MANUAL ON ENERGY CONSERVATION MEASURES IN SPONGE IRON MANUFACTURING CLUSTER ORISSA

ENERGY IS LIFE
BEE
CONSERVE IT

Bureau of Energy Efficiency (BEE)

Ministry of Power, Government of India

APITCO LIMITED Engineering Growth

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We assure you, always, of our best services.

[V Ramchander]

Managing Director

1. INTRODUCTION

1.1 Preamble

Small and Medium Enterprises (SMEs), in particular play an important role in creation of local employment and increasing the regional income. Efficient utilization of raw material, both thermal and electrical energy becomes imperative for their sustenance as they work on low profit margins. Moreover, the production processes are based on technology concepts, which sometimes tend to become inefficient in a long run. The inefficient utilization and excessive use of raw material, fuel & energy also contribute to exceeding levels of energy intensities and environmental loads. Excessive utilization of thermal and electrical energy also impacts the regional energy balance and has a direct impact on the local power utility, as also has stress on the backward linkages of fuel resources. It also impedes the improvement of productivity of local enterprises and the economic development of communities at large.

Energy efficiency and conservation issues traditionally were dealt with addressing the issues at an individual unit level, which is a discrete approach to resolve energy problems. Most of the energy consumption is unevenly distributed and is larger in a cumulative context among small enterprises. Due to low incomes and non-availability of immediate and next to door solutions the SMEs are continue to draw and use excessive energy in a business-as-usual scenario. The uneven use of energy resources have a toll on the investments and erode the competitiveness of the SMEs. The paradigm of addressing energy security issues at a local level, and in particular the SME level has now shifted to energy efficiency improvements with a “Cluster Approach”. This enables augmenting the forward and backward linkages to the SME units, developing the skill capabilities of the SMEs to go for energy efficiency improvements, technology up gradation and market development by linking the Local Service Providers (LSPs) and financial linkages with the local Banks / Financial Institutions in augmenting loans for investments in energy efficiency projects.

In this context, the Bureau of Energy Efficiency (BEE) has initiated the Small & Medium Enterprise (SME) Program in twenty-five clusters in the country to address the energy efficiency and overall productivity improvements.

1.2 The Bureau of Energy Efficiency (BEE) – SME Program

The Government of India has set up Bureau of Energy Efficiency (BEE) under the provisions of Energy Conservation Act, 2001. The mission of the BEE is to assist in developing policies and strategies with a thrust on self-regulation and market principles within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity by active participation of all stakeholders, resulting in accelerated and sustained adoption of energy efficiency in all sectors. The objective of the BEE SME Energy Efficiency program is to accelerate the adoption of Energy Efficiency (EE) technologies and practices in the chosen SME clusters through knowledge sharing, capacity building and development of innovative financing mechanisms. Further information is available at **www.bee-india.nic.in.** There are 29 clusters identified under the BEE- SME's Program, these are as follows:

Table 1.1: List of Identified Clusters under BEE SME's Programme

S. No	Name of Cluster/ Sector	Product
1	Jamnagar, Gujarat	Brass
2	Warangal, Andhra Pradesh	Rice Milling
3	Surat, Gujarat	Textiles
4	Pali, Rajasthan	Textiles
5	Morvi, Gujarat	Ceramics
6	Ahmedabad, Gujarat	Chemical Industries
7	Solapur, Maharashtra	Textile
8	Alwar & Sawai Madhopur, Rajasthan	Oil Mills
9	Bangalore, Karnataka	Machine Tools
10	Batala, Jalandhar & Ludhiana, Punjab	Casting & Forging
11	Bhimavaram, Andhra Pradesh	Ice Making Plants
12	Bhubaneswar, Orissa	Utensils
13	East & West Godavari, Andhra Pradesh	Refractory
14	Ganjam, Orissa	Rice Milling
15	Gujarat	Dairy
16	Howrah, West Bengal	Galvanizing /Wire Drawing
17	Jagadhri, Haryana	Brass & Aluminum Utensils
18	Jodhpur, Rajasthan	Limestone
19	Jorhat, Assam	Tea Gardens
20	Kochi, Kerala	Sea Food Processing
21	Muzaffarnagar, UP	Paper
22	Orissa	Coal based Sponge Iron
23	Vapi, Gujarat	Chemicals
24	Varanasi, UP	Brick Kilns
25	Vellore, Tamilnadu	Rice Milling
26	Tirupur,Tamilnadu	Textile
27	Mangalore, Karnataka	Tiles
28	Allepe, Kerala	Coir
29	Firozabad, Uttar Pradesh	Glass

