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CII

ENERGY IS LIFE BEE CONSERVE IT

Technology Compendium

On

Energy saving Opportunities

Iron & Steel Sector

August 2013

Disclaimer

This report is part of Shakti Sustainable Energy Foundation (SSEF) and Confederation of Indian Industry, CII – Godrej GBC's effort to assist the Indian industry achieve greater energy efficiency levels and to facilitate designated consumers meet their Perform, Achieve & Trade (PAT) targets set by Bureau of Energy Efficiency (BEE), Government of India.

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Foreword by Director General – Bureau of Energy Efficiency

With the growth of economy, the demand for energy has grown substantially. Further, the high level of energy intensity in certain major industrial sectors, and more so, the variation between the most & least efficient facility within them is a matter of concern. In such scenario, efficient use of energy resources and their conservation assume tremendous significance and become imperative for sustainable growth of the industrial economy and the country at large.

The efficient use of energy and its conservation is the best option to meet the increasing energy demand, Government of India has enacted the Energy Conservation Act, 2001. The Act provides for institutionalizing and strengthening delivery mechanism for energy efficiency services in the country and provides the much-needed coordination between the various entities.

The Ministry of Power and Bureau of Energy Efficiency (BEE) are entrusted with the task of preparing the implementation for the National Mission on Enhanced Energy Efficiency (NMEEE) under National Action Plan on Climate Change (NAPCC). This mission has a component which deals with the market based mechanism to improve the energy efficiency in energy intensive large industries and facilities by certification of energy savings which could be traded.

This scheme known as Perform, Achieve and Trade (PAT) is expected to save about 6.686 million metric tonne of oil equivalent (mMtoe) by 2014-15. Eight industrial sectors namely Power, Iron & Steel, Fertilizer, Cement, Aluminium, Pulp & Paper, Textile and Chlor-alkali have been included in this scheme where in about 478 industries (known as Designated Consumers (DCs)) are covered. In the ensuing PAT scheme, all the DCs will be required to achieve a reduction of Specific Energy Consumption (SEC) from their baseline SEC within 3 years time (2012-13 to 2014-15).

These industry specific technology compendiums will provide ready-to-use information on national & international energy conservation opportunities, Best Operating Practices (BOP), Best Available Technologies (BAT), with their techno-economic considerations. These compendiums will be helpful for DCs to prepare their energy efficiency action plans and to achieve their SEC reduction targets set by BEE.

I am sure that this Technology Compendium manual will receive an overwhelming response from the cross section of the industry. I take this opportunity to thank Shakti Sustainable Energy Foundation (a part of Climate Works Foundation) for supporting this initiative.

(Ajay Mathur)

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EXECUTIVE SUMMARY

Economic growth is contingent upon the growth of steel industry. Consumption of steel is taken to be an indicator of economic development. The greater the infrastructure growth of a country, greater will be the consumption of steel.

The iron & steel industry in India is one of the important industries in the country from several points of view. This sector, since independence has been focused as one of the basic sectors which would contribute to the "development journey" of the country.

From a one million tonne capacity at the time of independence, the iron & steel industry has come a long way and India has now risen to be the 4th largest crude steel producer in the world [1] and the largest producer of sponge iron. From a negligible global presence, the Indian steel industry is now globally acknowledged for its product quality.

The iron and steel industry presents one of the most energy intensive sectors within the Indian economy and is therefore of particular interest in the context of energy, environment and sustainable development discussions.

Iron & Steel industry account for 36 million MTOE, about 15% of Indian industrial energy consumption. Under PAT scheme, there are 67 designated consumers, both from integrated steel plants and sponge iron. They are mandated to improve their present energy efficiency levels and save 1.4 million MTOE, accounting for about 22% of overall reduction anticipated from first PAT cycle (ending FY 2014-15)

With this background, this Technology Compendium, which comprises of various technologies and best practices to save energy, has been prepared. This compendium is expected to assist the designated consumers to improve their energy efficiency levels and finally to achieve the targets under PAT scheme.

However, implementation of these technologies calls for a sustained effort from the designated consumers. Some of the technologies mentioned in this report are capital intensive and time consuming to implement. But implementation of these projects can surely be beneficial.

[1] World steel association

METHODOLOGY

Formation of Technical Advisory Committee

A core technical advisory committee was formed to assess the progress made in the sector. Mr C S Gupta (formerly of RINL), T K Chakravaty (Steel Expert) ,Mr Prakash Bapat (Steel Expert) & Mr Ramani Iyer (Forbes Marshall) constituted the advisory committee for iron & steel sector. The advisory committee supported the project by assessing the findings of the project and providing the necessary guidance.

Secondary Research

Secondary research formed an important activity in this project. Secondary research was conducted for sectoral information, identification of international best practices and the major technological advancement in the sector.

Annual report of *Ministry of Steel, India*, Energy Efficiency opportunities in iron & steel sector, *LBNL*, Japanese Technologies for Energy Savings/GHG Emissions Reduction, *NEDO,* Energy Efficiency opportunities in iron & steel sector, *PCRA*, Energy Transition For Industry: India And The Global Context, IEA were the documents referred for the secondary research.

Stakeholder Interactions:

The compendium was sent to the stakeholders to get their views. The draft compendium was sent to Dr Siddiqui (NEDO), Nippon Steel Engineering India, Mr Nimish Parikh (ESSAR Steel India Limited), Mr J P N Singh (Energy Manager, TATA Steel), Mr M V Rao (Energy Manager, RINL), Mr C P Sharma (Rourkela Steel Plant), Dr Mohanty (Torsteel Research Foundation India). The comments received from them were incorporated into this report.

Review and Analysis:

All the information derived from the secondary research and stakeholder consultation phases were studied and analyzed. The analyzed data was incorporated in the report.

1.0 INDIAN IRON & STEEL INDUSTRY

India had only three steel plants – the Tata Iron & Steel Company, the Indian Iron and Steel Company and Visveswaraya Iron & Steel Ltd and a few electric arc furnace-based plants before independence in the year 1947. However after independence the iron and steel industry saw an exponential growth and has a strong global presence. India produces almost 5% of the world's total crude steel production[1].

The iron & steel industry is dominated by the Government owned public sector undertaking (in terms of no. of units) of SAIL, followed by the few other private sector players such as TATA steel, Jindal, ESSAR & JSW.

India's per capita consumption of steel is 56.3 Kg, compared to the world average of 220.8 Kg[2]. The massive infrastructure growth as well as the growth in automobile & engineering sector is expected to further accelerate its growth.

The basic hot metal production is predominantly through the blast furnace route in the large integrated steel plants and through direct reduction route in the smaller sponge iron plants distributed across the country.

1.1 Capacity

The Indian iron & steel sector has seen a regular increase in the capacity addition over the years. The capacity addition in iron and steel sector has been growing steadily at the rate of 10% year–on–year from 2006 and has seen rapid expansion plans pursued by private as well as public sector companies. From a capacity of 47.99 million tonne per annum (million MTPA) in 2004-05, the sector has grown to 84.46 million MTPA in the year 2011 – 2012[3].

Table 1: Crude Steel Capacity & Production[4]

Year	Crude Steel		
	Capacity (MILLION MTPA)	Production (MILLION MTPA)	Capacity Utilization %
2005 – 2006	51.17	45.78	89.5
2006 – 2007	56.84	49.4	86.9
2007 – 2008	59.84	53.4	89.2
2008 – 2009	66.34	57.7	87.0
2009 – 2010	72.96	63.5	87.0
2010 – 2011	75.46	68.3	90.5

[2] Government of India
[3] Ministry of Steel Annual Report
[4] World Steel Association

Crude steel production has shown a sustained rise since 2004-05 along with capacity. India, 4th largest crude steel producer, produced 68.3 million tones of crude steel in the year 2010 and accounted for 5% of the world's total crude steel production. Crude steel production grew at a Compound Annual Growth Rate (CAGR) of 8.4 per cent during the five years, 2005-06 to 2009-10.

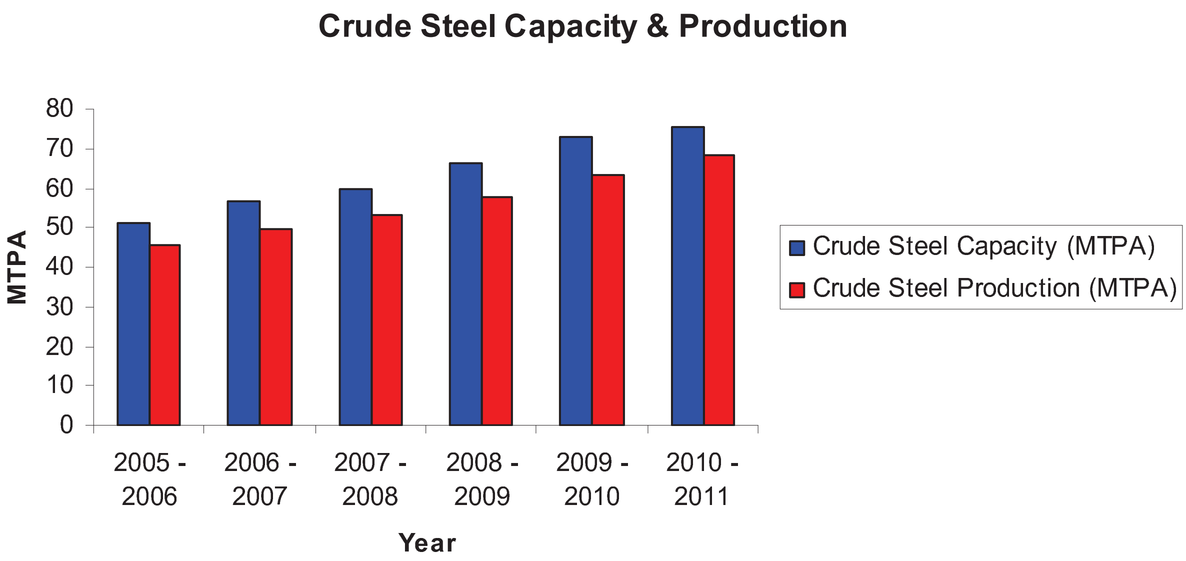

Figure 1: Crude Steel Capacity & Production

By 1991, when the economy was opened the steel production grew to 14 MILLION MTPA and multiplied itself in the following years. Steel production in India is expected to reach 124 MILLION MTPA in 2012 and 275 MILLION MTPA by 2020 which could make India the second largest steel producer in the world.

The sponge iron capacity over the years also has increased since the capacity utilization of these plants is largely dependant on the internal market price of the scrap. The National steel policy[5] of 2005 envisaged 110 million tones out of which 30% will be through the sponge iron route.

India is also a leading producer of sponge iron with a host of coal based units, located in the mineral-rich states of the country. Over the years, the coal based route has emerged as a key contributor to overall production. Capacity in sponge iron making has also increased over the years and currently stands at 32 million tonne.

[5] steel.nic.in/nspolicy2005.pdf

Table 2: Production of Sponge Iron in India[6]

Production of Sponge Iron (million tones)						
Year	**2005-06**	**2006-2007**	**2007-2008**	**2008-2009**	**2009-10**	**2010 - 2011**
Coal based	10.28	13.08	14.53	15.57	18.18	20.92
Gas based	4.54	5.26	5.84	5.52	6.15	5.79
Total	14.82	18.34	20.37	21.09	24.33	26.71

The major players in DRI route are TATA Sponge, ESSAR, JSPL and ISPAT. The major production of sponge iron (about 60%) comes from the States of Chattisgarh, Orissa and West Bengal. These are plants operating in smaller capacities and are coal based. The larger capacity gas plants contribute to about 30% and are based in the western region (Gujarat / Maharashtra)

Table 3: Production of Sponge Iron from 1980 in India

Year	Production million MTPA	Major Players
1980	0.01	Orissa Sponge Iron, ESSAR, ISPAT, TATA Sponge, JSPL
1990	1.25	
2000 - 2001	5.44	
2005 - 2006	14.82	
2006 - 2007	18.34	
2007 - 2008	20.37	
2008 - 2009	21.09	
2009 - 2010	24.33	
2010 - 2011	26.71	

1.2 World Steel Production

The world's total crude steel production for the year 2011 was 1515 MT, a growth of 6.8% over 2010. In the five years preceding the financial crisis, global steel production basked a robust CAGR of 7% to reach 1329 million MT in 2008. The booming market of 2004–08 rapidly declined during the global financial crisis and as a result the total production came down to 1232 million MT in the year 2009. The steady rise in steel demand in 2010 brought back the production level and it is more likely to increase in the coming years.

[6] Ministry of Steel Annual Report

Regional Production

China, Japan, USA, India, Russia & South Korea together produces around 71% of the world's total crude steel production. China alone produces 45% of the world's total crude steel production, producing 683 MILLION MTPA.

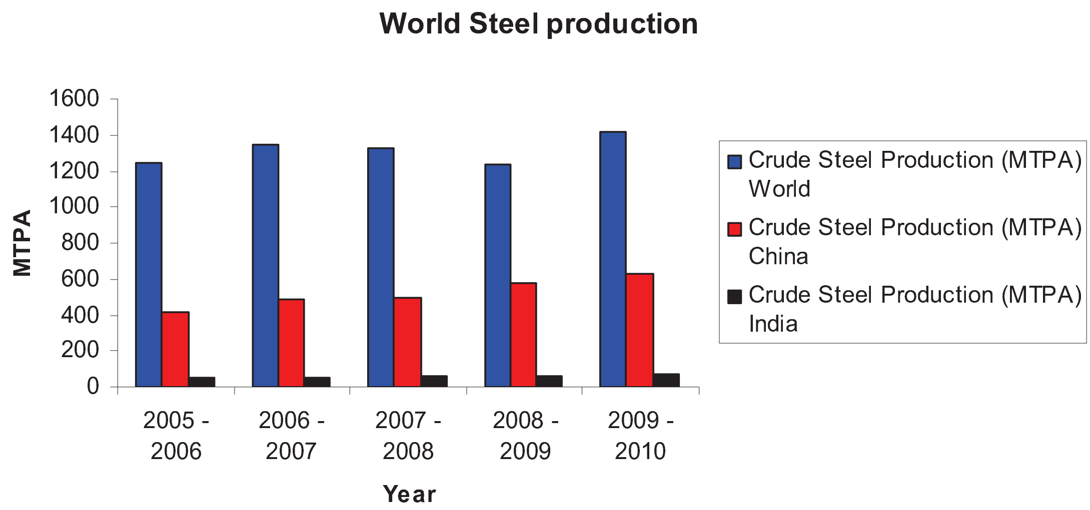

Figure 2: World Crude Steel Production

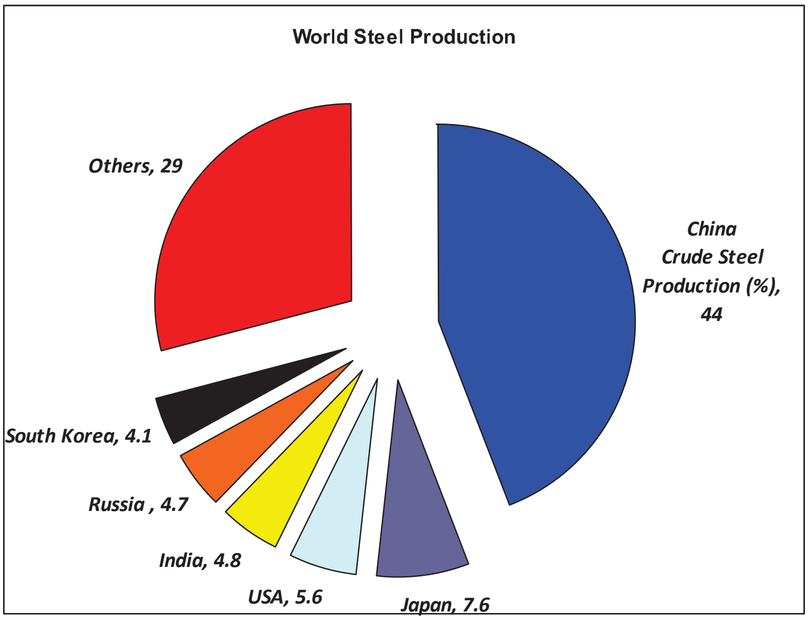

Figure 3: World Crude Steel Production Region Wise

1.3 Trends in Production: Public & Private Sector (INDIA)

Indian iron & steel sector can be divided into two main sectors: *public sector & private sector*. The main players in public sector are SAIL plants and Vizag Steel. The private sector is dominated by TATA Steel, ESSAR Steel, JSW & Jindal Power & Steel Limited.

