.57
6	Silico Manganese	27.95	48.29
7	Pig Iron	59.33	56.07
8	Ferro Silicon	69.14	53.20
9	Rolling Mill	45.04	42.67

Table 9: Capacity Utilization of Steel Plants (in percentage)

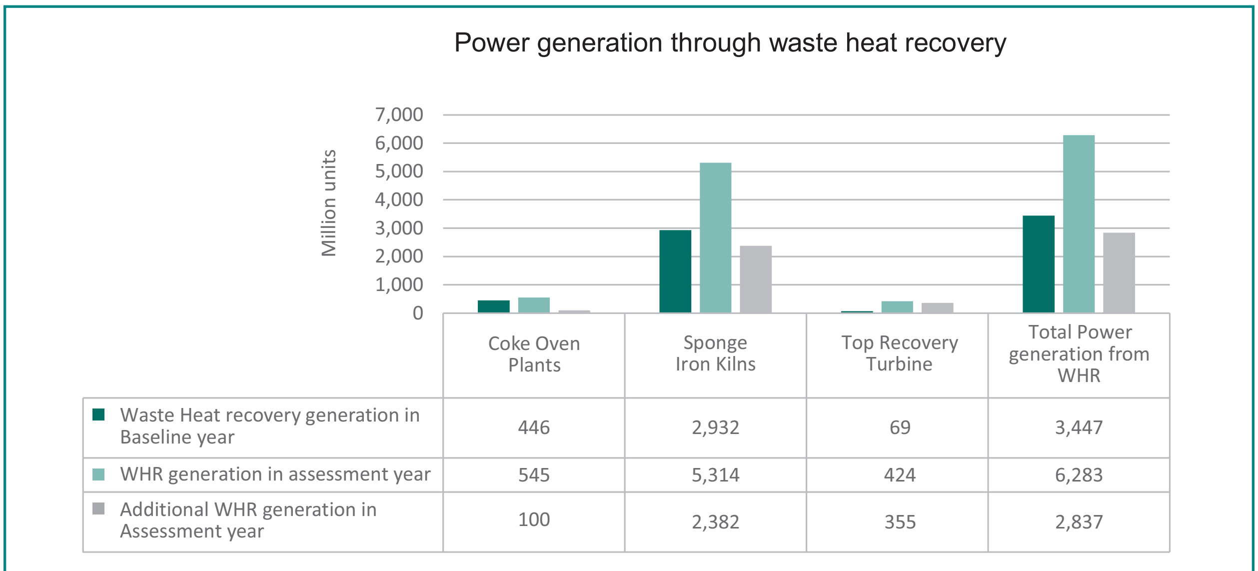
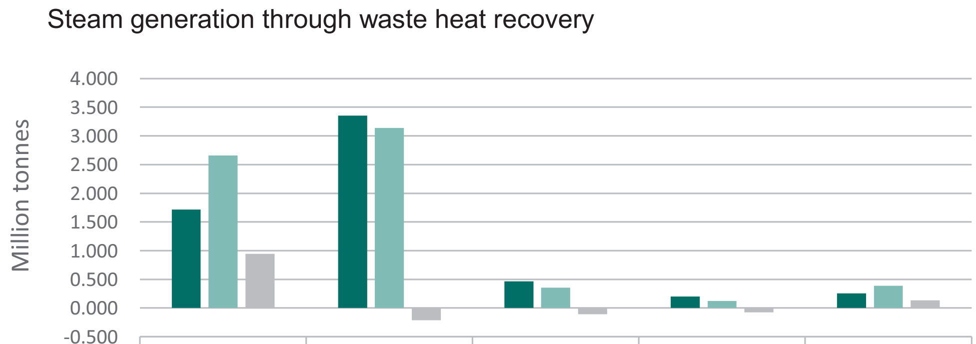


Figure 9: Power generation through waste heat recovery

Waste heat recovery installation (WHR) in Iron and Steel sector

Iron and steel sector has several waste heat recovery opportunities for achieving better energy efficiency. Several waste heat recovery opportunities are available from coke oven batteries to rolling mills in a steel plant. The waste heat recovery installed in the integrated steel plants are mentioned in Figure 9 and Figure 10 separately for integrated steel plants and plants of lesser capacity with DRI or Mini blast furnace technologies. Installed capacity of Top recovery turbine increased by 30 MW and waste heat recovery of sponge iron kiln increased by 80 MW.



	Coke Oven plants	Coal based HBI/DRI	Calcining plants	Plate mills	Compact strip mills
Waste Heat recovery generation in Baseline year	1.717	3.352	0.466	0.200	0.255
WHR generation in assessment year	2.662	3.141	0.357	0.124	0.390
Additional WHR generation in Assessment year wrt Baseline	0.945	-0.211	-0.108	-0.077	0.135

Figure 10: Steam generation through waste heat recovery[25]

The minimum specific energy consumption of individual sections of PAT designated consumers is mentioned for Integrated as well as for plants less than 1 million Tonne per annum capacity in Table 10 and the specific energy consumption of plants less than 1 million MTPA were analysed for baseline and PAT sector and are mentioned Table 11. The mini blast furnace has higher specific thermal energy in comparison to sponge Iron but down lying process consume lesser in a mini blast furnace system, thereby reducing the overall specific energy consumption compared to sponge Iron.