BEE-SME program is one of the activities to improve the energy efficiency in SME clusters across the selected industrial clusters. The broad objective of the BEE-SME program is to improve the energy intensity of the Indian economy by undertaking actions in the SME sector which directly or indirectly produce 45% of the manufacturing output. Majority of SME's in these clusters are run by the manufacturers who do not have skilled manpower and who can practice energy efficiency programs for conservation of energy. The awareness of energy conservation in these areas is minimal which also affects the manufacturing cost.

Therefore, it will be useful to build their energy efficiency awareness and through studies give energy conservation recommendations including identification of technology up-gradation opportunities and demonstration of the same. This would help to address the cluster specific problems and enhancing energy efficiency in SME Clusters.

These studies would provide information on technology status, best operating practices, gaps in skills and knowledge, energy conservation opportunities, energy saving potential, capacity building of local service providers and entrepreneurs/ managers etc for each of the sub sector in SME's. For each of the cluster an executing agency has been entrusted with this activity.

APITCO is selected as an executing agency by the BEE in Sponge Iron Manufacturing units in Orissa to execute the project. The main objective of the implementing agency is to accelerate the adoption of Energy Efficiency Technologies and practices in cluster through knowledge sharing, capacity building and development of innovative financial mechanisms. The main role of the executive agency is to facilitate the implementation of project activities in the SME–BEE Sponge Iron Manufacturing cluster activities suggested by BEE.

Energy i.e. electrical or thermal energy is produced using the fuels. Natural resources such as Coal, natural gas, kerosene and diesel etc are used to generate energy. Fuel is burnt to produce thermal energy for the process requirement. Whereas, electric energy is converted to mechanical energy through electric motors for moving, blending, crushing, compressing or any form of displacement activity.

In some end-uses (electrical equipments or appliances) electricity is converted to thermal energy according to industrial process requirements. Electricity is generated by thermal energy and delivered to end-users through a transmission and distribution system. Using electricity to produce thermal energy is not a wise decision due to considerable energy has already been lost during the generation, transmission and distribution. Thus producing thermal energy using electricity will further increase the losses. More energy can be saved if fuel is used to directly produce thermal energy near to the end-use. This line of thinking relates to the phrase 'energy efficiency' in the title above.

If the term efficiency alone is used in the technical world, then the definition refers to performance of a particular machine or a system. It indicates how much quality output is obtained after deducting the losses in the system. This figure will be normally given in percentage form. When the word 'energy' is added to the word 'efficiency', then the whole perspective changes and a new definition is born.

1.3 Objectives of the Study

As we have seen the importance of the Energy Efficiency (EE), and the encouragement given by the Government in urging private and government institutions towards the realization of energy security in India, it is worth to investigate the potential of implementing Energy Efficiency (EE) options in Sponge Iron Manufacturing units in Orissa. Accordingly the objectives of this study were structured as below:

- To carry out energy use and technology audit in the Sponge Iron Manufacturing Units, To identify the energy efficiency measures and to provide guidelines to other industries on no cost, low cost, medium-cost EE measures illustrated with case study
- To identify local service providers and their capacity building in technology augmentation
- To develop bankable Detailed Project Reports for Energy Efficiency Measures
- To link up financial institutions to the SMEs for implementation of EE Measures
- Capacity building of all local stakeholders in EE in Sponge Cluster.