The Indian integrated steel industry consists of nine major plants located mostly in the Eastern areas rich in both iron ore and coal deposits. The location of the plants was conceived with the intention of having them close to raw material sources.

Table 4: Major Indian Iron & Steel Industries

S. No	Company	Location	Year of establishment
1	Bhilai Steel Plant	Chhattisgarh	1959
2	Durgapur Steel Plant	West Bengal	1962
3	Rourkela Steel Plant	Orissa	1955
4	Bokaro Steel Plant	Jharkhand	1965
5	IISCO Steel PLant	West Bengal	1972
6	Visveswaraya Iron and Steel Plant	Karnataka	1923
7	Rashtriya Ispat Nigam Ltd. (RINL)	Andhra Pradesh	1982
8	TATA Steel Ltd	Jharkhand	1907
9	JSW ISPAT	Maharastra	1984
10	Essar Steel India Ltd. (ESL)	Gujarat	1990
11	Bhushan Power & Steel Ltd	Orissa	1970

The steel policy adopted by Government of India has opened up iron & steel sector for private investment by removing it form the list of industries reserved for public sector and exempting it from compulsory licensing. Imports of foreign technology as well as foreign direct investment have given a definite drift for entry, participation and growth of private sector in steel industry.

Table 5: Steel production: Public sector & private sector[7]

Year	Crude Steel Production (MILLION MTPA)		
	Total	Public Sector	Private Sector
2005 – 2006	46.5	16.96	29.50
2006 – 2007	50.8	17.00	33.81
2007 – 2008	53.9	17.09	36.77
2008 – 2009	58.4	16.37	42.07
2009 – 2010	65.84	16.71	49.13
2010 – 2011	69.57	16.99	52.67

[7] Ministry of Steel Annual Report

The percentage share of production from private sector units has been steadily increasing over the years. This is because of the aggressive approach adopted by the private sector to constantly increase its production capacity and to introduce new units.

Some of the key players in the Indian iron & steel sector have been a permanent feature in the list of world's top steel manufactures.

Table 6: Top Steel Producers[8]

World Rank	Company	Production (MILLION MTPA)
7	Tata Steel (India)	23.2
18	SAIL	13.6
33	JSW Steel	6.4
35	Essar Steel (India)	6
46	RINL	3.2

The major share of the steel production in India is from the strong major players in the industry. These major players constitute 77% of the total production of steel in India.

Table 7: Crude steel capacity of major Indian Steel Producers

Crude Steel Capacity (million tones)	2007	2008	2009	2010
Tata Steel (India)	5.0	5.0	6.8	6.8
Essar Steel (India)	4.6	4.6	4.6	4.6
Ispat, Dolvi	3.6	3.6	3.6	3.6
JSW Steel	3.8	3.8	3.8	7.8
RINL	3.5	3.5	3.5	3.5
JSPL	2.9	2.9	2.9	2.9
SAIL	13.8	13.8	13.8	13.8
Bhushan Steel	03	03	03	03
Bhushan Power & Steel	1.4	1.4	1.4	1.4
Others	17.9	20.9	25.6	28.1

[8] World Steel Association

Table 8: Capacity Utilization Details

Capacity utilization (Percentage)			
Plant/Group	**2007-08**	**2008-09**	**2009-10**
1.0 SAIL Plants			
a) Bhilai Steel Plant	129	132	129
b) Durgapur Steel Plant	106	105	108
c) Rourkela Steel Plant	110	110	111
d) Bokaro Steel Plant	95	82	82
e) IISCO Steel Plant	92	83	79
f) Alloy Steel Plant	67	72	87
g) Vis. Iron & Steel	134	81	87
Total SAIL	**109**	**104**	**105**
2.0 RINL (VSP)	108	102	110
3.0 Tata Steel	100	113	97
4.0 JSW Steel	75	77	78
5.0 Ispat Industries	79	61	73
6.0 Essar Steel	77	73	75
7.0 Jindal Steel & Power	51	61	81
Other EAF/MBF/EOF	77	95	85
Induction Furnace Units	81	81	97
Total	90	88	89

2.0 ENERGY CONSUMPTION IN INDIAN IRON & STEEL INDUSTRY

Eight industries in India have been identified as energy intensive industries under PAT scheme: Aluminum, cement, fertilizer, iron & steel (including sponge iron), pulp &paper, Chlor-alkali, power plant & aluminum. They consume nearly 230 million Metric Tonnes of Oil Equivalent. Iron & Steel industry account for 15% of this total consumption.

The iron & steel sector is one of the most energy intensive sectors in India. The iron and steel industry, which primarily consumes coking coal and some high-grade non-coking coal, is the second largest consumer of domestic coal, although its consumption has decreased from 20% of total consumption in the country in 1970 to about 5% in 2008. Much of India's coal imports are being used by the steel industry as domestic coking coal supply has declined since the mid-1990s.

On an average, iron & steel plants are spending about 20-40% of the total manufacturing cost to meet their energy demands. In fact, Energy cost is considered as a major factor in pricing of the steel.

Table 9: Specific Energy Consumption figures of major Iron & Steel Industries in India[9]

Company	SEC (GCal / tcs)
Tata Steel (India)	6.46
Essar Steel (India)	5.90
RINL	6.05
Bokaro Steel Plant	6.43
Bhilai steel plant	6.32
Durgapur steel plant	6.63
IISCO Burnpur	8.18
Visvesvaraya Iron and Steel Plant	11.87
Rourkela Steel Plant	6.29

Predominantly, the power requirements of the iron & steel plants are met by the captive power plant. In case of many SAIL plants, the operations of the captive power plant have been taken over by NSPCL (NTPC – SAIL). NTPC Ltd formed a joint venture with SAIL on 50:50 basis in the name NTPC-SAIL Power Company Private Limited (NSPCL). NSPCL took over captive power plants of Bhilai Steel Plant, Rourkela Steel plant & Durgapur Steel Plant. The captive power plants of these plants have been operated on 50:50 basis by SAIL & NTPC. The other steel plants operate their own captive power plants and plants like Visveswaraya Iron and Steel Plant rely totally on the state electricity board.

Table 10: Captive Power Plant capacities of major Iron & Steel Industries in India

S. No	Company	Capacity (MW)
1	Bhilai Steel Plant	124 MW
2	Durgapur Steel Plant	120 MW
3	Rourkela Steel Plant	120 MW
4	Bokaro Steel Plant	302 MW
5	Rashtriya Ispat Nigam Ltd. (RINL)	250 MW
6	Jindal Steel & Power Ltd	250 MW
7	Essar Steel India Ltd. (ESL)	50 MW

The energy efficiency of steelmaking facilities vary depending on the production route, type of iron ore and coal used, the steel product mix, operation control technology, and material efficiency.

The major energy consumption energy consuming process in steel making is coke oven, sintering & blast furnace. They consume about 61.3% of the total energy consumed. The slabbing mill and hot strip along with others consume about 36.5% of the energy.

[9] BEE Notification

Steel producing routes:

The integrated steelmaking route, based on the blast furnace (BF) and basic oxygen furnace (BOF), uses raw materials including iron ore, coal, and limestone. On average, this route uses 1,400 kg of iron ore, 770 kg of coal, 150 kg of limestone, and 120 kg of recycled steel to produce a tonne of crude steel.

In BF – BOF route, energy is consumed in coke making, sintering, in blast furnace and for casting.

The electric arc furnace (EAF) route, based on the EAF, uses primarily recycled steels and/or direct reduced iron (DRI) and electricity. On average, the recycled steel-EAF route uses 880 kg of recycled steel, 150 kg of coal and 43 kg of limestone to produce a tonne of crude steel.

In the coal DRI – EAF route, energy is consumed as coal to produce sponge iron. Electricity is consumed for steel making. Electricity is consumed in the electric arc furnace for steel making.

The process route-wise production of crude steel in the country during 2005-06, 2009-10 and 2010-11 are shown in the table below and indicates the emergence of the electric route of production compared to the oxygen route:

Table 11: Production and share of different routes of crude steel in India[10]

Crude steel production by Process Route		**Percentage Share (%)**	
	2005-06	**2009-10**	**2010 - 11**
Basic Oxygen Furnace (BOF)	52	45	45
Electric Arc Furnace (EAF)	18	24	23
Induction Furnace (IF)	30	31	32
Total	100	100	100

The specific energy consumption (SEC) of Indian steel plants ranges from 6.09 GCal/tcs (25.3 GJ/tcs) to 8.17 GCal/tcs (34.2 GJ/tcs) . On an average the SEC is 30 GJ/tcs in India which is almost twice the world's leading plants.

The variation in SEC among the steel plants is mainly because of different processes, quality of coal, types of products and different energy efficiency levels.

2.1 Cost of Steel Making & Financial Strength

India is one of the most cost effective manufactures of steel in the world. The main reason behind this is India houses one of the largest iron ore deposits in the world. India is one of the main exporters of iron ore. The other reason behind cost effective production is that, labor cost associated with steel production is very less in India.

[10] Ministry of Steel Annual Report

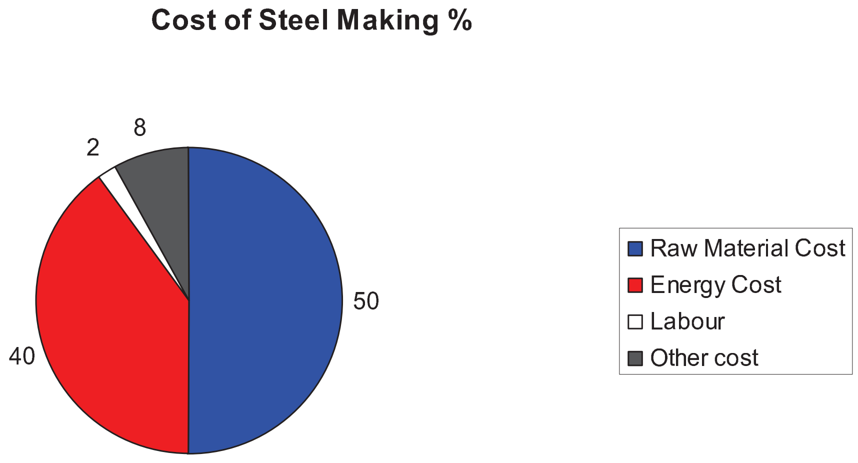

Figure 4: Variable cost percentage

The raw material cost has been in an increasing trend for the past 3 years and has increased almost up to 200%. Post 2009, recession period, the steel industry has been doing well financially. However, the raising trend in the cost of raw materials has been a cause of worry. If this trend continues, the steel makers might experience further raise in the manufacturing cost.

2.2 Future Growth Opportunities

The current low per capita consumption of steel of 56.3 Kg, compared to the world average of 220.8 Kg, strengthens the argument that the domestic steel industry has a huge growth potential.

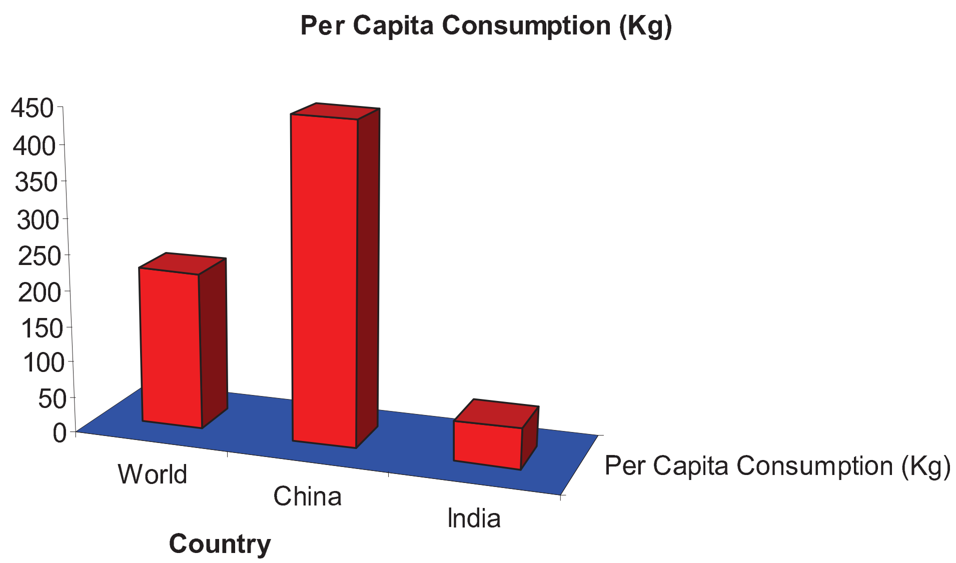

Figure 5: Per capita Consumption

India is heading to catch up with the world average of per capita income which will increase the growth of the iron & steel sector. India's GDP is constantly growing at the rate of 8 -9 % and to sustain this growth rate India will require to invest heavily in infrastructure. This in turn will have a positive effect in the growth of iron & steel sector.

The Indian steel industry has made significant progress in recent years backed by strong fundamentals. Even during the economic slowdown, the industry succeeded in sustaining positive growth, driven by strong domestic demand from the construction, automobile and infrastructure sectors and export of steel from India is less which has shielded it from international market fluctuations. The progress made by private sector players in brownfield expansions is significant. There is much upside in per capita consumption of steel in the country from its low base of around 56kg, with the increasing demand expected to lift per capita consumption to far higher levels.

The growth projections by several agencies unanimously predict that there would be significant growth in Indian steel industry. The projections by E&Y, IEA, CSE and CII are given below:

a) <u>Ernst & Young Estimate (E&Y)</u>

According to E&Y predictions, based on planned capacity of expansion projects, the total crude steel capacity in India is expected to be around 112 million tonnes by 2015, a growth rate of 9%. India is expected to become the world's second largest producer by 2015–16 if all planned capacity expansion projects become operational. Projects which are expected to be operational in the next three years include those by Tata Steel, JSW Steel, SAIL and Essar.

Table 12: Projected Steel Growth

Crude steel capacity (million tones) year-ending 31 March	2007	2008	2009	2010	2013F	2015F
Tata Steel (India)	5.0	5.0	6.8	6.8	9.7	12.7
Essar Steel (India)	4.6	4.6	4.6	4.6	9.2	9.2
Ispat	3.6	3.6	3.6	3.6	3.6	3.6
JSW Steel	3.8	3.8	3.8	7.8	11.0	11.0
RINL	3.5	3.5	3.5	3.5	6.3	6.3
JSPL	2.9	2.9	2.9	2.9	6.9	6.9
SAIL	13.8	13.8	13.8	13.8	18.0	24.17
Bhushan Steel	0.3	0.3	0.3	0.3	2.2	5.1
Bhushan Power & Steel	1.4	1.4	1.4	1.4	1.4	1.4
Others	17.9	20.9	25.6	28.1	29.2	31.6
Total crude steel capacity	56.8	59.8	66.3	72.8	97.4	112.5

b) *IEA Estimate*

International Energy Agency (IEA) has done a study on the Indian steel industry considering two scenarios for a 2050 perspective. One is the Baseline Scenario which reflects the developments that are expected on the basis of the energy policies that have been implemented or that have been approved and are to be implemented. Second is the BLUE Scenario which is target-driven and aims to achieve total emissions from the industry that are 28% lower in 2050 than the 2007 level. The BLUE Scenario, developed by the International Energy Agency, examines the least-cost pathways for meeting the goal of reducing global energy-related CO_2 emissions to 50% of 2005 levels by 2050 while also proposing measures to overcome technical and policy barriers. The BLUE Scenario is consistent with a long-term global rise in temperatures of 2.0°C, but only if the reduction in energy-related CO_2 emissions is combined with deep cuts in other GHG emissions.