Table 11 respectively. The capacity utilization as mentioned earlier has been low for Iron and Steel Industry for assessment period in comparison to baseline period. In spite of low capacity utilization target was exceeded by several plants. The minimum consumption of Integrated Iron and Steel plant is 5.96 GCal/tcs during the assessment period. The minimum consumption mentioned Table 10, does not include any normalization factors.

25. The negative values for steam generation is due to low capacity utilization, shutdown or issues in the waste heat recovery system, change in technology etc.

Section	Baseline year			Assessment year		
	Minimum	Average	Maximum	Minimum	Average	Maximum
Material Handling (Sinter+Pelletisation +Coking)	0.729	1.571	2.604	1.091	1.520	2.287
Iron Making (Blast furnace+DRI+HBI+Corex)	3.237	3.670	4.559	3.279	3.771	6.003
Calcination	0.021	0.102	0.184	0.069	0.107	0.199
Steel melting and casting	0.093	0.567	1.905	0.235	0.530	1.515
Hot strip Rolling	0.285	0.270	0.594	0.195	0.235	0.565
Cold rolling	0.103	0.156	0.223	0.107	0.143	0.213
Others (Rest of the Rolling Section)	0.048	0.409	1.170	0.036	0.419	0.758
Compact strip mill	0.000	0.000	0.000	0.121	0.161	0.281
Boiler	-0.846	0.151	0.568	-0.715	-0.110	1.770
Oxygen plant	-0.010	0.064	0.258	0.025	0.051	0.734
Power plant	-0.001	0.315	2.793	0.041	0.282	4.058
Auxiliary Plant	0.020	0.196	0.379	0.065	0.169	2.087
Component losses	0.000	0.318	2.749	0.093	0.258	3.886
Total	**6.331**	**7.261**	**9.537**	**5.960**	**7.171**	**9.126**

Table 10: Specific energy consumption in integrated steel plants (in Gcal/tcs)[26]

The specific energy consumption of plants less than 1 million MTPA were analysed for baseline and PAT sector and are mentioned Table 11. The mini blast furnace has higher specific thermal energy in comparison to sponge Iron but down lying process consume lesser in a mini blast furnace system, thereby reducing the overall specific energy consumption compared to sponge Iron.

Section	Parameter	Units	Baseline Period	Assessment Period
Sponge Iron	Thermal SEC	million kcal/Tonne of Product	3.56	3.92
	Electrical SEC	kWh/Tonne of product	57	59
Electric Arc Furnace	Electrical SEC	kWh/Tonne of product	216	199
Ferro Chrome	Electrical SEC	kWh/Tonne of product	3773	3643
Ferro Manganese	Electrical SEC	kWh/Tonne of product	3545	3600
Silico Manganese	Electrical SEC	kWh/Tonne of product	3563	4001
Mini Blast Furnace	Thermal SEC	million kcal/Tonne of Product	4.09	3.53

Table 11: Minimum Specific energy consumption of different sections in Steel plants (less than 1 MTPA)

Pelletisation plant is an excellent opportunity available in Indian steel plants to improve the quantity of agglomerates in the blast furnace. Plants have reported improved savings in energy consumption by increasing the use of agglomerates in the blast furnace or DRI kilns. In blast furnace overall 85% agglomerate (Sinter + Pelletisation) and in DRI kilns around 100% addition has been reported respectively. 2 Integrated steel plants and 4 Sponge Iron plants/Mini Blast furnace plants have Pellet plants in their facility. 1 Integrated steel plant and 1 Sponge Iron plants/Mini Blast furnace plants have installed Pellet plant between Baseline and Assessment period. Two integrated steel plants have also installed thin slab casting in their facility which is in line with global standards in energy efficiency.

26. The values are in negative since the energy is generated and there is no consumption of energy

6.0 Benchmarking in Iron and Steel Industry

Benchmarking is an important tool to establish how one is performing and what avenues can be adopted to achieve the highest level in energy efficiency. The following section provides the comparison of India's Iron and steel sector performance with the best efficiency levels in the world.

The best specific energy consumption in the world achieved by a plant is 5.38 GCal/tcs and the best specific energy consumption of Indian plant is 5.67 GCal/tcs in the financial year 2016 – 17. The India and global best specific energy consumption for Iron and steel sector is mentioned in the Table 13.

Particulars	Units	Global Best	India Best	India Average
Specific energy consumption	GCal/tcs	5.38[27]	5.67[28]	7.171

Table 12: Specific energy consumption Global and India best

The best specific energy consumption for various process path is mentioned in Table 12. The minimum specific energy consumption mentioned is arrived by adding the best specific energy consumption in individual sections where best practices on energy saving are implemented and is not related to a single plant.

Process path	GCal/ton of steel
Blast furnace – Basic Oxygen Furnace – Thin Slab Casting	3.53
Smelt reduction – Basic Oxygen Furnace – Thin Slab Casting	4.25
Direct Reduced Iron – Electric Arc Furnace – Thin Slab Casting	4.06
Scrap – Electric Arc Furnace – Thin Slab Casting	0.62

Table 13: Best Specific Energy Consumption for Various Process Flow Path Based on World's Best Practices[29]

The World's best practice values are also provided for hot rolling and cold rolling mills & finished steel using a continuous caster. The specific energy consumption values for thin slab casting are also mentioned by not considering the continuous casting, hot rolling and cold rolling.