1.3.1 Activities, Expected Outcome and Project Duration

Under this BEE SME Program, the following outcome is envisaged for Sponge Iron Cluster:

Activity 1: Energy Use and Technology Analysis

This activity has developed information base on the status of Sponge Iron Manufacturing cluster, identification & detailing of all possible energy efficiency measures, their techno economic feasibility, overall potential to impact energy and environment scenario. Energy use and status of adaptation of technology in order to improve energy performance of the units in the cluster has been studied and analyzed. 15 technologies, energy conservation measures have been identified for preparation of Detail Project Report (DPR). This stage has been completed and findings have been presented in this manual.

Activity 2: Capacity Building of Local Service Providers (LSP's) and SME's

The Capacity Building Introductory Experts workshop will be conducted by APITCO under the guidance of the BEE. The objective of this activity is to create capacities among local services providers/technology provides in the SME clusters that would help in the uptake of the energy efficiency measures. The Local Service Providers (LSPs) and the technology providers identified during Activity 1, will be registered as experts with the SME program of the BEE. A one-day Introductory Local Service Providers (LSPs) workshop will be organized with these experts and representatives from the industry/associations to share the outcome of Activity 1. The workshop will also identify issues regarding avenues for implementing energy efficiency measures, roadblocks in terms of capacities in the cluster, financing issues and carbon-market related issues. This activity will also involve the concerned SDA(s).

The output of this Activity will be a workshop proceeding which cover the entire activities of the workshop along with the outcome of the workshop on issues regarding implementation of energy efficiency measures. The activity will also enroll all the attending experts for the BEE SME Program.

A one-day Information Dissemination Workshop will be conducted in this cluster with the help of local industry association and enrolled Local Service Providers. The main focus of the workshop will be to share with the cluster the Energy Use and Technology Analysis manual prepared for the cluster. The workshop will discuss the energy efficiency measures identified in the cluster manuals and shortlist a minimum of 5 projects for which bankable Detailed Project Reports (DPR) will be prepared across maximum three segments of capacities in each cluster. Another important focus of the cluster workshop will be to share the best practices prevailing in the cluster. The workshop will also discuss managerial issues related to implementing energy efficiency measures. These will have mainly the financing component: how to keep books, what types of financing schemes are presently available and discuss what further can be done in this regard. State Designated Agenesis (SDA) will also be involved in order to help disseminate information. The output of this activity will be a list of 15 projects for this cluster for which bankable Detailed Project Reports (DPR) will be prepared.

Activity 3: Implementation of Energy Efficiency Measures

Scope of this activity is to facilitate the implementation of energy efficiency measures in Sponge Iron Manufacturing cluster through development of ready to use DPR's to facilitate bank financing. The development of 15 DPR's is in progress.

Activity 4: Facilitation of Innovative Financing Mechanism

The objective of this activity is to facilitate the implementation of energy efficient measures through innovative financing mechanisms without creating market distortion. Efforts are in progress to develop such mechanisms.

1.3.2 Project Duration

Project has started in March 2009 and duration is about 2.5 years. Most of the activities will be completed by December 2010. Most of the activities will be completed by June 2011.

1.4 Methodology

The methodology of the BEE-SME program is described below.

Preliminary Energy Audit

- Establish energy consumption in the organization
- Estimate the scope for saving
- Identify the most likely and the easiest areas for attention
- Identify immediate (especially no-low-cost) improvements/savings
- Set a reference point
- Identify areas for more detailed study/measurement
- Preliminary energy audit uses existing, or easily obtained data

Detailed Energy Audit

A Comprehensive audit provides a detailed energy project implementation plan for a facility, since it evaluates all major energy using systems. This type of audit offers the most accurate estimate of energy savings and cost. It considers the interactive effects of all projects, accounts for the energy use of all major equipment, and includes detailed energy cost saving calculations and project cost.

1.5 Structure of the Manual

Chapter II of the manual describes the Sponge Iron Manufacturing cluster, the products, cluster actors, energy consumption patterns, current policies and initiatives of local bodies, and technology up gradation needs.