In each scenario considered, the demand of the steel under low and high demand is also taken into consideration. Despite India's strong growth in demand for steel in recent years, the 2007 consumption of 53 kg/cap is well below the global average of 220 kg/cap.

Table 13: Projected Steel Growth

	2007	**Baseline – 2050**			**BLUE - 2050**		
		Low demand	**high demand**	**Strong growth**	**Low demand**	**High demand**	**Strong growth**
Crude steel production (million MT)	53	266	355	550	266	355	550

c) *Centre for Science and Environment Estimate*

The total steel production in India is expected to be around 300 million MILLION MTPA in the year 2030 -31. The total production through BOF route is expected to grow to 90 million MILLION MTPA in the year 2030 -31.

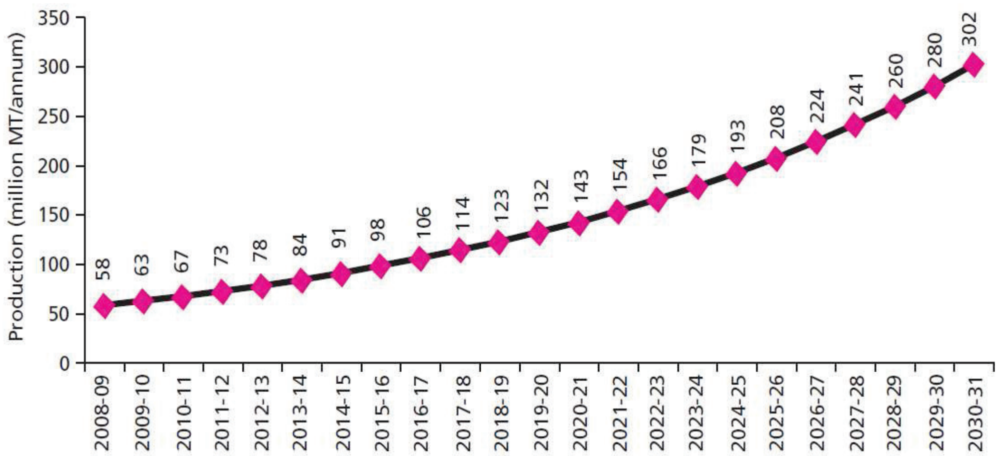

Figure 6: Green Rating Project 2009, Centre for Science and Environment, New Delhi

d) *CII Growth Projection*

CII's growth projection is based on the assumption that the GDP of India will grow at the rate of 8% till 2030. It is also based on the fact that the steel consumption's elasticity with respect to GDP is 1.33%.

Elasticity of 1.33% is taken, considering the fact that steel industry growth has been 1.33% more than that of GDP's growth for a period of last ten years.

Assuming an elasticity of 1%, steel production will be:

- 2020 : 158 MILLION MTPA
- 2030 : 374 MILLION MTPA

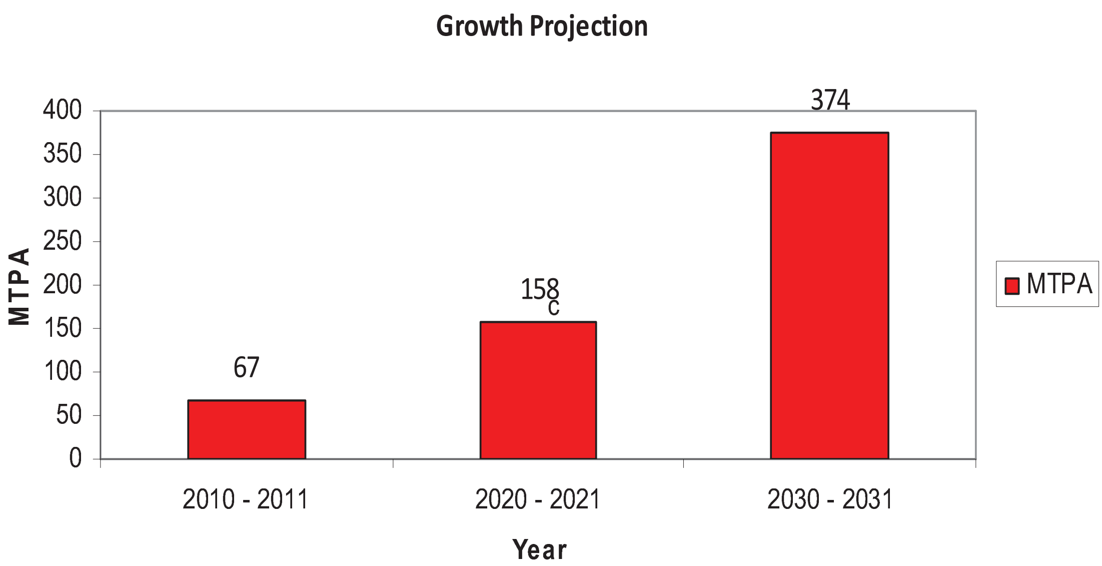

Figure 7: CII Estimate on steel industry growth projection

Growth projections for sponge iron industry:

- Growth projection for the year 2020:
  - Planning Commission Interim report : 45 million MTPA of crude steel
  - CSE : 68 million MTPA of crude steel
- Growth projection for the year 2030:
  - IEA : 79 million MTPA of crude steel
  - CSE : 176 million MTPA of crude steel

Table 14: Growth projections of Indian Steel industry

Year	Growth Projections (million MTPA)
2020	1) CSE - 143 2) CII - 158
2030	1) CSE - 302 2) CII - 374
2050	1) IEA - 550

2.3 Challenges Faced By the Iron & Steel Industry

Indian iron & steel faces some serious challenges which affect the energy efficiency of the industry. Though certain problems can be solved by the industry itself, some factors are beyond the control of the industry.

Factors which are beyond the control of the industry and which affects the energy efficiency to a large extent are:

i. *Low quality of iron ore*

Higher alumina content in iron ore will reduce the productivity of blast furnace. Due to higher alumina content, the quantity of slag produced will be higher and thus higher quantity of ore has to be added for achieving same quantity of output. For every 1% increase in alumina content, coke rate in BF increases by 20 – 25 kg/thm[11]

ii. *Inferior quality of coal*

Quality of coal, in terms of calorific value and ash percentage, available to iron & steel industry is deteriorating by day which in turn decreases the energy efficiency of the industry

iii. *Scarcity of coking coal*

The availability of coking coal is a key issue for the Indian steel industry. The scarcity of the resource in the country will have a huge impact on the production target. Majority of the coking coal is presently being imported. China continues to be the world leader in coking coal production and consumption. China has imposed several regulations on the export of coking coal in order to meet its ever growing domestic steel production. This has caused an imbalance in the world's coking coal market and this is also affecting the Indian steel industry.

[11] thm – tons of hot metal

iv. *Raw material price volatility*

The price of raw materials has become a major factor of concern for the Indian steel producers. All the major steel producers in India are trying to secure raw material for their future needs by acquiring mines or entering into joint ventures. Strict land acquisition laws can slow the process. The volatility in price of raw materials has also increased the cost of steel making.

The other factors which affect energy efficiency are detailed below.

v. *Retrofitting*

Projects like coke dry quenching, top pressure turbine and sinter bed heat recovery are found to be suffering on account of space availability. Plants which do not have these projects by design find it very difficult to retrofit within the available space. Therefore retrofitting of these projects is almost non-existent in Indian steel plants.

vi. *Vintage of the plants*

Vintage of the plants has a key role in higher energy consumption of Indian steel plants. Many of the public sector units are old plants with vintage technologies. Introduction of new technologies in these plants proves to be very tedious and thus hindering the progress of energy efficiency activities.

vii. *Cost of energy efficiency*

Any modification in the process for energy efficiency activities in steel plant is capital intensive. Therefore, several plants are apprehensive to go ahead with energy efficiency activities. The industrial lending rates of the banks are very high in India and thus the Internal Rate of Return (IRR) is also high. This makes projects less attractive. In addition to this, there are no separate funds available for energy efficiency activities.

2.4 Policies favouring energy activities:

i. *Pollution Control Board's stand on Coke Dry Quenching*:

Jharkand, one of the states with several iron and steel plants in India, has made it mandatory for all new installation of coke oven batteries to be with coke dry quenching. Indian iron & steel industry is in the midst of an expansion stage. This ruling of the pollution control board will force all new installations to be with CDQ. This may also motivate the other steel intensive states to come out with a similar ruling and may make the CDQ common in the Indian Iron and Steel industry.

ii. ***PAT Mechanism*:**

Under PAT mechanism all the designated consumer are required to reduce their energy consumption by a certain percentage. This policy is sure to drive the energy efficiency activities of the industry on a longer run.

2.5 Environmental Issued Faced by the Sector

Environmental protection in Iron & Steel plants is essentially linked to technology adopted for iron & steel making, adoption of cleaner technologies and efficient disposal/re-use of generated bye-products and waste.

Despite significant progress and intent by stake holders, environmental issues in Steel sector still continue to be the focus of policy debates, legislation and regulation.

Issues prevalent in sector

- Air emissions include contributions from every stage of the process:
  - Coke making is a major source of VOCs[12] and carbon monoxide emissions
  - Blast furnace iron making generates large quantities of sulfur and nitrogen oxides and carbon monoxide
  - Downstream processes such as casting and rolling account for significant releases of sulfur oxides as sulfur is liberated from the metal surface
- Wastewater
  - Wastewater from coke making has high contaminant levels, requiring extensive removal and treatment before disposal.
  - Wastewater generation from iron making, steelmaking, and downstream processes, much of which results from cooling. water and from wet scrubbers, is somewhat mitigated by significant rates of reuse and recycling
- Solid waste produced are of high quantity
- The sector is a very large consumer of energy, and as such is a major contributor to greenhouse gas emissions.

[12] Volatile Organic Compound

2.6 Energy Consumption Trends in Indian Steel Industry

India produces around 68.3 MT of crude steel per annum contributing 4% of the total world crude steel production. Indian iron & steel industry has one of the highest SEC figures in the world.

Decline in Energy Consumption:

Historically, energy consumption is on the declining trend

- 1990 : 10 GCal / tcs
- 1995 : 8.69 GCal / tcs
- 2010 - 11 : 6.9 GCal / tcs

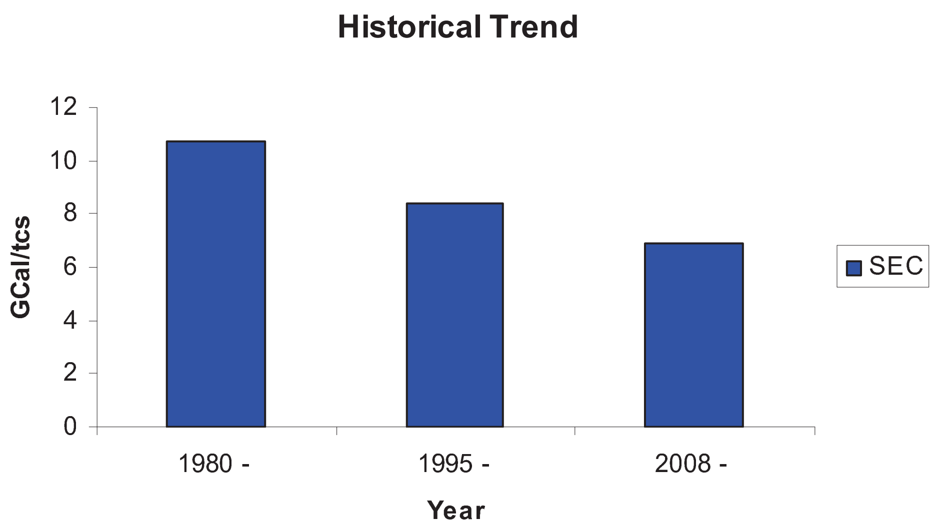

Figure 8: Historical Trend[13]

From the historical data it can be decoded that the decline in the energy intensity has been in the range of 2.5 percent annually. 1990's saw a drastic increase in capacity addition and production in the iron & steel industry. Majority of the addition came from the private sector. The private sector went in with advanced technologies which reduced the energy consumption to a large extent. This had a direct bearing on the SEC figures of the industry.

[13] SAIL Presentation

3.0 MAPPING STAKE HOLDER INITIATIVES

Indian iron & steel industry contributes 4% of the total steel produced in the world and are considered to be the next biggest thing in world steel industry. However, the energy efficiency levels of the Indian steel industry are low compared to its global counter parts.

Several initiatives have been taken by the sector by itself in terms of energy efficiency and GHG emission reduction opportunities. In case of integrated steel plants, there has been a continuous interaction among the plants and the best practices are being shared throughout the sector. However, what the sector as a whole lacks is the support from external agencies in terms of mitigation opportunities. The cost of mitigation in steel industry has traditionally been very high and assistance from the external agencies in terms of financial and technical help would be highly appreciated. External agencies can help the industry in terms of technology transfer, cross pollination of ideas, financial and technical aid.

There exists a contrary scenario in the case of sponge iron plants. Most of the sponge iron plants in India are entrepreneur style and the interactions within the sector is very low. Best practices in the sector are not shared, expect for a very few cases like waste heat recovery from kiln. Awareness creation and energy efficiency financing in this sector would be highly appreciated.

This section deals with various stake holders and their initiatives in iron and steel sector

International agencies actively participating in efficiency improvements

- NEDO : New Energy and Industrial Technology Development Organization, Japan
- APP : Asia Pacific Partnership
- UNIDO : United Nations Industrial Development Organization
- IFC : International Financial Corporation
- WSA : World Steel Association

National agencies in efficiency improvement of steel industry

- Ministry of Steel
- BEE : Bureau of Energy Efficiency
    - Perform Achieve and Trade
- JPC : Joint Plant Committee, Government of India
- CII : Confederation of Indian Industry

a) NEDO: New Energy and Industrial Technology Development Organization

NEDO is one of the most active players in the Indian iron and steel industry. NEDO has helped in implementation of several energy saving measures in Indian steel plant.

NEDO's Role

- Promotion of research and development of energy, environmental and industrial technologies as well as acquisition of emission reduction credits through the Kyoto Mechanisms.
- Development, demonstration and introduction of promising technologies that private sector enterprises cannot transfer to the practical application stage by themselves due to the high risk and long development period required.
- Efficient project management making the best use of the R&D capabilities and know-how of industry, academia and government.

NEDO's projects in India

- Coke dry quenching and waste gas recovery from hot stove for TATA Steel, Jhamshedpur
- Waste heat recovery from sinter bed
    - Projected power generation is 20 MW

The mode of operation of NEDO is that technology and all the equipment necessary to set up an energy saving measure would be given to the plant by NEDO. The expenses of installation have to be borne by the plant.

b) Asia Pacific Partnership

The Asia-Pacific Partnership on Clean Development and Climate is an innovative new effort to accelerate the development and deployment of clean energy technologies. It is an International public-private partnership among Australia, Canada, India, Japan, China, South Korea and the United States.

The partnership aimed at deployment of best available technologies, practices and environmental management systems in partnership countries.

c) UNIDO

UNIDO is a specialized agency of United Nations which supports industrial development for inclusive globalization and environmental sustainability.

UNIDO's mandate is to promote and accelerate sustainable industrial development in developing countries and economies in transition. UNIDO promotes sustainable patterns of industrial consumption and production.

As a leading provider of services for improved industrial energy efficiency and sustainability, UNIDO assists developing countries and transition economies in implementing multilateral environmental agreements and in simultaneously reaching their economic and environmental goals

d) IFC

IFC, a member of the World Bank Group, is the largest global development institution focused exclusively on the private sector in developing countries.

IFC aim to increase investments in the efficient use of energy, water, and materials leading to reduced costs for businesses, less waste and measurable reductions in greenhouse gas emissions. IFC supports development of profitable and environmentally sound projects, business models, and sector wide engagements to change market behavior and support more environmentally sustainable, low carbon economic growth.

IFC's projects in India

IFC has funded Kalyani Gerdau Steels, India for the waste heat recovery project from coke oven

e) WSA

The World Steel Association is one of the largest industry associations in the world. WSA members produce around 85% of the world's steel.

WSA acts as the focal point for the steel industry, providing global leadership on all major strategic issues affecting the industry, particularly focusing on economic, environmental and social sustainability.