The breakup of benchmark considering fuel, steam, electricity and total energy is provided in Table 14 and is mentioned for various process paths. The specific energy consumption values are mentioned per metric ton of steel, to compare different processes. The best specific energy consumption values mentioned are based on the following assumptions (as mentioned in World Best Practice Energy Intensity Values for Selected Industrial Sectors):

- 1.389 t sinter is required to produce 1 t hot rolled steel
- 0.9923 t pig iron required to produce 1t hot rolled steel(90% pig iron and 10% scrap)
- 1.05 t crude steel to make 1 t hot rolled steel

27. JFE Steel CSR report for 2016; http://www.jfe-holdings.co.jp/en/csr/pdf/csr2017e.pdf
28. Annual report 2017 – 18, Ministry of steel 2018
29. World Best Practice Energy Intensity Values for Selected Industrial Sectors, ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY 2008

	Process parameter	Blast Furnace – Basic Oxygen Furnace	Smelt Reduction – Basic Oxygen Furnace	Direct Reduced Iron – Electric Arc Furnace	Scrap – Electric Arc Furnace
Units		GCal/t	GCal/t	GCal/t	GCal/t
Material Preparation	Sintering	0.45		0.45	
	Pelletizing		0.14	0.14	
	Coking	0.19			
Iron making	Blast Furnace	2.91			
	Smelt Reduction		4.13		
	Direct Reduced Iron			2.80	
Steelmaking	Basic Oxygen Furnace[30]	-0.10	-0.10		
	Electric Arc Furnace			0.62	0.57
	Refining	0.02			
Casting and Rolling	Continuous Casting	0.01	0.01	0.01	0.01
	Hot Rolling	0.44	0.44	0.44	0.44
Subtotal		3.94	4.66	4.47	1.03
Cold Rolling and Finishing	Cold Rolling	0.10	0.10		
	Finishing	0.26	0.26		
Total		4.30	5.02	4.47	1.03
Alternative: Casting and Rolling	Replace continuous casting and rolling with thin slab casting	0.05	0.05	0.05	0.05
Alternative Total		3.53	4.25	4.06	0.62

Table 14: Specific Energy Consumption for Best Practices in Iron and Steel Sector

BLAST FURNACE – BASIC OXYGEN FURNACE ROUTE

The specific energy consumption values mentioned for BF – BOF considers the best practices, taken in BF-BOF route is obtained by considering best practices such as high-pressure ammonia liquor spray, coke dry quenching, variable speed drives on motors and a recovery type coke ovens. The sinter plant considered consists of waste heat recovery from exhaust cooler, uses coke and coke breeze as fuel and utilizes natural gas for ignition.

The Blast furnace is the largest consumer of energy in an Iron and Steel plant. The best practice to be considered for a blast furnace is waste heat recovery system to pre –heat combustion air and stoves having high heating efficiency of 85% using a mixture of coke oven & blast furnace gas without oxygen enrichment.

The BOF process injects oxygen into the furnace, wherein the carbon in the steel reacts with oxygen and is an exothermic process, hence the negative value for Basic oxygen furnace. This process does not consume any energy since, BOF gas will have a high calorific value as it contains 95% CO and the heat recovery from BOF gas can be explored.

30. Basic oxygen furnace operation is an exothermic process and does not use any additional energy

Section	Process	Energy Parameter (GCal/tonne of steel)			Final Energy (GCal/t)	
		Fuel	Steam	Electricity	Oxygen	International
Material Preparation	Sintering	0.47	-0.05	0.04		0.45
	Coking	0.14	0.02	0.02		0.19
Iron Making	Blast Furnace	2.73	0.10	0.02	0.05	2.91
Steel Making	Basic Oxygen Furnace	-0.17	-0.05	0.02	0.10	-0.10
Casting	Refining			0.02		0.02
	Continuous Casting	0.007		0.006		0.01
Hot Rolling	Hot Rolling – Strip	0.31		0.08		0.39
	Hot Rolling – Bar	0.38		0.06		0.44
	Hot rolling – Wire	0.41		0.10		0.50
Sub Total (Based on hot rolling bars)		3.56	0.02	0.20	0.15	3.93
Cold Rolling		0.01	0.02	0.06		0.10
Finishing		0.17	0.07	0.02		0.26
Total		3.75	3.74	0.12	0.45	0.15
Casting and Rolling	Replace continuous casting, Hot rolling, Cold rolling and Finishing with Thin Slab casting	0.01		0.04		0.05
Total (Considering thin slab casting)		3.19	0.02	0.17	0.15	3.53

Table 15: Blast Furnace – BOF Route

SMELT REDUCTION – BASIC OXYGEN FURNACE ROUTE (COREX)

Smelt reduction process is the latest development in alternate processes, it omits coke production and combines the gasification of coal with melt reduction of iron ore. Energy is reduced because of production of omission of coke and reduction in iron ore. The smelt reduction processes include COREX, FINEX, Hismelt, CCF, DIOS etc. The values for specific energy consumption mentioned here is for COREX process only.

The coal consumption in a COREX plant is higher in comparison to blast furnace, but a large volume of off gas is produced, which can be used for power generation or Direct Reduced Iron (DRI). The recovery of heat from off gas is not considered in the specific energy consumption values listed in the Table 16. The off gas exported has a potential of 3.21 GCal/ton of steel.