The Chapter III details on energy audit and technology assessment, methodology adopted, production processes and unit operations, energy consumption in production activities, and technology gap analysis. The details energy conservation technologies, benefits of implementing energy efficiency measures, cost of implementation, savings and payback, barriers in implementation, availability of technology for implementation at local and regional level, identification of technologies / equipments for DPR preparation, techno-economics of technologies, barriers for implementation etc. the list of local service providers are annexed at the end.

Chapter IV Introduces approach to Small Group Activity (SGA) / Total Energy Management (TEM). It details the Small Group Activity (SGA) standards for practice, TEM and further, describes the ten stage activity. The chapter concludes with the tools used for SGA for TEM.

The annexure are followed by chapters briefing technical calculations, list of LSPs, Techno Commercial offers for suggested technologies, Power Tariff and financial Schemes available to Industries.

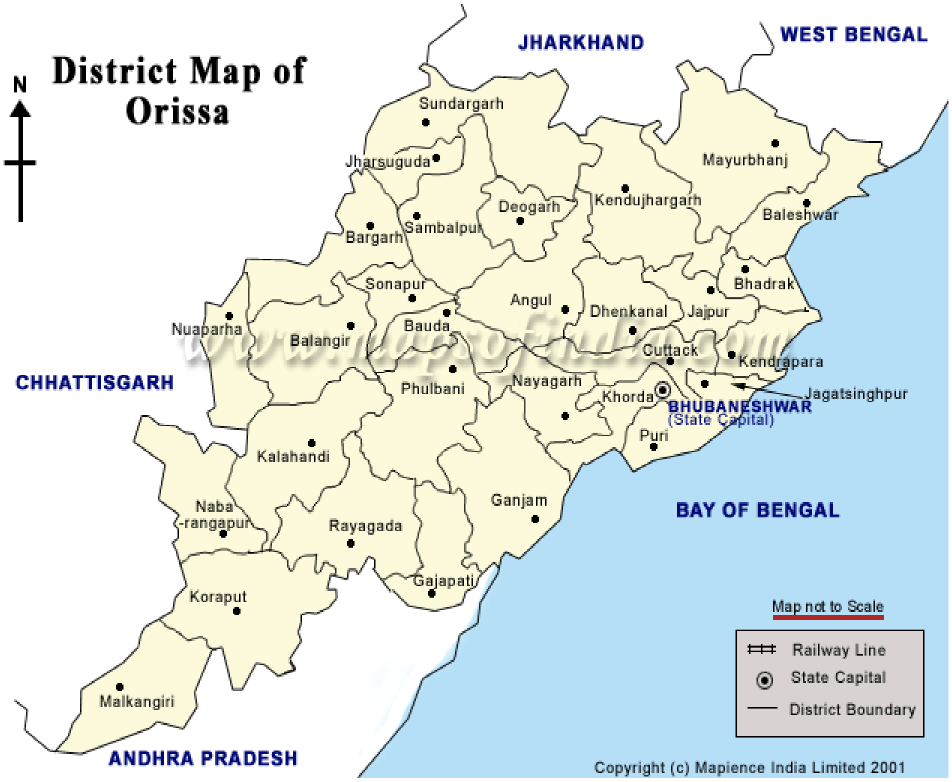
2. SPONGE IRON CLUSTER-ORISSA

2.1 Sponge Iron Cluster Scenario

2.2 Overview of Sponge Iron Cluster Scenario-Orissa

Orissa is one of the States of India. It is located between the parallels of 17.49'N and 22.34'N latitudes and meridians of 81.27'E and 87.29'E longitudes. It is bounded by the Bay of Bengal on the east; Madhya Pradesh on the west and Andhra Pradesh on the south.

Fig No: 2.1 Orissa Map



The following resources are available in Orissa State.

2.2.1 Natural Resources

The state is a rich in minerals and natural resources. It is often said that Orissa has everything under the sky, meaning its forest and agricultural wealth, lots under the earth, an obvious reference to its mineral reserves and a coastline that is a dream come true. Bauxite, chrome, iron ore, coal, manganese, etc mineral are available in Orissa .The state's unique geographical position also endows it with abundant forest resources.