WSA has recently launched CO_2 Breakthrough Program which creates a platform for exchanging information on innovative technologies

f) Confederation of Indian Industry (CII)

CII is a non-government, not-for-profit, industry led and industry managed organization founded over 117 years ago plays a proactive role in India's development process. It works to create and sustain an environment conducive to the growth of industry in India, partnering industry and government alike through advisory and consultative processes. It plays a proactive role in promoting the Latest Technologies, Energy Efficiency and GHG inventorisation in the Indian industry.

CII is actively involved in promoting energy efficiency improvement in Indian Iron & Steel industry. CII National Committee on Steel is represented by all segments of Steel and its allied industries across India. "Steel Summit" is an annual event which is organized under the aegis of CII National Committed on Steel in partnership with the Government of India, which discusses and deliberates on issues pertaining to the Steel Industry and makes recommendations to the Government.

g) Ministry of Steel

Ministry of steel plans and coordinates the growth and development of steel industry in both public and private sector. Ministry of steel formulates policies in the areas of:

- Pricing & production
- Import and export of iron and steel

Ministry of steel works relentlessly to make steel industry to be the most sustainable industry in India and aligns policies to transform India into leader in Steel sector

h) BEE & Perform Achieve & Trade

Perform Achieve, and Trade (PAT), a market-based mechanism to make improvements in energy efficiency in energy-intensive large industries and facilities more cost-effective by certification of energy savings that could be traded.

The PAT scheme is expected to act as a catalyst for all the energy efficiency activities in India. Under PAT mechanism all the designated consumer are required to reduce their energy consumption by certain percentage. This policy is sure to drive the energy efficiency activities of the industry on a longer run.

i) Joint plant committee

JPC was constituted by the Government of India to formulate guidelines for the production, allocation, costing and supply of iron and steel materials. JPC has a comprehensive and impartial data bank on the industry.

4.0 ACTION PLAN FOR ENERGY EFFICIENY

Present Status

Indian steel industry is one of the oldest industries in India. Several integrated iron & steel industry are almost 40 – 50 years old.

Newer technology adoption has taken longer time in steel industry as compared to other industries. Traditionally, Indian steel industries have been in plug and forget approach. For example, in some integrated steel plants, Russian technologies installed during installation stage of the plant are still in operation.

Around 60% of the plants are public sector plants. Though energy Efficiency in design is adopted in certain cases, further energy efficient activities are time consuming. Energy efficiency activities are not moving at the desired pace.

The following are some of the main factors affecting the energy efficiency activities in Indian iron & steel industry.

Reasons for high operating SEC:

- Inferior raw material
  - High alumina and silica content in iron ore
  - Poor quality of coal
- Vintage of plants
  - Most plants operate outdated technologies
  - Mostly set up in 60s – 70s
  - Problems in retrofitting
- Reluctant to go for higher technology because of higher investments
- Lower levels of recycling
  - Life of steel in India is high

Approach for Energy Efficiency:

The Sector activities should be focus on:

- ❖ Reducing gap between present Indian and global average SEC figures
    - ➢ Indian plants : 6.9 GCal/tcs
    - ➢ World average : 4.5 GCal/tcs
- ❖ System driven energy efficiency activities
    - ISO 50001
- ❖ Equipment level efficiency improvement
- ❖ Complete recovery of waste heat from furnaces, coke oven & sinter plants
- ❖ Higher level of technological adoption throughout the sector
- ❖ Complete utilization of waste heat recovery in sponge iron plants

From the SEC figures mentioned above, it is very clear that the opportunities for energy savings are very high.

Perform, Achieve & Trade Act (PAT):

Under PAT mechanism all the designated consumer are required to reduce their energy consumption by certain percentage. This policy is sure to drive the energy efficiency activities of the industry on a longer run.

Iron & Steel industry account for 36 million MTOE about 15% of Indian industrial energy consumption. Mmajority of the iron & steel industry has started taking initiatives in identifying the best ways of achieving and exceeding the PAT targets set by BEE. The minimum and maximum targets set for the iron & a steel industry is given below.

Table 15: PAT Target for Iron & Steel Sector

Sector	Minimum Target (%)	Maximum Target (%)
Iron & Steel	**2.52**	**9.07**

The target has been given to each of the designated consumers (67 in total) and total iron and steel sector has target of reducing 1.48 million MTOE[14].

Steel making: Major Sections

There are five major sections in an integrated steel plant. They are:

- Iron ore preparation - Sinter making
- Coke making
- Iron making - Blast furnace
- Steel making - Basic oxygen furnace
- Casting

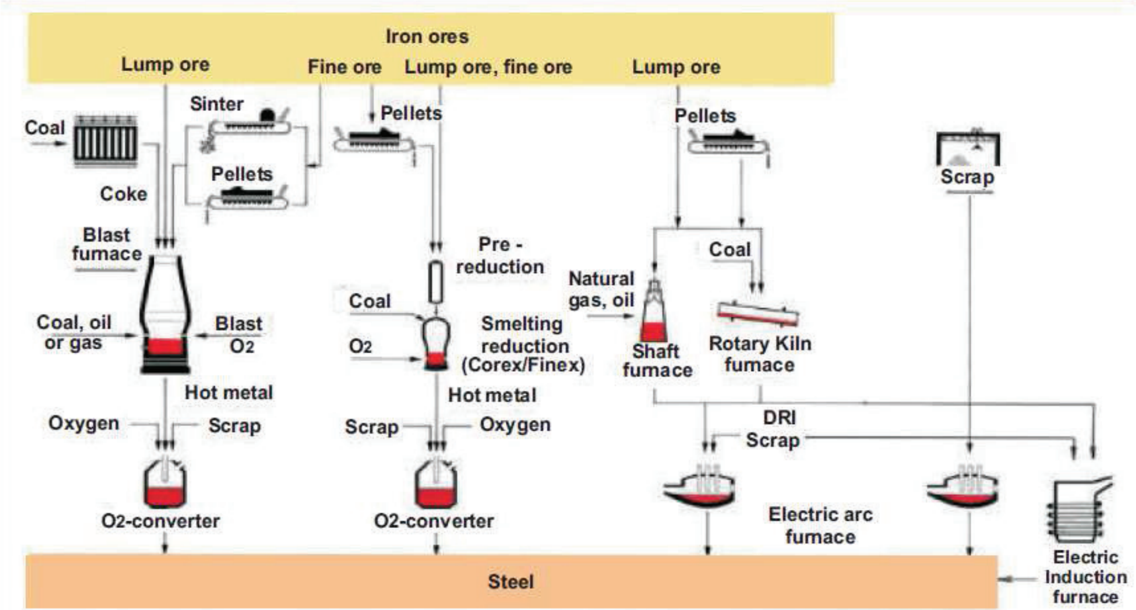

Figure 9: Iron & Steel Process

[14] BEE Notification

4.1 Energy Efficiency Options for Indian Iron & Steel Industry

List of Energy Efficiency Projects

The reduction opportunities in each of the section are mentioned below:

- Sinter Making
  - Improvement in segregated charging of sintering materials
  - Exhaust heat recovery system for sintered ore cooling
  - Sensible heat recovery from main exhaust gas of sintering machine
  - Arresting air leakages in Sinter plant
- Coke Making
  - Coal moisture control
  - Optimizing efficiency of ovens by arresting air leakages
  - Variable speed drives for coke oven gas compressors
- Iron Making
  - Preheating through waste heat recovery from Hot stoves of Blast Furnace
  - Computer-aided Hot stove operation for optimization of BF gas
  - SNORT valve operation
  - Blast furnace optimization via modeling using CFD
- BOF Steel Making
  - BOF gas and Sensible heat recovery
- Secondary Steel Making
  - Energy saving operation of electric arc furnace
  - *CoJet (*Coherent Jet Gas Injection Technology)

- Casting
  - Adoption of continuous casting
  - Thin slab casting
  - Efficient ladle preheating
  - Heat balance of Furnace
- Hot Rolling
  - Hot charging and direct rolling mill
  - Waste heat recovery from cooling water
- Cold Rolling and Finishing
  - Heat recovery from Annealing line
  - Reduced Steam use in Pickling line
  - 'Convectional' heating type heat treatment furnace of wire rod coil
  - Low temperature forge welded pipe production method
- Others
  - VFD for coke oven gas compressors
  - VFD for ventilation fans
  - Oxygen level control and variable speed drives for combustion air fans
  - Waste heat recovery from sponge iron kilns
  - Descaling pump (conversion to plunger pump)
  - Preventive maintenance, energy monitoring and management system

List of Best Available Technologies (BATs) for Iron & Steel

- Sinter Making
  - Multi – slit burner for sinter furnace
- Coke Making
  - Coke dry quenching (CDQ)
  - Automatic combustion control for coke ovens
- Iron Making
  - Top pressure recovery turbine (TRT) for BF top gas
  - Pulverized coal injection (PCI) system for BF
- Others
  - Recuperative burner

Technology No.1

Waste Heat recovery from sinter bed

Background

In Sintering process, fine iron ore is mixed with fine coke, powdered limestone and other ingredients, are agglomerated into a sintered ore in the sintering machine, which is the input raw material to the blast furnace.

Sintered ore discharged from the sintering machine is around 600 – 700 deg C, which cannot be transported directly to feed the blast furnace. Hence, an air-cooler installed after the sinter machine cools the red-hot sinter. In India, the present practice is to vent out the exhaust gas from the sinter cooler.

The exhaust gas from the sinter bed air-cooler carries a temperature of 250-300 deg C. Thus, heat recovery at the sinter plant is a means of improving efficiency of sinter making.

Energy Saving Project

The waste heat from the sinter cooler can be utilized in two ways:

- ❖ Power Generation
- ❖ Preheating of Combustion air

The Waste heat recovery project from the sinter cooler improves efficiency through preheating and power generation applications. Utilization of waste heat for preheating applications is being done by few plants like SAIL (Durgapur, Rourkela) and Tata Steel. Presently, there is no installation of power generation from the waste heat of sinter cooling. RINL is currently working on setting up a WHR boiler with a generation capacity of 17.5 MW with the support from NEDO.

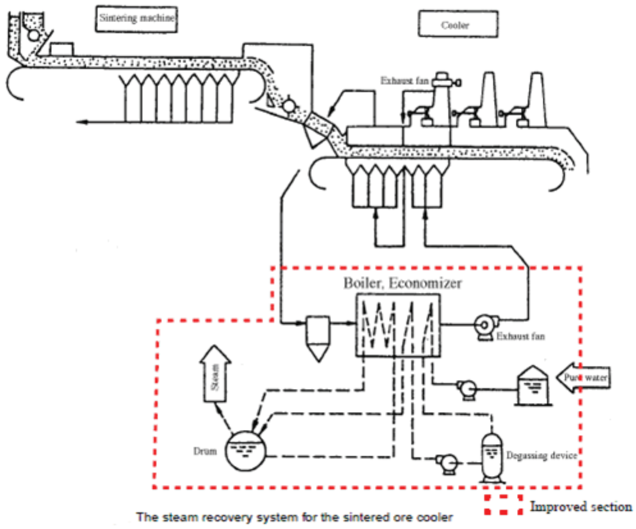

Figure 10: Waste Heat Recovery from Sinter Bed[15]

[15] NEDO Iron & Steel report

Barriers in Implementing

- High Investment cost for installing power generation plant
- Space availability for installing waste heat recovery boiler in existing plants

Cost Benefit Analysis

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 33.60 million	Rs. 33.60 million
MTOE equivalent	2800	2800
PAT benefit[16]	--	Rs. 28.00 million
Total benefit	Rs. 4.88 million	Rs. 61.60 million
Investment	Rs. 134.4 million	Rs. 134.40 million
Payback period	48 months	26 months
Replication Potential		
Saving potential	0.028 GCal / tcs[17]	
Number of plants	95% of the plants	
Sector savings	150000 Mtoe	

[16] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[17] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.2

Improvement in segregated charging of sintering materials

Background

Raw materials required for the blast furnace are first agglomerated in the sintering machine. The present charging operation process for the sintering machine has not been able to maintain constant particle size and reduce the material return ratio. Limonite, one among the raw materials for sintering is inexpensive, but it decreases the productivity in the sintering process because it has coarse particle size and combines strongly with water.

Energy Saving Project

To overcome these problems, an improved charging method is adopted using a drum chute and segregation slit wire. The purpose of the drum chute is to reduce the height difference (while dropping) during charging of material, while the particle size distribution is controlled by the segregation slit wire. During this process, constant particle size is maintained with an increased permeability of the sintering mixture, resulting in improved sintering efficiency and reduced material return ratio.

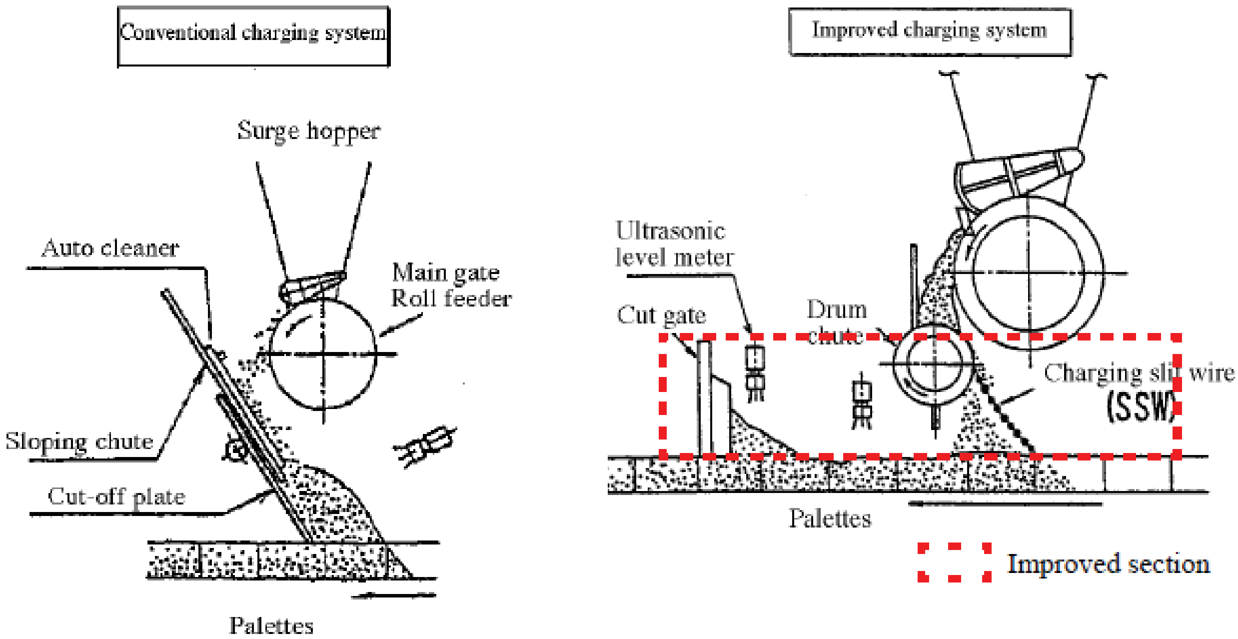

Figure 11: Improvement in segregated charging of sintering materials[18]

[18] **NEDO Iron & Steel report**

Cost-Benefit Analysis

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 34.80 million	Rs. 34.80 million
MTOE equivalent	2900	2900
PAT benefit[19]	--	Rs. 29.44 million
Total benefit	Rs. 34.80 million	Rs. 64.24 million
Investment	Rs. 69.60 million	Rs. 69.60 million
Payback period	24 months	13 months
Replication Potential		
Saving potential	0.029 GCal / tcs[20]	
Number of plants	100% of the plants	
Sector savings	174000 Mtoe	

[19] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[20] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.3

Sensible heat recovery from main exhaust gas of sintering machine

Background

The sintering process is a pre-treatment step in the production of iron, where fine particles of iron ores, limestone and secondary iron oxide wastes (collected dusts, mill scale), are agglomerated by combustion. The exhaust gas from the sintering machine, used to be dissipated into the atmosphere. From the adoption of Waste heat recovery from the sinter bed cooler, the potential for heat recovery from the exhaust gas was realized. In this improvement, the heat is recovered and circulated back to the sintering machine, thus enhancing recovery and energy efficiency.