Section	Process	Energy Parameter			Final Energy (GCal/t)	
		(GCal/tonne of steel)	Final Energy	Electricity	Oxygen	International
Material Preparation	Pelletizing	0.12	0.02			0.14
Iron Making	Smelt Reduction	3.80		0.07	0.29	4.16
Steel Making	Basic Oxygen Furnace	-0.18	-0.04	0.02	0.10	-0.10
	Refining			0.02		0.02
Casting	Continuous Casting	0.007		0.006		0.01
Hot Rolling	Hot Rolling – Strip	0.31		0.07		0.39
	Hot Rolling – Bar	0.38		0.06		0.44
	Hot rolling – Wire	0.41		0.10		0.50
Sub Total(Based on hot rolling bars)		4.13	-0.01	0.19	0.38	4.68
Cold Rolling		0.01	0.02	0.06		0.10
Finishing		0.17	0.07	0.02		0.26
Total		4.31	0.08	0.27	0.38	5.04
Casting and Rolling	Replace continuous casting, Hot rolling, Cold rolling and Finishing with Thin Slab casting	0.01		0.04		0.05
Total (Considering thin slab casting)		3.75	-0.01	0.13	0.38	4.25

Table 16: Smelt Reduction – Basic Oxygen Furnace

DIRECT REDUCED IRON – ELECTRIC ARC FURNACE

The direct reduced iron or MIDREX process utilizes the process of reducing Iron below the melting point and in India DRI utilizes coal for reduction. The MIDREX process has been installed in India in a few plants. Latest technology is to install a Coal gasification based MIDREX plant. The net waste heat generated from DRI is used for power generation and excess units produced is usually exported to the grid. The energy reduction due to power generation is not accounted in the Table 17. The power generation potential for DRI plant would be 509 kWh/t of DRI. The best practices considered for EAF is with eccentric bottom tapping, oxygen blowing and carbon injection. The scrap metal charging considered for EAF is around 40%.

Section	Process	Energy Parameter (GCal/t)				Final Energy (GCal/t)
		Fuel	Steam	Electricity	Oxygen	
Material Preparation	Sintering	0.47	-0.05	0.04		0.45
	Pelletizing	0.12	0.02	0.00		0.14
Iron Making	Direct Reduced Iron	3.08		-0.29		2.80
Steel Making	Electric Arc Furnace	0.14		0.41	0.07	0.62
Casting	Continuous Casting	0.007		0.006		0.01
Hot Rolling	Hot Rolling – Strip	0.31		0.07		0.39
	Hot Rolling – Bar	0.38		0.06		0.44
	Hot rolling – Wire	0.41		0.10		0.50
Sub Total(Based on hot rolling bars)		3.91	4.20	-0.03	0.22	0.07
Casting and Rolling Replace continuous casting, Hot rolling, Cold rolling and Finishing with Thin Slab casting		0.01	4.20	-0.03	0.22	0.07
Total (Considering thin slab casting)		3.83	-0.03	0.19	0.07	4.06

Table 17: Direct Reduced Iron – Electric Arc Furnace

7.0 List of major energy saving opportunities in the sector

A list of major energy saving opportunities in the sector have been identified and listed in Table 18. The projects are listed based on readiness level, co – benefits obtained by installing the system and based on expected payback range by implementing the project.

Technology Readiness Level (TRL):	Co-Benefits: PQCDSME	Payback Horizon (PB)
TRL 1 – Research (Basic or Advanced)	Productivity (P)	PB 1 - less than 1 year
TRL 2- Proof of concept	Quality (Q)	PB 3 – 1 year to 3 years
TRL 3- Demonstration(Pilot)	Cost(C)	PB 5 – 3 to under 5 years
TRL 4- First of a Kind	Delivery (D)	PB 8 – 5 to under 8 years
TRL 5- Fully Commercial	Safety (S)	PB 12 – 8 to under 12 years
	Moral (M)	PB >12 – over 12 years
	Ethics, Environment (E)	

S No	Technology	Co-Benefits eg: (P, Q, C, D, S, M, E)	Readiness Level (TRL-1, TRL-2 .....TRL5)	Payback
1.	Fuzzy logic based coil cooling control system for Induction furnace	P,Q,C,S,M,E	TRL-1	PB1
2.	Heat recovery from sponge Iron	P,Q,C,M,E	TRL-1	PB5
3.	Heat recovery from radiation of sponge Iron kiln surface	C,M,E	TRL - 3	PB3
4.	Dry Slag granulation	C,S,M,E	TRL-2	PB3
5.	Finex	P,Q,C,D,S,M,E	TRL-2	PB5
6.	Preheating through WHR from hot stoves of blast	C, E	TRL-5	PB5
7.	Coke dry quenching(CDQ) technology	P, C, E	TRL-5	PB5
8.	Segregated charging of sinter plant	P, C	TRL-5	PB3
9.	Installation of pelletisation plant	P, C, E	TRL-5	PB5
10.	Centrifugal compressors	C, E	TRL-5	PB2
11.	High efficient multi-slit COG burner	P, C, E	TRL-5	PB3
12.	Waste heat recovery from Sinter cooler	C, E	TRL-5	PB3
13.	Converter Gas Recovery System	C, E	TRL-5	PB3
14.	Ecological and Economical Arc Furnace	C, S, E	TRL-5	PB8
15.	Waste Heat recovery from sponge iron kilns	C, E	TRL-5	PB3
16.	Top Pressure Recovery Turbine (TRT)	C, E	TRL-5	PB3
17.	Pulverized Coal Injection (PCI) System	C, E	TRL-5	PB3
18.	Waste Heat recovery from Electric Arc Furnace	C, E	TRL-5	PB5
19.	Hot charging and direct rolling mill	P,C,E	TRL-5	PB5
20.	Thin slab casting	C, E	TRL-5	PB3
21.	Regenerative Burner total system for reheating furnace	P, C, E	TRL-5	PB3
22.	Use of Hydrogen to make steel process carbon free	P,Q,M,E	TRL-1	NA