In the mineral map of India, Orissa occupies an important position both in terms of deposit and production. Vast and diverse mineral deposits make Orissa one of the largest minerals bearing States in India. In fact the state boasts of 16.92% of the total reserves of the country. Mineral reserve of Orissa in respect of Chromite, Nickel ore, Graphite, Bauxite, Iron ore, Manganese and Coal is about 97.37%, 95.10%, 76.67%, 49.74%, 33.91%, 28.56% and 27.59% respectively of the total deposits in India.

2.2.1.1 Iron Ore

Orissa's iron reserves have always invited attention. The total Iron Ore reserves in the state is estimated at 4177 million tones ore which is 33.91% of the country's deposit. The Iron Ore mining operations in the State are open cast and mechanized. Most of the mechanized mines have crushing and screening facilities. At present 46.06milion tonnes of iron ore (2004-05) are produced in the sate. In view of growing world wide demand for steel, there has been a major surge of interest in this sector. Due to rich in Iron ore deposits in the state, reputed national /International steel makers have shown interest to establish steel plants in the State.

Not surprisingly German steel giants set their eyes on the state for setting up a steel plant in the public sector as long back as the 50s. The Rourkela Steel Plant was the result of the joint efforts of the Germans and our indigenous workforce. However the state has come a long way since then. It is now on the threshold of becoming a steel super power in not just the country but in the continent as well.

Due to availability of rich iron ore in the state many mineral resource base industries are established i.e. Iron making in the stale like Rourkela Steel Plant (RSP), aluminium plants by INDAL and National Aluminium Company (NALCO), three charge chrome plants at Bahmanipal, Bhadrak and Choudwar by Orissa Mining Corporation (OMC), Ferro Alloys Corporation (FACOR) and Indian Charge Chrome Ltd. (ICCL). At Theruvalli in Rayagada district, Indian Metals and Ferro-Alloys (IMFA) had set up a plant for production of charge chrome / ferro chrome.

The other important mineral based industries established are sponge iron plants. Due to availability of suitable iron ore and technology coal based DRI plants are established in Orissa both SME's and large scale Industries. These plants are spread over all parts of the Orissa where availability of Iron Ore and man power.

2.2.1.2 Coal

There are 57 Gondawana & 14 Tertiary coalfields for the national inventory of coal and Orissa state has only two coalfields. Yet their shares in the reserve are so far established in the country amounts to 24.78%. The geographical reserves in the two coal fields under the state are given below.

- IB River Coal Field - 22.23 bt
- Talcher Coal Field - 35.78 bt

Due to availability of rich content of Iron Ore and coal, many Sponge Iron Plants are established in Orissa State under SME and large Industries. These industries are spread over all parts of Orissa state where raw material are available.

2.2.2 Spread of Cluster

Many sponge Iron Plants are established in Sundergada & Keonjhar districts of Orissa. These industries are located in Kuarmunda, Kalunga, Rajgangpur & Bonei area in Sundergarh District, Joda-Badbil in Keonjhar district and Rengali & Jharsuguda Border in Sambalpur- Jharsuguda. The sponge iron units in Orissa are equipped with three types of Rotary kilns. They are

- 25, 40 and 50 TPD Kilns
- 100 TPD Kilns
- 300, 350 and 375 TPD Kilns.

All Sponge Iron Industries are using these kilns in their plants. The Overall capacity of each Sponge Iron Plant is depends on no of kilns installed and its kiln Capacity.