Energy Saving Project

In this process, using the waste heat boiler, the heat is recovered from the exhaust gas of the temperature of about 380°C exhausted from the sintering machine, and then the gas is returned back to the sintering machine. By this method, the amount of coal consumption reduces for the sintering process. The heat recovery is increased by about 30% and at the same time, consequent emission into the atmosphere is reduced.

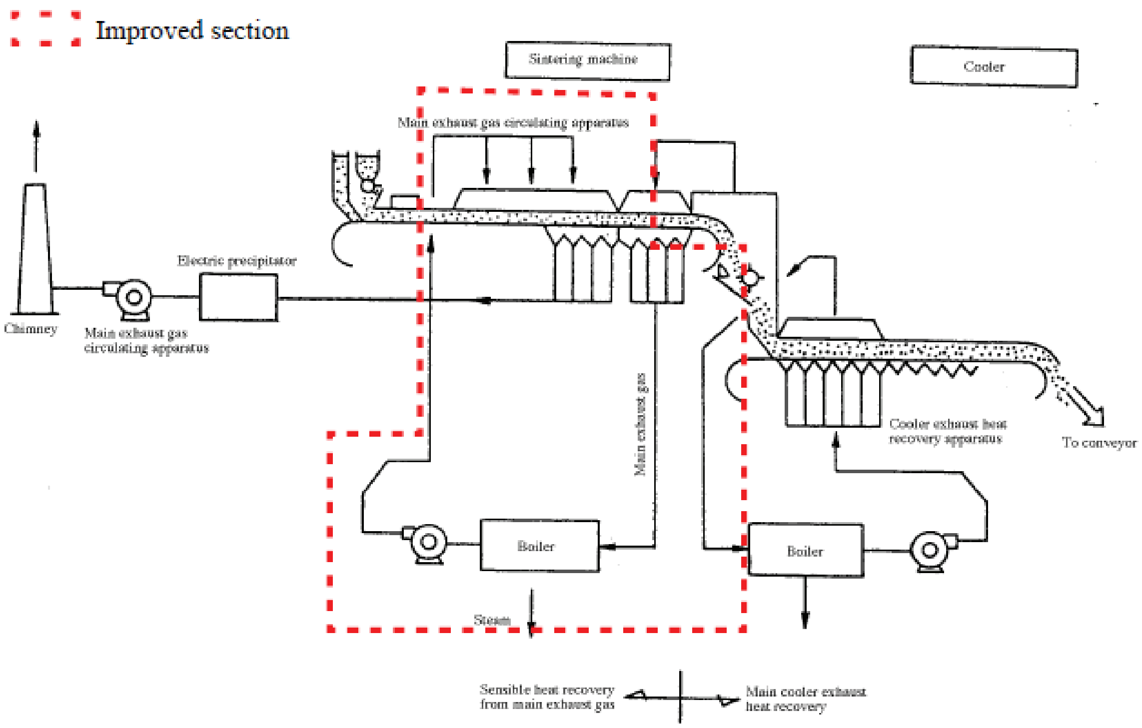

Figure 12: Schematic diagram of sensible heat recovery from sintering machine[21]

[21] **NEDO Iron & Steel report**

Cost-Benefit Analysis

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 45.00 million	Rs. 45.00 million
MTOE equivalent	4500	4500
PAT benefit[22]	--	Rs. 45.00 million
Total benefit	Rs. 45.00 million	Rs. 90.00 million
Investment	Rs. 135.00 million	Rs. 135.00million
Payback period	36 months	18 months
Replication Potential		
Saving potential	0.045 GCal / tcs [23]	
Number of plants	70% of the plants	
Sector savings	189000 Mtoe	

[22] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[23] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.4

Coal Moisture Control

Background

Coal is the major source of energy for an Iron & Steel industry. Majority of the coal is fed into the coke oven batteries for producing coke, which is required for the iron making process. In general, there is not much control on the moisture content of the coal before entering the process. This leads to loss of energy, as energy will be spent to evaporate the water content in the input coal. The methods for providing heat through external sources for vaporizing the water content in the coal before entering the process is not economical in nature. Hence, the Coal Moisture Control (CMC) which was started by the Iron & Steel industries of Japan, is a method to control the moisture content of the input coal, thus reducing the energy spent in the coke ovens.

Energy Saving Project

Coal moisture control uses the waste heat from the coke oven gas for drying the input coal for coke making. Generally, the moisture content in coke varies from 8 - 13% for good coking quality coal. Drying can further reduce its moisture content to a consistent 6.5% then controlled to 6% before entering the coke oven by belt conveyer. After drying, the coal material will be classified and separated according to granularity grade.

After moisture control and separation, the coal material of fine granules will be conveyed to coal tower through transportation system and coal material of coarse granules will be fed into the pulverizer to be pulverized and then conveyed to coal tower. The exhaust gas out of moist control will be gathered at the main pipe and dust-removed by dust remover and then discharged into the air. The coal dust collected from each dust remover will be formed through forming machine and then conveyed to coal tower.

This method reduces the heat consumption for carbonization and utilizes a large amount of non-coking coal. Thus, the reduction of moisture of coal before entering coke ovens can reduce the fuel consumption, increase productivity and quality of coke.

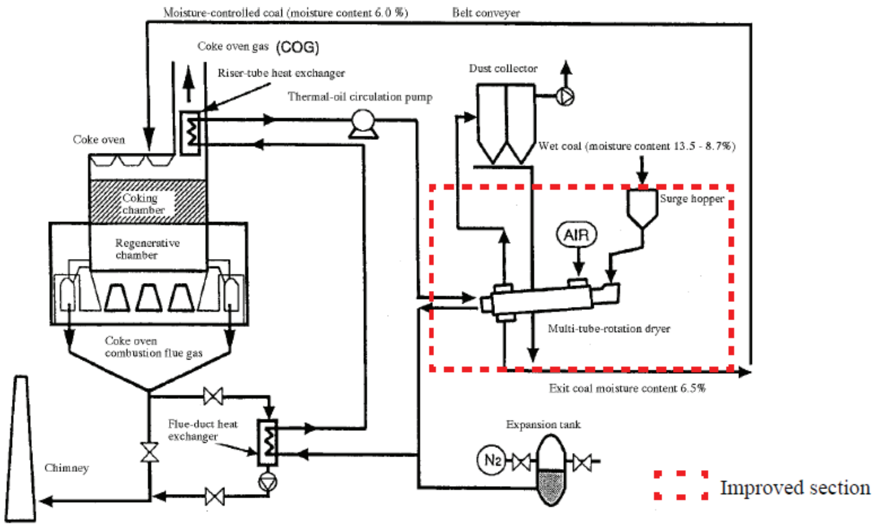

Figure 13 Schematic layout of moisture control in coal

Cost Benefits Analysis

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 64.60million	Rs. 64.60million
MTOE equivalent	6460	6460
PAT benefit[24]	--	Rs. 65.00 million
Total benefit	Rs. 64.60 million	Rs. 129.00 million
Investment	Rs. 193.80 million	Rs. 193.80 million
Payback period	36 months	18 months
Replication Potential		
Saving potential	0.065 GCal / tcs[25]	
Number of plants	70% of the plants	
Sector savings	273000 Mtoe	

[24] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[25] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.5

Automated Combustion Control of Coke Ovens

Program heating adjusts and optimizes the heating condition in each coking chamber in accordance with the state of coal carbonization. It saves energy by reducing coking energy consumption. It also improves the coke quality.

Automation includes

- Measurement of flue gas temperatures, coke oven gas temperature, red-hot coke temperature, etc
- Electric valve controllers, drafting pressure controlling waist dampers, air-fuel ratio and Charge scheduling
- Control of combustion in each chamber with specific parameters of charged coal (temperature, volume, moisture, etc) and operation (target heating time, etc)

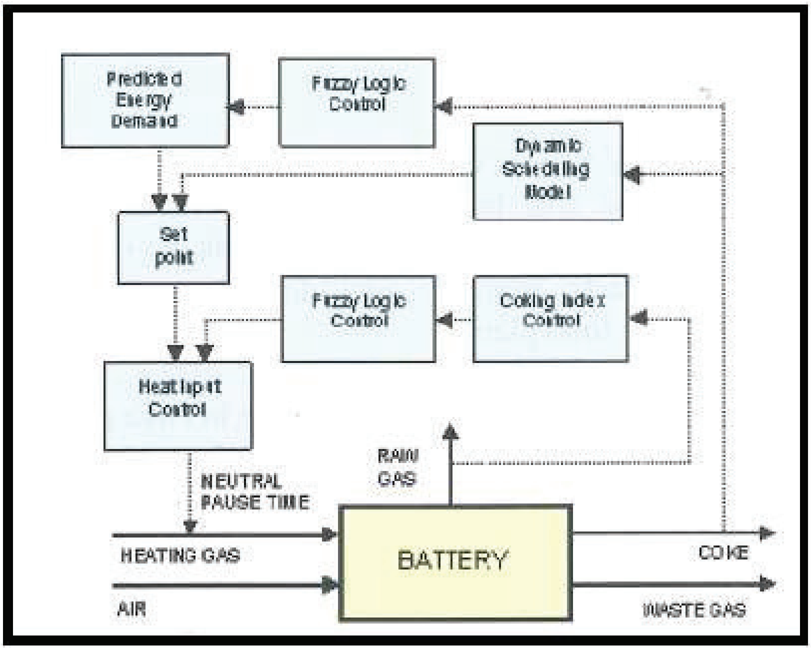

Figure 14: Automation combustion control of coke ovens

Present Status

Computerized operation of coke ovens has been implemented at plants of TATA Steel, RINL and Durgapur Steel plant. All other plants are being operated in manual control. Manual operation of coke oven increases the consumption of fuel since it doesn't have a finer control.

RINL has implemented computerized control for coke ovens for one of their new batteries. The savings of RINL is in around 70 kCal / kg of coke produced.

Barriers in Implementing

1) No wide knowledge of benefits of automation
2) Investment cost is very high
3) Retrofitting options are limited
4) Shut down of coke oven plants has to be taken for retrofitting options

Potential to scale up

Several plants have gone for computerized operation of coke ovens. TATA steel, RINL, Durgapur steel plant has gone for computerized operation. Other plants are still operating with manual control. Computerized operation of coke oven can be implemented in at least 5 plants in the remaining plants.

Benefits:

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 43.20 million	Rs. 43.20 million
MTOE equivalent	5400	5400
PAT benefit[26]	--	Rs. 54.00 million
Total benefit	Rs. 43.20 million	Rs. 97.20 million
Investment	Rs. 129.60 million	Rs. 129.60 million
Payback period	36 months	16 months
Replication Potential		
Saving potential	0.054 GCal / tcs[27]	
Number of plants	40% of the plants	
Sector savings	129600 Mtoe	

[26] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[27] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.6

Coke Dry Quenching (CDQ) Technology

In an integrated steel plant, huge quantity of heat gets wasted in direct and indirect cooling. In the conventional coke making process in steel plants, red hot coke is pushed out of coke ovens and quenched with large quantity of water resulting in evaporation of water into the atmosphere. Naturally the heat energy is lost in the process. In addition, quenching of coke results in air and water pollution. Wet coke quenching is the conventional process in Indian Iron & Steel sector.

Coke dry quenching (CDQ) is an alternative to the traditional wet quenching of coke. This process offers distinct advantages of sensible heat recovery, conservation of water and zero air and water pollution. This is an established technology, popular in the more advanced countries. The dry coke produced in the process enhances the productivity of blast furnaces, the work horses of integrated steel plants.

In the CDQ system, the red-hot coke is cooled by an inert gas circulating in an enclosed chamber, thereby preventing the release of coke dust into atmosphere. The thermal energy of the red-hot coke is captured by the inert gas and is then used for generating steam and thus power.

Presently, CDQ installations are successfully executed at RINL, NINL (Neelachal Ispat Nigam Limited) and Tata Steel. RINL has implemented CDQ at design and generate 15MW of energy from the set-up. Tata Steel has retrofitted their existing wet quenching process to CDQ with the support of NEDO.

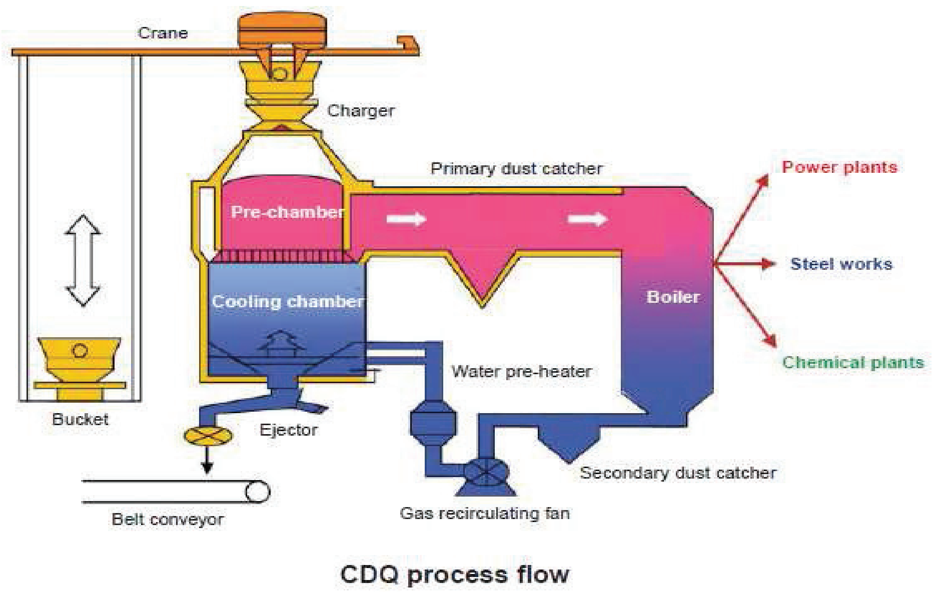

Figure 15: CDQ Process Flow

Barriers in Implementing

- Investment cost is very high & Space availability for installing in existing plants

Replication Potential

Only RINL & TATA steel has implemented this measure. No other plants have gone for Coke Dry Quenching. Potential to scale up this measure is enormous in Indian steel industry. All integrated steel plants can adopt this measure.

Benefits

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 336.00 million	Rs. 336.00 million
MTOE equivalent	28000	28000
PAT benefit[28]	--	Rs. 284.00 million
Total benefit	Rs. 336.00 million	Rs. 620.00 million
Investment	Rs. 1000 million	Rs. 1000.00 million
Payback period	36 months	8 months
Replication Potential		
Saving potential	0.28 GCal / tcs[29]	
Number of plants	70% of the plants	
Sector savings	1100000 Mtoe	

Table 16: Sample CDQ operating data

Tata Steel CDQ No. 5, 6, 7	
Capacity	135 ton/hr
Temperature of Charged coke	1025 deg C (Avg), 1050 deg C (Max)
Temperature of Discharged coke	200 deg C
Steam Generation	77 ton/hr
Steam Pressure	6.28 Mpa
Steam Temperature	485 deg C
Total gas volume	192,000 Nm3/hr

[28] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[29] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.7

Preheating through WHR from Hot stoves of Blast Furnace

Background

The exhaust from the heat stoves is around 275°C. This heat can be recovered and can be used for some other application. By recovering heat from the flue gas generated in heating the hot stoves and using this heat for preheating the fuel and stove combustion air, the overall thermal efficiency of the hot stoves can be improved resulting in substantial energy savings and optimized operating costs.

Presently, this project has been implemented in Tata Steel, Durgapur Steel plant and RINL for preheating the combustion air to the stove. In Tata steel, the project is supported by NEDO.

Energy Saving Project

This device recovers the sensible heat of the flue gas generated in heating the hot stoves which supply hot blast to the blast furnace and uses this heat in preheating fuel and combustion air for the hot stoves. Installation of this device improves the combustion efficiency of the hot stoves, thereby saving energy.

This device (system) comprises two heat exchangers.

- One is a heat-receiving side heat exchanger which receives the flue gas discharged from the hot stove
- The second is a heating side heat exchanger which preheats the combustion air and fuel using the sensible heat of the flue gas received by the heat-receiving side heat exchanger.