Table 18: List of key technologies in the sector

8.0 Success stories – Case Studies in Iron and Steel sector

8.1 Direct Charging of Hot Billets from CCM to Rolling Mill

Introduction

Shri Bajrang Power & Ispat ltd (Borjhara Division), a GOEL Group company has 2 x 350 TPD Sponge Iron Plants of capacity 2, 10,000 TPA with 18 MW Captive Power Plant, 5 x 8 MT Induction Furnace with Continuous Casting machine of capacity 1, 29,000 TPA, 8 MW Biomass Power Plant, 8 MVA Ferro Alloys plant of capacity 14,400 TPA, 0.60 Million Ton Coal Washery & Rolling Mill of 1.20 LTPA along with Fly Ash Bricks manufacturing plant of 30 Million Bricks per annum.

Project Background

Like all Steel Sector units, Shri Bajrang Power and Ispat Ltd (TMT Division), Urla Industrial Complex first used the conventional top-fired pusher type re-heating furnace for heating of billets. The unit used dual fuel in the form of furnace oil with provision for use of coal-based producer gas. The rising price of fuel was a major concern for the unit, which also led to higher production costs.

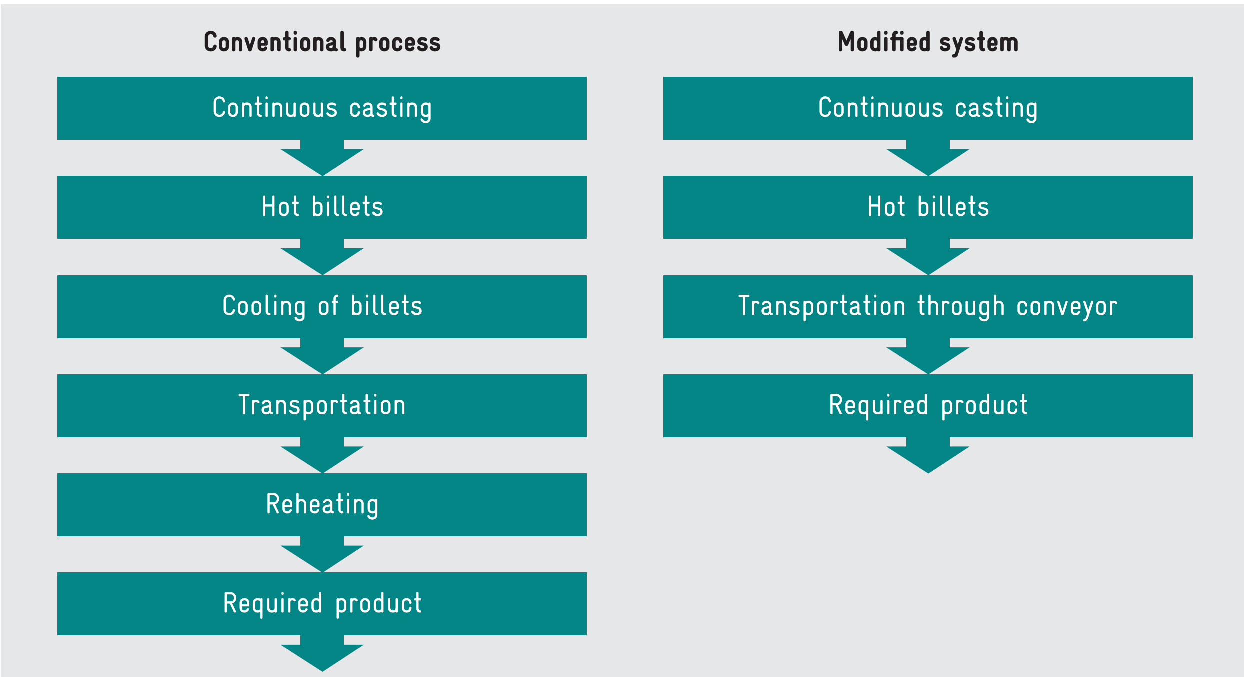


Figure 11: Schematic before implementation of direct charging

Under the energy efficiency measures, the company has installed Direct Rolling of hot continuous cast billet to produce TMT bars without any intermediated reheating arrangement.

Based on above technology the company in its Borjhara Division has installed Hot Re-Rolling Mill of capacity 1.2 Lakh TPA, led to the elimination of the re-heating furnace, and therefore the complete avoidance of fossil fuel. Moreover after implementation of this technology, the refractory cost in terms of capital as well as running cost is zero.