Table No.2.1: Spread of Sponge Iron Cluster in Orissa

S. No	District	No of Units	Capacity of Kilns (TPD)				No of Kiln
			25	40 & 50	100	300& 350	
1	Sundergarh	47	01	37	71	02	111
2	Keonjhar	20	Nil	15	31	6	54
3	Angul	03	Nil	Nil	03	1	04
4	Dhenkanal	04	Nil	Nil	2	2	10
5	Jajpur	05	Nil	02	05	2	11
6	Mayurbhanja	01	Nil	Nil	02	Nil	02
7	Sambalpur	10	Nil	01	10	4	20
8	Jharsuguda	13	Nil	01	22	5	28
9	Cuttack	04	Nil	02	04	Nil	07
	Total	**107**	**01**	**58**	**150**	**22**	**247**

Source: Status of sponge iron plants in Orissa, published by Environment Conservation Team in 2008

2.2.3 Categorization of Sponge Iron Units

The coal based sponge iron plants located in Sponge Iron Cluster; Orissa is categorized based on Installed Capacities.

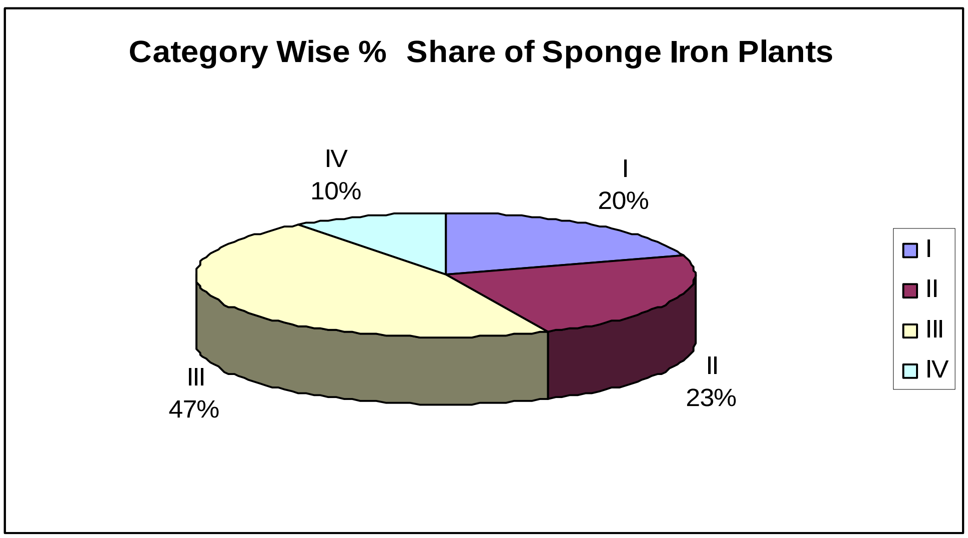
2.2.4 Installed Capacities in Sponge Iron Cluster-Orissa

The sponge Iron Industries in Orissa are categorized in to four Types based on the no of kilns installed in the Sponge Iron Plants. The details of installed capacities, no of industries and its % share in Sponge Iron Cluster, Orissa is presented below.

Table.2.2 Categorization of Sponge Iron manufacturing Units

S.No	Category Type	Installed Capacities (TPD)	No of Industries (30)	% Share
1	I	Up to 50TPD	6	20.00
2	II	Above 51 TPD & up to 100	7	23.33
3	III	Above 101 TPD & up to 200 TPD	14	46.67
4	IV	Above 201 TPD	3	10.00
	Total		**30**	100

Fig No .2.2 Category Wise Sponge Iron manufacturing Units in Cluster



All the Sponge Iron Industries are operating with coal based Technology due to availability of coal and raw material in around industries. All the sponge Iron Manufacturing Industries are operated with same Manufacturing Technology but with different capacities of kilns.

2.2.5 Types of Products

The Sponge Iron Industries located in Orissa are manufacturing Sponge Iron and no other product is manufactured from these Units.