The preheated combustion air and fuel gas are supplied to the hot stoves. Heat exchange methods are classified as (1) rotary type, (2) plate type, and (3) heat pipe type, depending on the type of heat exchanger.

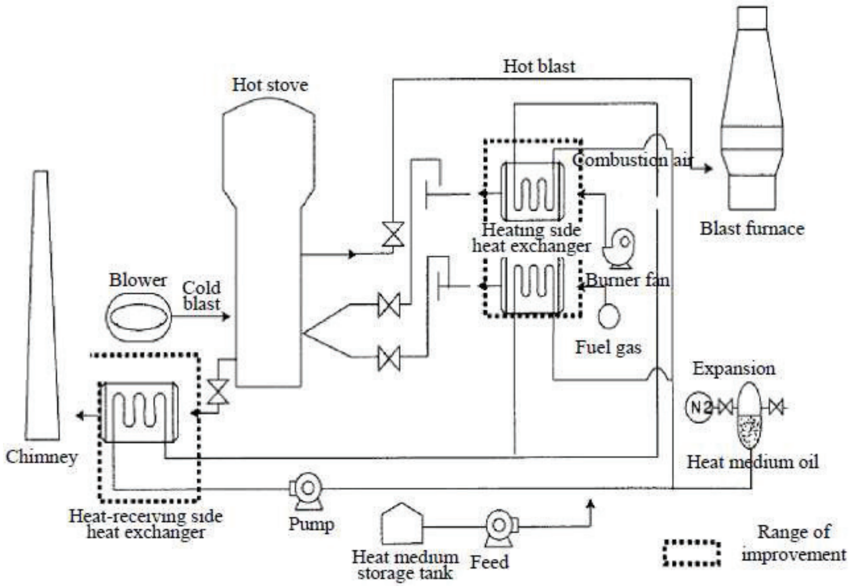

Figure 16: Preheating through WHR from Hot stoves of Blast Furnace

Cost Benefits *Analysis*

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 39.60 million	Rs. 39.60 million
MTOE equivalent	3300	3300
PAT benefit[30]	--	Rs. 33.50 million
Total benefit	Rs. 39.60 million	Rs. 73.10 million
Investment	Rs. 118.8 million	Rs. 118.80 million
Payback period	38 months	20 months
Replication Potential		
Saving potential	0.033 GCal / tcs[31]	
Number of plants	50% of the plants	
Sector savings	99000 Mtoe	

[30] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[31] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.8

Top Pressure Recovery Turbine

This is a power generating system which utilizes and converts the physical energy of high-pressure blast furnace top gas into electrical energy using an expansion turbine. Although the pressure difference is low, due to high volume of blast furnace gas generated, power generation is feasible by expansion through a turbine. In general, without the top pressure recovery turbine, the blast furnace gas is treated which decreases leads to decrease in its pressure and temperature. The key technology of TRT is to secure the stable and high-efficiency operation of the expansion turbine in dusty gas conditions without hindering the blast furnace operations.

The TRT system provides excellent operational reliability with a feature of abrasive resistance. The electricity generated by this system covers about 20 % of electricity necessary for all equipments attached to the blast furnace including air blowers.

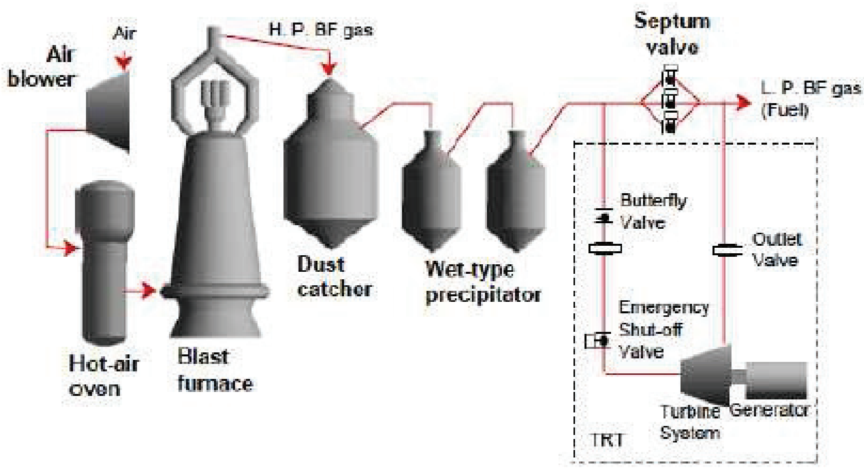

Figure 17: Top pressure recovery turbine

Present Status

RINL, JSW Bellary and TATA steel has installed top pressure turbine. Out of these installations, TATA steel has retrofitted top pressure turbine for its existing blast furnace and the other installations are by design.

RINL and TATA Steel generate 24 MW of energy through top pressure turbine (TRT) system.

Barriers in Implementing

- Space constraint for retrofitting
- Needs shut down for retrofitting
- Widely acknowledged that retrofitting not possible
- Higher cost of investment

Benefits

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 63.00 million	Rs. 63.00 million
MTOE equivalent	6000	6000
PAT benefit[32]	--	Rs. 60.00 million
Total benefit	Rs. 63.00 million	Rs. 123.00 million
Investment	Rs. 252.00 million	Rs. 252.00 million
Payback period	48 months	24 months
Replication Potential		
Saving potential	0.07GCal / tcs[33]	
Number of plants	75% of the plants	
Sector savings	315000 Mtoe	

[32] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[33] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.9

Pulverized Coal Injection

Pulverised Coal Injection (PCI) technology injects coal directly into the blast furnace avoiding the route of coke-making. This provides the carbon for iron-making, displacing some of the coke required for the process. A wider range of coals can be used in PCI, including steam coal which has lower carbon content than coking coal. This method has a number of advantages, including reducing overall costs and prolonging the life of existing coke batteries.

Pulverized coal is injected into the blast furnace through tuyeres attached to the blast furnace with a coal injection device. The type and size of the pulverized coal varies with the capacity and operation of the blast furnace.

Processes such as Corex have now been introduced in some of the steel plants to produce hot metal by predominantly using non-coking coal. Coal Dust/ Pulverised Coal Injection System have been introduced in several blast furnaces to partially substitute Coke. In addition, there has been large scale growth of sponge iron units based on non-coking coal.

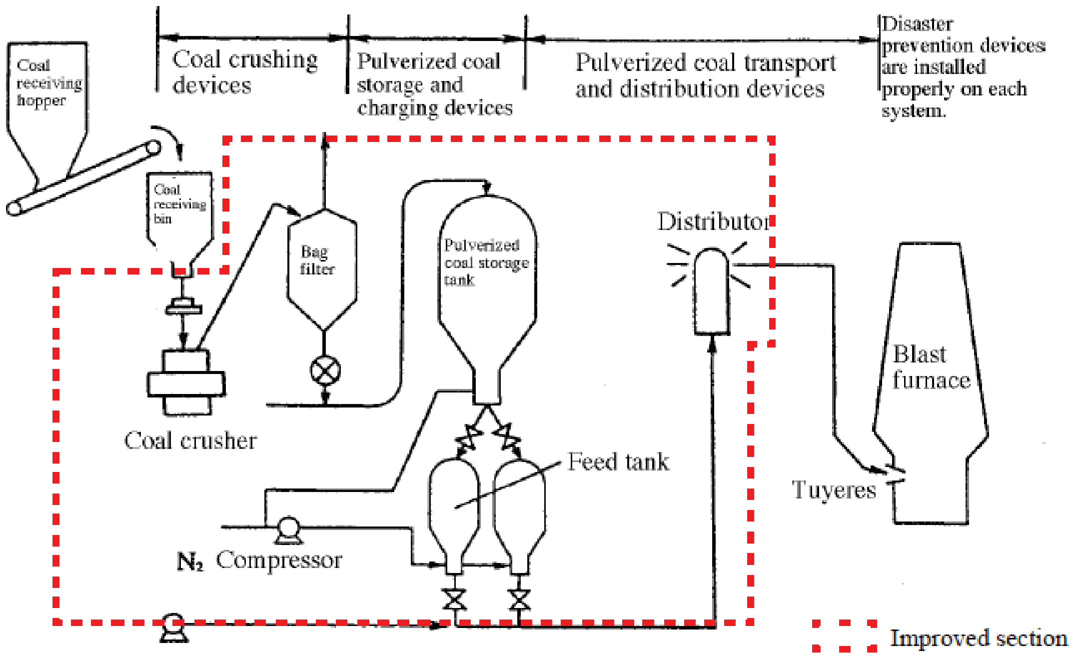

Figure 18: Pulverized coal injection

<u>Present Status</u>

Pulverized coal injection has been implemented in several plants. Durgapur steel plant, TATA steel, RINL have implemented this project.

However, the rate of injection is very low in India. The average injection rates is around 50 – 75 kg/ ton of hot metal in India and the highest being in TATA steel where the injection rate is 125 kg/ton of hot metal. With improvement in operation and technology, the injection range of pulverized coal can be 50 – 200 kg/ ton of hot metal.

Barriers in Implementing

- Quality of raw materials used in the blast furnace determines the rate of injection. Since the quality of raw materials used is low, achieving higher levels of injection might not be possible in India

Benefits

Reference Plant (1 MILLION MTPA)		
	Without PAT	With PAT benefit
Energy savings	Rs. 34.00 million	Rs. 34.00 million
MTOE equivalent	3500	3500
PAT benefit[34]	--	Rs. 35.00 million
Total benefit	Rs. 34.00 million	Rs. 69.00 million
Investment	Rs. 115.00 million	Rs. 115.00 million
Payback period	40 months	20 months
Replication Potential		
Saving potential	0.035GCal / tcs[35]	
Number of plants	80% of the plants	
Sector savings	168000 Mtoe	

[34] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

[35] Energy Efficiency and Carbon Dioxide Emissions Reduction Opportunities in the Iron and Steel Sector – LBNL

Technology No.10

Waste Heat Recovery from Sponge Iron Kilns

Present Status

Larger sponge iron plants in India have adopted this measure of recovering waste heat from kiln and utilizing the same in generating power. All 300 TPD sponge iron plants in India have adopted this measure. Smaller plants of 100 – 150 TPS are yet to capitalize on this.

Benefits

By implementing this measure a total of 1.91 million tons of CO2 can be mitigated. This measure has a generation potential of 250 MW of energy.

Barriers in Implementing

- Smaller plants have very little knowledge on waste heat recovery from sponge iron kiln
- Higher Investment Cost

Potential to scale up

This measure can be implemented in at least 100 – 120 plants in Odisha and West Bengal. The potential savings from this measure is enormous.

Sponge iron plant		
	Without PAT	With PAT benefit
Energy savings	Rs. 12.50 million	Rs. 12.50 million
MTOE equivalent	650	650
PAT benefit[36]	--	Rs. 6.50 million
Total benefit	Rs. 12.50 million	Rs. 18.50 million
Investment	Rs. 40.00 million	Rs. 40.00 million
Payback period	38 months	26 months
Sector savings		65000 Mtoe

[36] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

Technology No.11

Hot Charging and direct rolling mill

High-temperature semi-finished materials (slab, bloom, or billet) just after continuous casting (CC) is charged into the heating furnace with the temperature maintained as high as possible, thus reducing the fuel consumption at the heating.

Further, by improving the measures for preventing the temperature drop of the semis after CC, the semis are directly sent to the rolling mill without going through the heating furnace, eliminating the heating process and substantially reducing the fuel consumption.

The temperature drop of the semis is prevented by various measures: optimal temperature control in CC, hot surface defect inspection, shortened transportation and handling time, strengthened heat-retaining, etc. By the hot charging into the heating furnace and direct rolling made possible by these measures, the fuel for the heating furnace is saved.

In order to charge the high-temperature semis into the heating furnace with the temperature maintained as high as possible, various measures were incorporated as follows.

1. To shorten the time for transportation and handling.
2. To strengthen the heat-retaining measures.
3. To expand the flawless casting.
4. To synchronize the CC process and the hot-rolling process through appropriate scheduling.
5. To make the temperature of the semis as high as possible.

In order to perform direct rolling, following measures are required in addition to the above: strengthened heat-retaining measures at CC, higher CC speed, higher rolling speed, low-temperature rolling, etc. Low-temperature rolling is a technology to roll at a temperature as low as possible. One such technology put into practice is an in-line edge-heater.

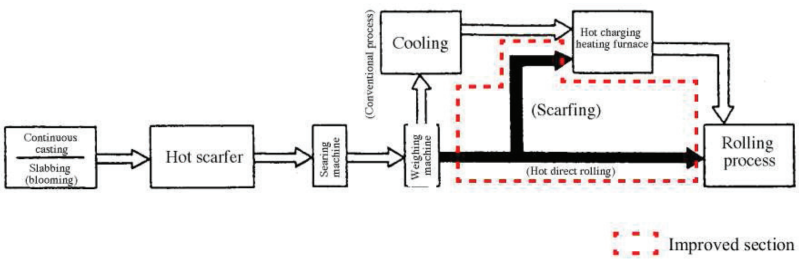

Figure 19: Hot Charging and direct rolling mill

Benefits

Hot Charging and direct rolling mill		
	Without PAT	With PAT benefit
Energy savings	Rs. 12.00 million	Rs. 12.00 million
MTOE equivalent	300	300
PAT benefit[37]	--	Rs. 3.00 million
Total benefit	Rs. 12.00 million	Rs. 15.00 million
Investment	Rs. 20 million	Rs. 20.00 million
Payback period	20 months	16 months
Replication Potential		
Number of plants	80% of the plants	
Sector savings	30000 Mtoe	

[37] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

Technology No.12

Descaling pump (conversion to plunger pump)

A descaling pump is used to apply high – pressure water jet to remove the scale during steel rolling operation. In order to reduce power consumption, various measures were taken, such as pressure and flow rate reduction. To achieve further power saving, the turbine pump was converted to the plunger pump.

Since high-pressure jet is applied intermittently in short duration, a plunger pump, which can perform no-load operation at a low pressure, significantly saves power consumption during the time when high-pressure water jet is not applied.

(Example of improvement)

Out of three descaling pumps, one was converted to a plunger pump as in figure, which is operated continuously.

	Before improvement (turbine pump)	**After improvement (plunger pump)**
Number of pumps operated	2 sets	1 sets
Flow rate	6.5 m3/min	5.5 m3/min
Pressure	170 kg/cm2	175 kg/cm2
Number of motors operated	2700 kW × 2 sets	2700 kW × 1 set

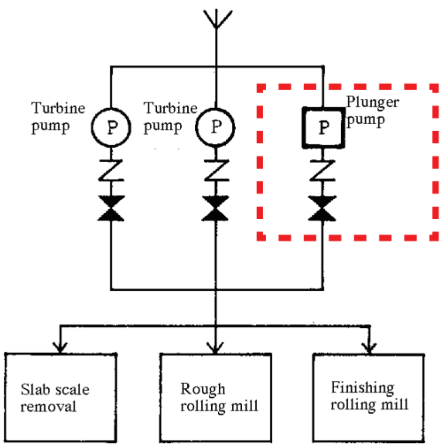

Figure 20: Systematic diagram of Plunger Pump

Benefits

Table 17: Energy savings comparisons

		Before improvement	After Improvement	Savings/Improvement
Power Consumption	Loaded	1930 kW	1890 kW	40 kW
	Unloaded	1210 kW	180 kW	1030 kW
Annual energy consumption		9456 MWh/y	3948 MWh/y	5508 MWh/y
Reduction in crude oil equivalent				1338 kl/y

Descaling pump		
	Without PAT	With PAT benefit
Energy savings	Rs. 19.00 million	Rs. 19.00 million
MTOE equivalent	450	450
PAT benefit[38]	--	Rs. 4.50 million
Total benefit	Rs. 19.00 million	Rs. 23.50 million
Investment	Rs. 45 million	Rs. 45.00 million
Payback period	30 months	23 months
Replication Potential		
Number of plants	40% of the plants	
Sector savings	42700 Mtoe	

[38] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

Technology No.13

Convection heating type heat treatment furnace for wire rod coil

In order to shorten the time required for spheroidizing annealing of wire rod coils, a forced circulation fan was installed, which blows a large amount of hot air into the coils from inside, and performs forced convection heat transfer cooling, which improves the heat transfer efficiency and shortens the treatment time.