Description of the project

Under the energy efficiency measures, the company had installed Direct Rolling of hot continuous cast billet to produce TMT bars without any intermediated reheating arrangement. It contributes towards the conservation of energy and environment as well. The main recommendations for upgrading the unit are as follows:

- **Changes at the Induction Furnace:**

Tapping temperature of molten steel is increased and modifications are done in ladle and transfer mechanism to retain high temperature of molten steel. Induction furnace operation is synchronized with CCM and rolling mill for better mill utilization.

- **Changes at the Continuous casting machine:**

Modification is done in the caster with regards to speed of casting, water pressure and temperature, cooling zone, and water circulation system. Cast billet temperature is set around 1080-1100oC. PLC-based automation system is installed for the operation of secondary cooling system. Manual gas cutting system is changed to hydraulic shearing for better operation. High-speed billet conveyor is installed with VFD drives.

- **Changes at the Rolling Mill:**

Operating practice is modified to handle direct rolling. Two-strand casting and increase in the input for rolling reduce the ideal time and increase the productivity of rolling mill at the same time. RPD is also modified to cater to direct rolling.

- **Changes at the Finished materials yard:**

The material handling is carried out in an organized and systemized way through 5S implementation.

Figure 12: Photographs of direct charging of billets

How reduction in specific energy is achieved:

- Elimination of the use of Fossil fuel in the reheating furnace and this would save tonnes of furnace oil annually.
- Saving in Consumption of power at auxiliaries such as air blowers, oil pre-heater & pumps, and pusher & ejector with associated conveyors.
- Higher yield percentage due to reduction in losses on account of less burning/scale loss and reduction in Miss-roll & end cuts as well.

Process path for which technology is applicable: Any Mini-Steel Plant, who have Induction Furnace (SMS) with Continuous Casting Machine as well as Rolling Mill within the same campus.

Timeline for the project (project start date and end date): 6 Months

How was the financing done – Internal funds

Benefits of implementing the project	
Energy savings	Rs 146 million
Annual TOE savings	4,100 TOE
Investment	Rs 22 million
Payback(months)	2 Months
GHG reduction from the project	13,000 TCO2 equivalent of GHG reduced
Replication Potential[31]	70% of Sponge iron plants in India can implement this scheme
	400,000 TOE is the achievable sectoral savings
	Rs 2,500 million

Table 19: Benefits of implementing Direct Charging of Hot Billets from CCM to Rolling Mill

Other Benefits

Benefits from the project (Direct Charging of Hot Billets from CCM to Rolling Mill)

1. Reduction in the mill scale loss to the extent of 1.5%-2%, which would have been burned in the billet re-heating furnace.

2. Significant contribution towards pollution control measures for the purpose of Environment conservation as it will reduce CO_2 per annum.

Challenges faced during Implementation

Shutdown required – Maximum one month

Plant Contact details of the project	
Plant Name	Shri Bajrang Power & Ispat Ltd
Person to be contacted	Mr. S.k Goyal
Designation	Director
Contact number	+91 98264 22320
Email – ID	skgoyal@goelgroup.co.in
Address for communication	Village: Borjhara, Urla-Guma Road, Raipur-493221 (Chhattisgarh)

Table 20: Plant Contact details of the project

31. The energy saving for the sector is projected based on the production and replication potential multiplied with overall production for the sector.

8.2 Reheating Furnace with Re-Generative Burner at Tata Steel, Jamshedpur

Introduction

Tata Steel Limited is an Indian multinational steel-making company headquartered in Mumbai, Maharashtra, India, and a subsidiary of the Tata Group. It is one of the top steel producing companies globally with annual crude steel deliveries of 27.5 million tonnes (in FY17), and the second largest steel company in India (measured by domestic production) with an annual capacity of 13 million tonnes after SAIL.

Project Background:

Various phases of capacity expansion at Tata Steel, Jamshedpur Steel Works, along with continuous improvement in operating practices have resulted in surplus by-product gases; primarily blast furnace gas with lower caloric value of 800-850 kCal/Nm3. In spite of continuous effort of 100 % utilization of by-product gases arising out of steel making processes, surplus blast Furnace gas to the tune of 70-80 kNm3/hr used to get flared, which was equivalent to approx. 63Gcal/hr energy loss.

In 2008-2009, there was a need of reheating furnace at Hot Strip Mill (HSM) for its capacity upgradation from 2.9 MT/annum to 3.55 MT/annum. The challenge was to supply of reach gas for the conventional reheating furnace which operates with reach gas of more than 2000 kCal/Nm3 calorific value in combination with preheated air up to 550oC through recuperator. However, as per the plant fuel balance, rich gas was not available for conventional reheating furnace, which has triggered to go for reheating furnace with regenerative burners.