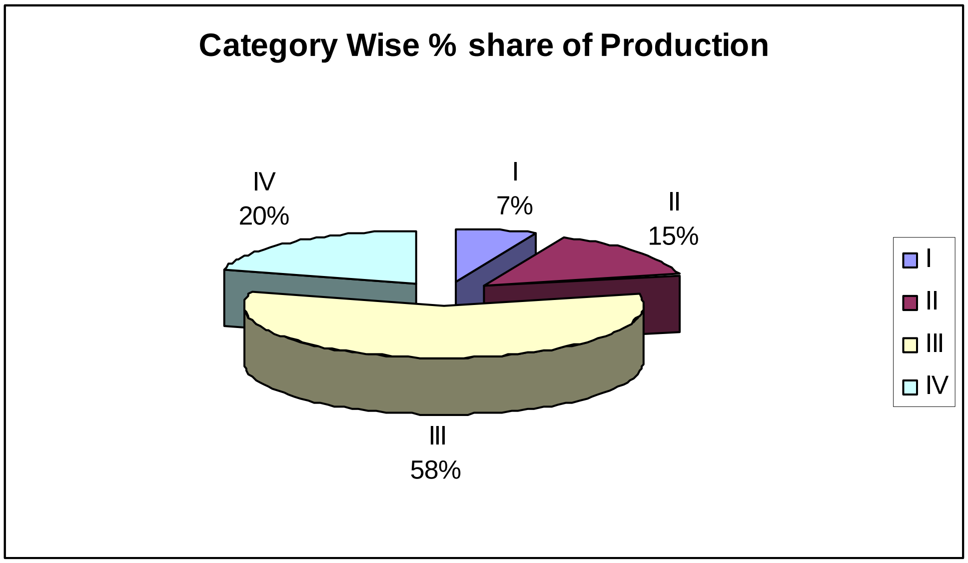
2.2.6 Production, Turnover and Employment

The total production in sponge Iron Cluster, Orissa covering all categories is varies with installed capacities, capacity utilization and quality of raw material used. Based on information collected from sponge Iron cluster, Orissa the total production form all sponge Iron Industries are presented below.

Table.2.3 Category Wise Production Details and its % share

S.No	Category Type	Kilns Range TPD	No of Industries	Production (TPA)	% Share
1	I	Up to 50TPD	6	91080	6.62
2	II	Above 51 TPD & up to 100	7	207770	15.09
3	III	Above 101 TPD & up to 200 TPD	14	796015	57.81
4	IV	Above 201 TPD	3	282000	20.48
	Total		**30**	**1376865**	**100**

Fig .2.3 Category Wise Production Details and its % share



The category-I (i.e. up to 50 TPD Capacity) contribution 7%, category-II (i.e. above 50 TPD & Below 100 TPD) contribute 15% and category-III (i.e. above 100 TPD and Below 200 TPD) contribute 58% of Share and category-IV (i.e. above 200TPD) contribute 20 % of Share. The details of production, turnover and employment in Sponge Iron manufacturing cluster are presented below.

Table.2.4 Production-Turnover- Employment in Sponge Iron Cluster

S.No	Particulars	Unit	Value
1	Total Production	TPA	1376865
2	Turnover	Rs. Crore	1376
3	Employment	No	1800

The actual production is depends on plant utilization, raw material used in the Industries.

2.3 Energy Situation in the Cluster

All manufacturing Industries are required energy to produce different products. The type of energy required is depending on equipment/machinery and raw material used in the plant. The details of energy used for manufacturing of Sponge Iron from Iron Ore are discussed below.

2.3.1 Energy types and Prices

The following energy is required for manufacturing of sponge Iron from Iron Ore.

- Thermal Energy
- Electrical Energy

Major energy consumption in Sponge Iron Plants is thermal followed by electrical energy.

Thermal Energy

All sponge Iron units are operated the rotary kiln and operated with coal based. Coal is used as a fuel for heating the Iron Ore and as well as reaction agent in process. The Temperature required for heating of Iron Ore is 700-900 C which is below the Iron melting point. The required coal for major sponge Iron Plants are procured from Mahanadhi Coal and few plants are used both local and imported coal mix.