The outside of the wire rod coils is heated by the radiation from the radiant tube heat source as well as by the convection heat transfer by the forced circulation fan installed at the top cover. Hot air is forced into the inside of the coils by the fan. It passes through among the individual strands of the coils, and heats up the coils. Forced convection heat transfer by the fan improves the heat transfer efficiency, shortens the treatment time, and saves energy. At the time of cooling, an indirect gas cooler is employed for rapid cooling, instead of the radiant tubes.

In a conventional heat treatment of wire rod coils, a heat source is installed along the outer periphery of the coils, and the outside of the coils is kept at a designated temperature. Figure shows the cross section of a heat treatment furnace equipped with a rapid heating device. Hot air is forced into the inside of the coils by the forced circulation fan installed at the top cover. It rapidly passes through among the individual strands of the coils, and heats up the coils. The hot air which exchanged its heat with the coils passes through the hot air circulation duct equipped with radiant tubes, is given the required heat, and returns to the forced circulation fan.

Thus, the coils are rapidly heated by the forced convection heat transfer within the coils. At the time of forced cooling, an indirect gas cooler is employed for rapid cooling, instead of the radiant tubes.

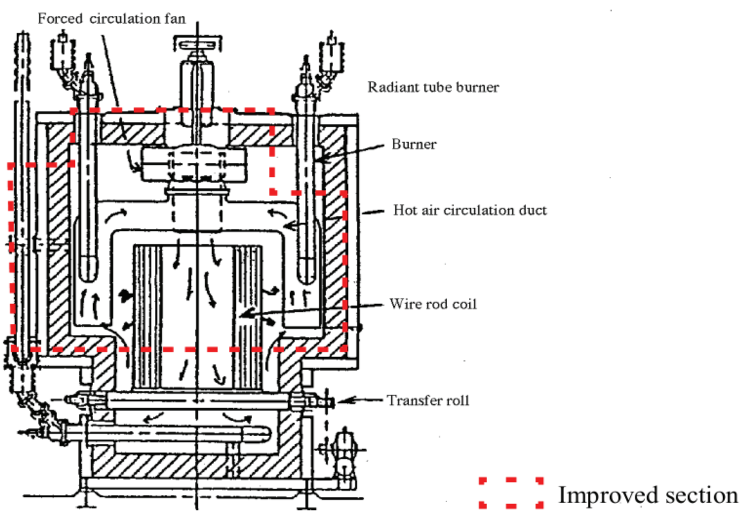

Figure 21: Structure of a rapid heating surface

Benefits

Heating time reduced by approximately 2.5 hours and cooling time reduced by approximately 3 hours.

Convection heating type heat treatment furnace for wire rod coil		
	Without PAT	With PAT benefit
Energy savings	Rs. 1.00 million	Rs. 1.00 million
MTOE equivalent	100	100
PAT benefit[39]	--	Rs. 1.00 million
Total benefit	Rs. 1.00 million	Rs. 2.00 million
Investment	Rs. 3.00 million	Rs. 3.00 million
Payback period	36 months	12 months
Replication Potential		
Number of plants	50% of the plants	
Sector savings	9300 Mtoe	

[39] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

Technology No.14

Regenerative Furnace

Regenerative burner is a high performance burner for heating furnace use. This burner has a unitary composition comprising a combustion section (burner) and heat storage section (regenerator). Two burners are used as a pair. While one burner is in the combustion phase, heat storage is performed by the burner on the opposite site. Approximately 85% of waste or higher can be recovered by this alternate switching between combustion and heat storage.

Regenerative Burner:

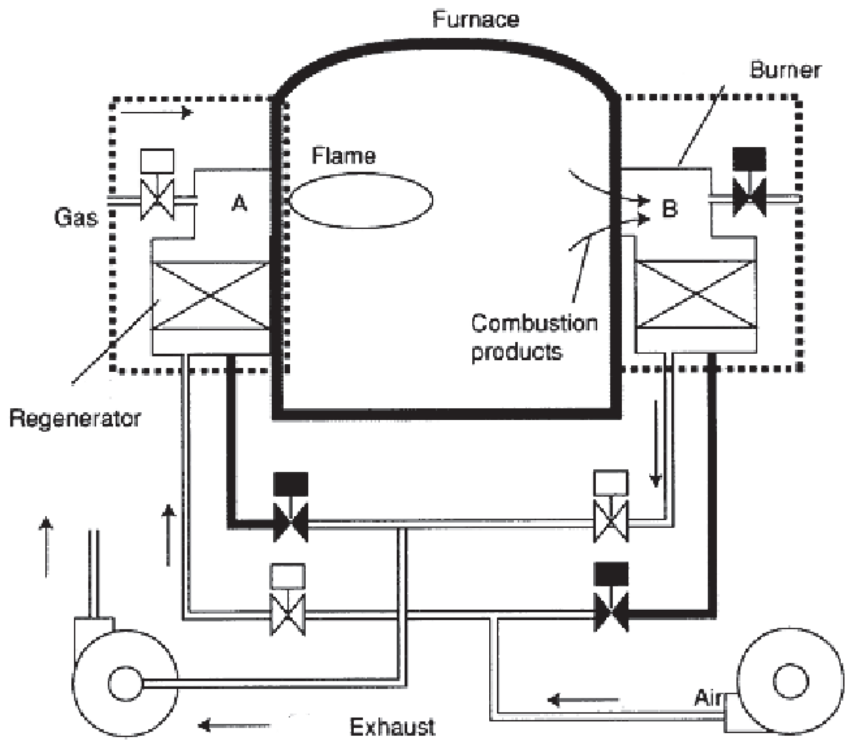

Figure 22: Regenerative Furnace

As shown in figure, when burner A in 1 pair is in the combustion phase, the combustion gas generated by burner A is taken into the burner section of burner B, heat exchange is performed in the heat storage section, and the gas is then discharged out of the system.

When the heat storage section in burner B has stored sufficient heat by heat exchange with the combustion exhaust gas, a combustion switching device switches operation to burner B, and burner B begins combustion. Waste heat can be efficiently used by performing this operation, repeatedly alternating between A and B.

Benefits:

Regenerative Furnace (Reference plant : 100 t-steel/h billet heating furnace)		
	Without PAT	With PAT benefit
Energy savings	Rs. 28.00 million	Rs. 28.00 million
MTOE equivalent	700	700
PAT benefit[40]	--	Rs. 7.00 million
Total benefit	Rs. 28.00 million	Rs. 35.00 million
Investment	Rs. 90.00 million	Rs. 90.00 million
Payback period	39 months	31 months
Replication Potential		
Number of plants	90% of the plants	
Sector savings	61200 Mtoe	

[40] PAT benefits calculated based on the MTOE Savings. One MTOE equals Rs.10154 for the year 2011-12 as per the PAT notification. Refer Annexure 2 for detailed calculation.

Technology No.15

CoJet (Coherent Jet Gas Injection Technology)

CoJet® **Coherent Jet Gas Injection Technology** is a state-of-the-art oxygen injection system that lowers costs and improves productivity of electric arc furnace (EAF) and Twin Shell Furnace operations. The technology provides an easily operated method for lancing/decarburization, post-combustion, and burner operation in a single, integrated system using oxygen

CoJet® **Coherent Jet Gas Injection Technology**

An injector nozzle delivers a 3 to 5-foot (0.9-1.5 meters) laser-like coherent jet of oxygen at **supersonic speeds** into the molten bath. The fixed, wall-mounted injector nozzle retains the original diameter and velocity of the oxygen jet, delivering precise amounts of oxygen to the steel bath with less cavity formation and splash compared to traditional manipulators.

Once the oxygen jet impinges on the steel bath, the concentrated momentum of the oxygen beam dissipates in the steel as fine bubbles, providing deep penetration and effective slag-metal mixing. The nozzle also operates as a conventional sidewall burner to melt scrap and as a supplemental oxygen source for post-combustion, improving furnace productivity and decreasing power consumption.

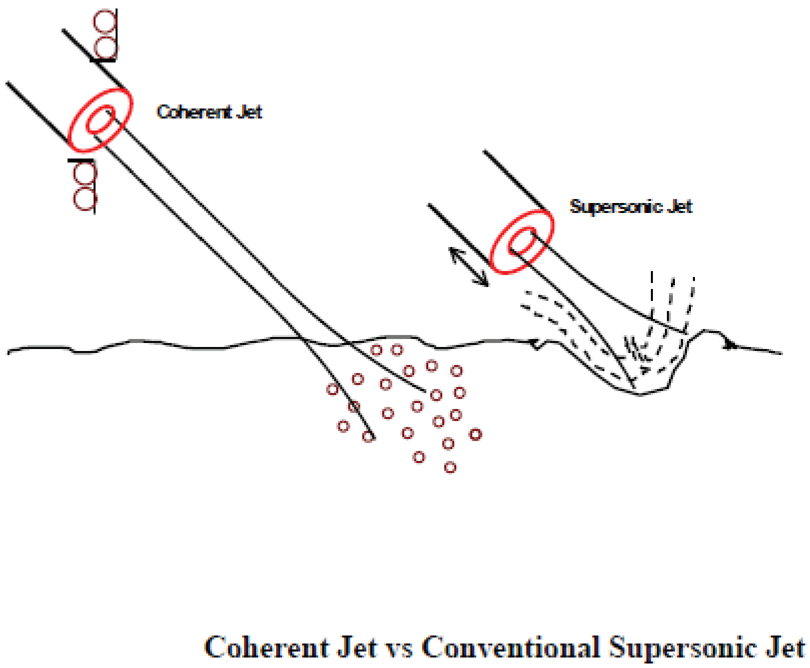

Figure 23: Coherent vs Conventional Supersonic jet

<u>Benefits</u>

- ❖ Lancing with fixed injectors is completely automated, not operator dependent. No need to move lances in and out of the furnace
- ❖ Chemical energy of all forms (burners + lancing + PC) is supplied uniformly around the furnace by the injectors -- not concentrated near slag door area.
- ❖ Less splashing/furnace damage because oxygen flow per injector is lower than a traditional door lance and coherent jets inherently produce less splash.
- ❖ Faster decarburization and lower overall oxygen consumption due to more effective and efficient use of oxygen in the furnace.
- ❖ Improved and continuous slag foaming with significantly less carbon injection.
- ❖ Slag door can be kept closed — air infiltration is reduced.
- ❖ Reduced refractory wear

5.0 FUTURE TECHNOLOGY OPTIONS

About 90% of the steel produced world wide is through blast furnace route. Alternate methods of steel making are being explored for reduce the burden on raw materials, such as coke & coal, used.

Production of non – liquid iron also known as direct reduced iron (DRI) through EAF & MIDREX and production of liquid iron through COREX & FINEX are the some of the technologies considered for alternate iron making.

- Direct Reduced Iron making (DRI Process)
  - **EAF**

An Electric Arc Furnace (EAF) is a furnace that heats charged material by means of an electric arc. This process reduces the burden on coal and coke, the resources which are scare in India. Electric arc furnace is already in use for melting scraps in India.

  - **MIDREX**

A MIDREX Direct Reduction (DR) Plant is composed of two main facilities: the Shaft Furnace, where iron ore is reduced, and the Reformer which generates the reforming gas to be charged into the Shaft Furnace. The MIDREX DR Process is able to use both lump and pellet as the raw material and recycles the used gas, therefore the process has both low energy consumption and low environmental impact, making it an environmentally friendly process.

MIDREX DR has been highly evaluated throughout the world in response to the need for new iron making resources, in lieu of the Blast Furnace route.

- Production of liquid iron
  - **COREX**

The highlight of the process is it does not require coking coal. The process differs from the conventional blast furnace route; where un-treated non-coking coal can be directly used for ore reduction and melting work, eliminating the need for coking plants. The use of lump ore or pellets also dispenses with the need for sinter plants.

  - **FINEX**

It is an optimized fine-ore reduction process for the direct utilization of the low-cost iron ore fines for the production of iron. In this process fine iron ore is preheated and reduced to fine direct reduced iron (DRI) in a three or four stage fluidized bed reactor system. The fine DRI will be compacted and then charged in the form of hot compacted iron (HCI) into the melter gasifier. The charged HCI is subsequently reduced to metallic iron and melted.

Prioritizing the projects:

The projects can be categorized into three heads namely, Level 1, Level 2, Level 3 based on the simplicity of implementation level 1 being the easiest and level 3 being the most difficult to implement.

Level 1: Low investment and easier to implement

Level 2: Medium investment and moderate level of difficulty in implementation

Level 3: High investment and high level of difficulty in implementation

Level 1:

a) Variable Frequency Drive for centrifugal equipments

b) Preventive Maintenance

c) Sinter Plant Air Leakages

d) Energy efficiency improvements in captive power plant

The above measures are easier to implement and can be taken up as Kaizen activity.

Level 2:

a) Multi slit burner – Sintering furnace
b) Coal Moisture Control
c) Hot stove waste heat recovery
d) Blast Furnace Gas Sensible Heat Recovery
e) Continuous casting
f) Sensible heat recovery from main exhaust gas of sintering machine

Level 3:

a) Waste heat recovery form sinter bed
b) Coke Dry Quenching
c) Top Pressure Turbine
d) Computerized Operation of Coke Ovens
e) Pulverized Coal Injection
f) Waste heat recovery from sponge iron kiln

Table 18: Priority Table

Opportunities	Ease of Implementation				Priority of Activity		
	Easy	Moderate	Difficult		Short	Medium	Long
Waste heat recovery form sinter bed			x				x
Coke Dry Quenching			x				x
Top Pressure Turbine			x				x
Captive Power Plant	x				x		
Variable Frequency Drive	x				x		
Preventive Maintenance	x				x		
Multi slit burner – Sintering furnace							
Sinter Plant Air Leakages	x				x		
Computerized Operation of Coke Ovens		x					x
Coal Moisture Control			x			x	
Pulverized Coal Injection	x					x	
Hot stove waste heat recovery		x				x	
Blast Furnace Gas Sensible Heat Recovery	x				x		
continuous casting							
Sensible heat recovery from main exhaust gas of sintering machine		x				x	
Waste heat recovery form Kiln		x			x		

Table 19: Cost Abatement Curve

Description of proposal	***Investment, Rs/MTOE***	**savings, MTOE**
A) Improvement in segregated charging of sintering materials	24000	2900
B) Automated Combustion Control of Coke Ovens	24000	5400
C) Sensible heat recovery from main exhaust gas of sintering machine	30000	4500
D) Coal Moisture Control	30000	6460
E) Pulverized Coal Injection	33000	3500
F) Convection heating type heat treatment furnace for wire rod coil	33000	100
G) Coke Dry Quenching (CDQ) Technology	36000	28000
H) Preheating through WHR from Hot stoves of Blast Furnace	36000	3300
I) Top Pressure Recovery Turbine	42000	6000
J) Waste Heat recovery from sinter bed	48000	2800
K) Waste Heat Recovery from Sponge Iron Kilns	62000	650
L) Hot Charging and direct rolling mill	66000	300
M) Descaling pump (conversion to plunger pump)	100000	450
N) Regenerative Furnace	125000	700