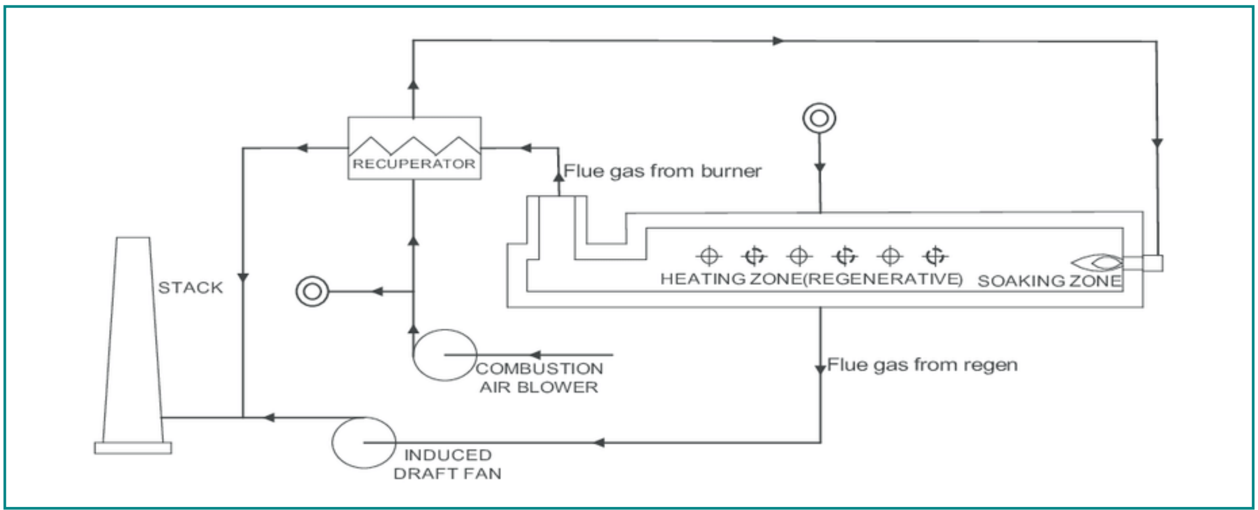


Figure 13: Schematic of reheating furnace

Description of the project

Adopting regenerative burner technology makes it possible to utilize the available surplus Blast Furnace gas for the heating of slabs. The advantage of this technology compared to conventional combustion system is that, it can use low CV gas, e.g blast furnace gas with preheating provision up to 1000oC. This also helps to achieve rolling temp of slabs as well as fuel saving of about 30-40%.

Total of 108 regenerative burners are provided to the furnace, among which, 56 nos. are located

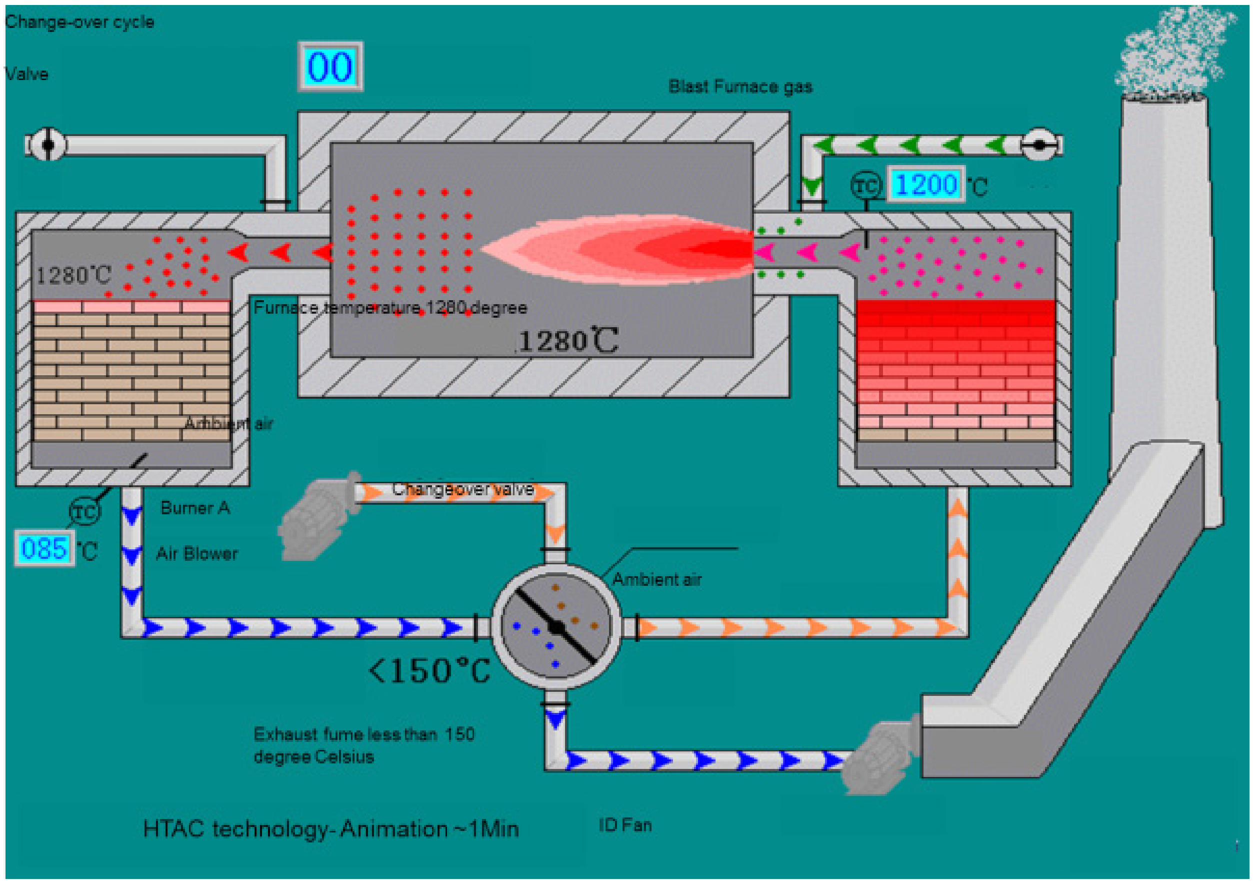


Figure 14: Operating principle of Regenerative burner

at air side, 52 nos. are located at gas side. Each air nozzle and adjacent gas nozzle combines one combustion unit. The furnace is equipped with three-way reversing valve to help the combustion process and fume-exhaust process of burner.