6.0 COST ABATEMENT CURVE

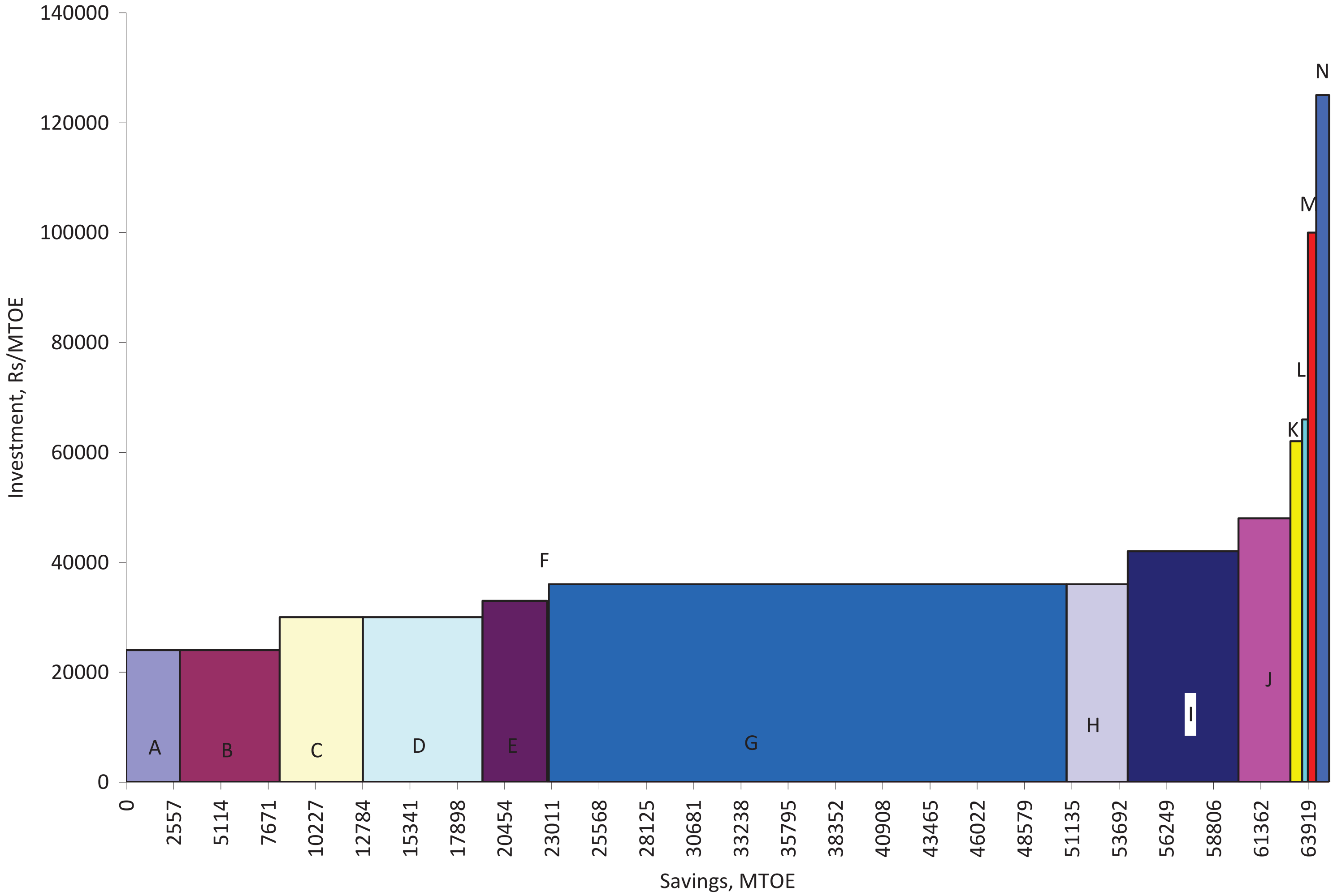

Figure 24: Cost Abatement Curve

Description of proposal
A) Improvement in segregated charging of sintering materials
B) Automated Combustion Control of Coke Ovens
C) Sensible heat recovery from main exhaust gas of sintering machine
D) Coal Moisture Control
E) Pulverized Coal Injection
F) Convection heating type heat treatment furnace for wire rod coil
G) Coke Dry Quenching (CDQ) Technology
H) Preheating through WHR from Hot stoves of Blast Furnace
I) Top Pressure Recovery Turbine
J) Waste Heat recovery from sinter bed
K) Waste Heat Recovery from Sponge Iron Kilns
L) Hot Charging and direct rolling mill
M) Descaling pump (conversion to plunger pump)
N) Regenerative Furnace

7.0 CONCLUSION

The technologies and best practices presented here is only a small effort to help the designated consumers to achieve their PAT targets. Apart from this, several activities like regular maintenance, equipment level energy efficiency, i.e.., efficiency testing of pumps, fans, compressors, motors, can result in energy savings. Effective utilization of by product gases, instead of flaring, is another step towards saving of conventional energy sources.

Indian iron & steel industry is bound to grow for the next few decades, thanks to the strong demand from the domestic and international market. On the flip side, it would place a huge burden on the energy market. This compendium is an effort towards this direction discussing not only on the efficient use of energy but also the utilization of waste energy.

Iron & Steel industry account for 36 million MTOE (15% of the total consumption) of Indian industrial energy consumption. Under PAT scheme, there are about 67 designated consumers, both from integrated steel plants and sponge iron. They are mandated to improve their present energy efficiency levels and save about 1.4 million ton of oil equivalent which is 22% of the overall industrial target. We believe that this compendium would help designated consumers to choose appropriate technology and achieve PAT targets.

Annexure 1: GHG INVENTORIZATION & TREND ANALYSIS

Present Status

Iron & Steel industry is one of the major industries releasing appreciable quantity of Green House Gases. From 90.53 million tonnes of CO_2 in the year 1994, the direct emissions from iron & steel process has increased to 184 million tonnes of CO_2 in the year 2009-2010[41].

Emission intensity for steel industry is given below:

Emission for BOF route:

- Indian plants : 2.7 MT CO2 / tcs
- World average: 1.6 MT CO2 / tcs

Emission for Sponge Iron route:

- Indian plants : 3.1 MTCO2 / tcs
- World average: 2.5 MTCO2 / tcs

Indian iron & steel industry is more emission intensive than global average. CO2 emissions from steel making are from intense consumption of fossil fuel. Emission analysis:

- 60% from fossil fuel
- 40% from process fuel

Future Emissions Scenario

The growth in iron & steel industry is projected to reach new heights. As per CII estimate, steel production will reach 158 MTPA in 2020 and would be 374 MTPA in 2030. The emission from iron & steel industry would also increase with respect to the increase in production.

The future emission scenario projected by various agencies is listed below:

- Low Carbon Strategies for inclusive growth
  - Planning Commission of India
- CII projections

[41] Steel Authority of India

1) <u>Low carbon strategies for inclusive growth</u>:

The report, Low carbon strategies for inclusive growth, by Planning Commission of India projects the growth of the industry for 2020 by considering two scenarios. The growth projections are based on the assumptions that India's GDP grows at 9% each year and the elasticity factor for sectors growth as 1.5%.

a) Determined Effort

Implementation of policies that are already in place or contemplated are pursued vigorously and implemented effectively up to 2020

- Emission intensity by 2020 will be 2.03 MT CO2 / tcs
- Overall emissions will be 406 MT CO2

b) Aggressive Effort

In addition to the determined effort it includes implementation of new policies, new technologies and additional finance

- Emission intensity by 2020 will be 1.83 MT CO2 / tcs
- Over all emissions at 366 MT CO2

2) <u>CII GHG Projection:</u>

Future projections are based on two scenarios:

a) Business as Usual Scenario (BAU):

In BAU, it is considered that the present energy efficiency activities will continue and energy will keep reducing by 2.5% annually. The present emission intensity is considered to be 2.7 MT CO2 / tcs. By this, the emission scenario would be:

- Emission intensity will be:
  - 2020 : 2.6 MT CO2 / tcs
  - 2030 : 2.5 MT CO2 / tcs
- Corresponding emission for CII's projected growth rate of 158 MTPA for 2020 and 374 MTPA for 2030
  - 2020 : 410 MT CO2
  - 2030 : 935 MT CO2

b) Determined steps to improve energy efficiency:

This scenario is based on the consideration that determined steps for reducing energy consumption will be taken. In this scenario, the emission intensity would be:

- 2020 : 2.3 MT CO2 / tcs
- 2030 : 2.2 MT CO2 / tcs

Corresponding emission for CII's projected growth rate of 158 MTPA for 2020 and 374 MTPA for 2030

- 2020 : 363 MT CO2
- 2030 : 860 MT CO2

GHG mitigation potential for the projects specified in the report is as follows:

Description of proposal	Savings MTOE	Sector savings MTOE	Thermal / Electrical savings	Multiplication factor	Sectoral savings tons of CO2 saved
Improvement in segregated charging of sintering materials	2900	174000	Thermal	4.1	713,400
Automated Combustion Control of Coke Ovens	5400	129600	Thermal	4.1	531,360
Sensible heat recovery from main exhaust gas of sintering machine	4500	189000	Thermal	4.1	774,900
Coal Moisture Control	6460	273000	Thermal	4.1	1,119,300
Pulverized Coal Injection	3500	168000	Thermal	4.1	688,800
Convection heating type heat treatment furnace for wire rod coil	100	9300	Thermal	4.1	38,130
Coke Dry Quenching (CDQ) Technology	28000	1100000	Electrical	10.6	11,660,000
Preheating through WHR from Hot stoves of Blast Furnace	3300	99000	Thermal	4.1	405,900
Top Pressure Recovery Turbine	6000	315000	Electrical	10.6	3,339,000
Waste Heat recovery from sinter bed	2800	150000	Electrical	10.6	1,590,000
Waste Heat Recovery from Sponge Iron Kilns	650	65000	Electrical	10.6	689,000
Hot Charging and direct rolling mill	300	30000	Thermal	4.1	123,000
Descaling pump (conversion to plunger pump)	450	42700	Electrical	10.6	452,620
Regenerative Furnace	700	61200	Thermal	4.1	250,920

**** GHG savings indicated is calculated only for the reference plant of 1 MTPA. Projects explained in this compendium should be seen individually for its applicability in a particularplant.***

**** The reader is advised not to sum up individual GHG emission savings and extrapolate for the sector as it might be misleading***

Annexure 2: BASIS OF SAVINGS ESTIMATIONS/SAMPLE CALCULATION

Basis for calculation:

Operating hours of the plant	=	8000 hrs
Plant size	=	1 MTPA
Cost of electrical energy	=	Rs. 3.50 / kWh
1 MTOE value	=	Rs. 10,154

Sample Calculation:

Savings without PAT

Energy saved	=	500 kWh
Annual savings	=	500 kWh X Rs. 3.50 / kWh X 8000 hrs
	=	Rs. 14.00 million / annum
Investment	=	Rs. 20.00 million
Payback	=	Rs. 20.00 million X 12 months Rs. 14.00 million
	=	18 months

Savings with PAT

Energy saved	=	500 kWh
Annual savings	=	500 kWh X Rs. 3.50 / kWh X 8000 hrs
	=	Rs. 14.00 million / annum
MTOE saved	=	344
MTOE savings	=	344 X Rs. 10, 154 / MTOE
	=	Rs. 3.40 million
Total savings	=	Rs. 14.00 million + Rs. 3.40 million
	=	Rs. 17.40 million
Investment	=	Rs. 20.00 million
Payback	=	Rs. 20.00 million X 12 months Rs. 17.40 million
	=	14 months

Miscellaneous:

1 kWh	=	860 kCal
1 MTOE	=	10^7 kCal

Cost of heat (sample calculation):

1 Mtoe	=	1 * 10^7 kcal
1 Mtoe	=	Rs. 10154[42]
Annual coal savings	=	5000 kg
Calorific value	=	6000 kcal / kg
Kcal savings	=	5000 kg * 6000 kcal / kg
	=	30000000 kcal
Mtoe savings	=	30000000 kcal / 1 * 10^7 kcal
	=	3 Mtoe
Annual cost savings	=	Rs. 10154 / Mtoe * 3 Mtoe
	=	Rs. 30462

[42] BEE PAT notification

Calculation of GHG emissions:

GHG emission depends on the type of fuel being used i.e.., coking coal, diesel, furnace oil or electricity. Emission reduction for a particular project has been arrived on the basis of CO_2 emitted per MTOE.

If a process runs only with electricity, then CO_2 emitted per MTOE is calculated as follows:

Electricity (1 kwh)	=	860 kcal
Electricity emission factor	=	0.91 kg of CO_2/kwh[43]
1 MTOE	=	10^7 kcal
kwh / MTOE	=	10^7 kcal / 860 kcal
	=	11627.9 kwh / MTOE
Tons of CO_2 / MTOE	=	0.91 kg of CO_2/kwh * 11627.9 kwh / MTOE
	=	10.6 MT of CO_2 / MTOE

Similarly, if a process uses only coking coal, then tons of CO_2 / MTOE would be 4.1 considering, calorific value of coking coal to be 6900 kcal / kg and emission factor of coking coal to be 2.8 ton of CO_2/ ton of coking coal[44].

Emission per MTOE is listed below for other fuel types:

Diesel	=	2.7 MT of CO_2 / MTOE
Natural gas	=	2.2 MT of CO_2 / MTOE

As mentioned before, emissions depend on the type of fuel being burnt / used and composition of fuel. Generally, no process runs on single fuel. Usually, a fuel mixture will be used. In that case, the emission multiplication factor has to be calculated based on the fuel mixture.

In order to calculate the GHG emission savings, the projects have been classified based on the type of savings it achieves. For example, if a project gives coking coal savings, the MTOE savings has been multiplied with the corresponding coking coal CO_2 emission / MTOE and the value is arrived.

[43] Central Electricity Authority
[44] IPCC emission factor

Example 1,

Type of project	=	Thermal
Fuel saved	=	coking coal
MTOE saved	=	100 MTOE
tons of CO_2 / MTOE	=	4.1
GHG savings	=	100 MTOE * 4.1 tons of CO_2 / MTOE
	=	410 tons of CO_2

Example 2,

Type of project	=	Electrical
Fuel saved	=	electricity
MTOE saved	=	100 MTOE
tons of CO_2 / MTOE	=	10.6
GHG savings	=	100 MTOE * 10.6 tons of CO_2 / MTOE
	=	1060 tons of CO_2

Annexure 3: LIST OF EQUIPMENT/TECHNOLOGY SUPPLIERS

1) Ardee Business Services Pvt.Ltd
   - www.ardeebusiness.info
2) FLSmidth Private limited
   - www.flsmith.com
3) Honeywell International Private (I) Ltd
   - www.honeywell.com
4) Mettalon Holdings Limited
5) Siemens India Limited
   - www.siemens.com
6) Stork HKB India PVT Limited
   - www.storkindia.com
7) Thermax Limited
   - www.thermaxindia.com
8) Transparent Energy Systems PVT Limited
9) Encon Thermal Engineers
   - www.encon.co.in

ABBREVIATIONS:

APP	– Asia Pacific Partnership
BAT	– Best Available Technologies
BEE	– Bureau of Energy Efficiency
BF	– Blast Furnace
BOF	– Basic Oxygen Furnace
BOP	– Best Operating Practices
CAGR	– Compound Annual Growth Rate
CDQ	– Coke Dry Quenching
CFD	– Computational Fluid Dynamics
CMC	– Coal Moisture Control
CoJet	– Coherent Jet Technology
DRI	– Direct Reduced Iron
E & Y	– Ernst & Young
EAF	– Electric Arc Furnace
GCal	– Giga Calories
GDP	– Gross Domestic Product
GJ	– Giga Joules
IEA	– International Energy Agency
IFC	– International Financial Corporation
JPC	– Joint Plant Committee, Government of India
kCal	– Kilo Calories
kW	– Kilo Watt
LBNL	– Lawrence Berkeley National Laboratory
mMtoe	– Million Metric Tonne of Oil Equivalent
MTOE	– Metric Tonne of Oil equivalent
million MTPA	– million Tons per Annum
MW	– Mega Watt

NEDO – New Energy and Industrial Technology Development Organization

NSPCL – NTPC - SAIL Power Corporation Limited

PAT – Perform, Achieve & Trade

PCI – Pulverized Coal Injection

PCRA – Petroleum Conservation Research Association

RINL – Rashtriya Ispat Nigam Limited, Vishakapatnam

SAIL – Steel Authority of India Limited

SEC – Specific Energy Consumption

tcs – Tons Of Crude Steel

TRT – Top Recovery Turbine

UNIDO – United Nations Industrial Development Organization

VFD – Variable Frequency Drive

WHR – Waste Heat Recovery

WSA – World Steel Association

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14) Future Technologies For Energy-Efficient Iron And Steel Making, LBNL, 1998

15) India's GHG Emissions Profile , Results from Five Climate Modeling Studies, Ministry of Environment and Forests, Government of India

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18) Japanese Technologies for Energy Savings/ GHG Emissions Reduction, NEDO, 2008

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