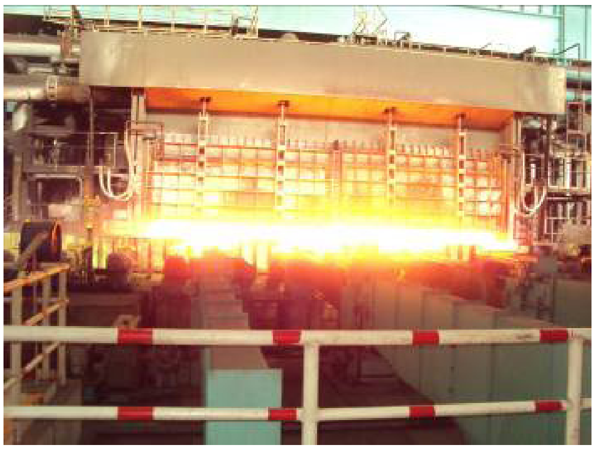


Figure 15: Photographs of regenerative burner

Process path: This technology can be used in all sort of heating or reheating furnaces including ladle dryers.

How was the financing done: Internal

Benefits

Tata Steel, Jamshedpur Steel Works implemented this project as a part of HSM capacity up-gradation project.

Benefits of implementing the project	
Annual Energy savings	Rs 110 million
Annual TOE savings	2,800 TOE
Investment	Rs 200 million
Payback(months)	22 months
GHG reduction from the project	170,000 Tonnes of CO_2 equivalent
Replication Potential[32]	70% of the Integrated steel plants can opt for this technology
	45,000 TOE is estimated Investment required for the sector
	Investment potential for the sector is Rs 1,000 million

Table 21: Benefits of implementing Reheating Furnace with Re-Generative Burner at Tata Steel, Jamshedpur

Other Benefits

- Minimized CO emissions
- Lesser Carbon footprint
- Rapid heat transfer and improved temperature uniformity

Plant contact details for the project	
Plant Name	Tata Steel Limited, Jamshedpur Works
Person to be contacted	Mr. Pradip Chakraborty
Designation	Designated Energy Manager,
Contact number	Tel +91-657 66 42188
Email – ID	p.chakraborty@ tatasteel.com
Address for communication	Power House-4 | Tata Steel Works | Bistupur | Jamshedpur 831 001

Table 22: Plant contact details for the project

32. The energy saving for the sector is projected based on the production and replication potential multiplied with overall production for the sector.

9.0 List of Technology suppliers

S No	Company Name	Technology	Website link
1	Bloom Engineering	Regenerative burners	https://www.bloomeng.com
2	Claudius Peters	PCI, Injection system for solid fuels	http://www.claudiuspeters.com/en-GB/888/iron-and-steel
3	Danieli India Limited	Modern Blast furnaces, Hot blast stoves, PCI, Thin Slab casting	https://www.danieli.com
4	Electrotherm (India) Ltd.	Energy efficient Induction furnace, Direct rolling of hot billets, Hydraulic grab, Lining vibrators	www.electrotherm.com
5	ENCON Thermal Engineers (P) Ltd.	Regenerative burners	http://www.encon.co.in
6	Shenwu Thermal engineering co ltd	Regenerative burners	http://www.shenwu.com.cn/english/index.php?app=article&act=index&column_id=149
7	Bloom Engineering	Regenerative burners	https://www.bloomeng.com/
8	Inductotherm group India	Energy efficient Induction furnace	https://inductothermindia.com/
9	JP Steel Plantec Co	Coke Dry Quenching, Waste heat recovery for Sinter cooler, Pulverised coal Injection, Energy efficient electric arc furnace, Continuous casting, LD Gas recovery system	http://steelplantech.com/
10	Nippon Steel	Coke dry quenching, Coal moisture control, COG Desulphurisation, Energy saving Blast furnace, Pulverised Coal Injection, LD Gas recovery system, Blast furnace top charging	http://www.eng.nssmc.com/english/
11	Outotech	Iron ore pelletisation	https://www.outotec.com/
12	Paul Wurth India Private Limited	Top recovery turbine, Coke dry quenching, Blast furnace top charging, MIDREX Direct reduction, Iron ore pelletisation,	http://www.paulwurth.com
13	Primetals Technologies India Private Limited	Hybrid floatation technology, Circular Pelletizing Technology, COREX, FINEX and MIDREX, Energy efficient Electric Arc Furnace, Continuous casting, Waste heat recovery for Electric Arc furnace	https://www.primetals.com
14	SAINT-GOBAIN INDUSTRIAL CERAMICS,Grindwell Norton Limited	Neutral refractory for Induction machines	http://www.grindwellnorton.co.in/high-performance-refractories

Table 23: List of key technology suppliers in Iron and Steel sector

Abbreviations

Bureau of Energy Efficiency

Ministry of Power, Government of India
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066 (INDIA)
T: +91 11 26766700 I F: +91 11 26178352
Email: admin@beenet.in I www.beeindia.gov.in
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