Electrical Energy

Another form of energy required for the Sponge Iron Plant is electrical energy. The electrical Energy is used to operate the different equipments involved in Sponge Iron Plants. The electrical energy is used to prepare the raw material, rotating the kilns and cooler kilns. The source of electrical energy is from Western Electricity Supply Company of Orissa Ltd (WESCO). The detail of supply and contract demand is based on the equipments installed in the Industries.

Table 2.5: Energy Consumption and Availability in Cluster

S. No	Type of Fuel	Units	Quantity /year	Availability
1	Electricity	Lakhs kWh	**6177**	Available from WESCO
2	Coal	MT	**9535612**	Available form Mahanadhi coal fields

2.3.2 Details of Energy

The major energy consumption in all sponge Iron industries in cluster is coal followed by electricity. The details of energy used and particulars are presented below.

Table.2.6 Details of Energy used and sources of Energy

S.No	Particulars	Energy Type	
1	Energy	Coal	Electricity
2	Source	Mahanadhi Coal	WESCO
3	Type of supply	Open Source/ Industries Dept	HT
4	Coal Grade/Category	E/F	HT
5	Calorific Value (kcal/kg)	3000-3500	-
6	Tariff	Rs.3000 / Ton	Rs.3.30-3.75/ kWh

The coal is procured from Mahanadhi Coal Fields and Imported Coal through Dept. of Industries and local suppliers and coal tariff is depends on coal grade and power tariff from WESCO is Rs.3.30-3.75 /kWh depending upon electricity consumption.

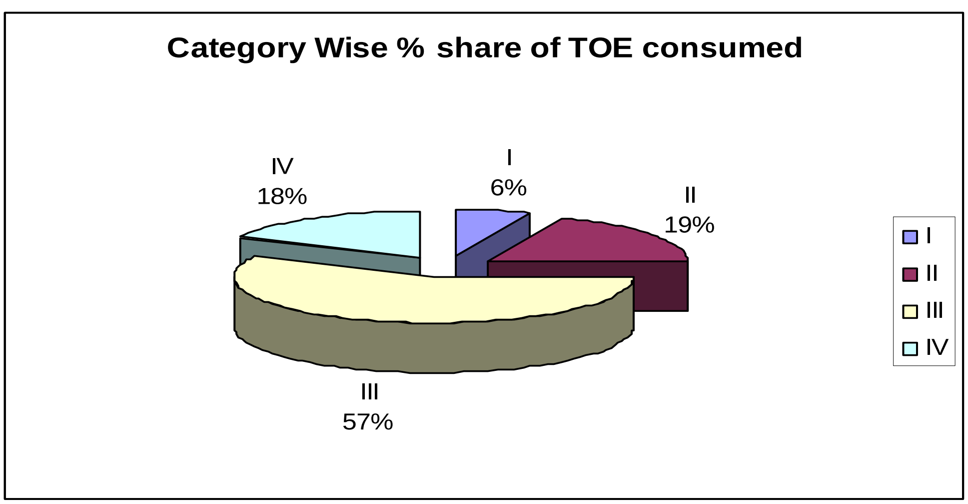
2.3.3 Energy Consumption Pattern in different category industries

The Category wise both coal and electricity consumption profile of Sponge Iron Industries are presented below.

Table.2.7 Details of Energy Consumption-Product Wise in Sponge Iron Cluster

S. No	Category Type	No of Industries	Total Production (TPA)	Coal Consumption (Tons/Year)	Electricity Consumption (Lakhs kWh/Year)	TOE	% Share
1	I	6	91080	139343	13.17	41916	6.25
2	II	7	207770	423872	23.92	127367	18.98
3	III	14	796015	1275267	64.48	383134	57.10
4	IV	3	282000	394562	23.5	118570	17.67
	Total	**30**	**1376865**	**2233044**	**125.07**	**670987**	**100**

Fig No: 2.4 Category Wise Energy Consumption in Terms of TOE (%)



The total Electricity Consumption by 30 Sponge Iron kilns with different Installed capacities consumes 125 Lakhs kWh per year and coal consumption by the Industries is 2233044.

Fig No: 2.5 Category Wise Electricity Consumption in Sponge Iron

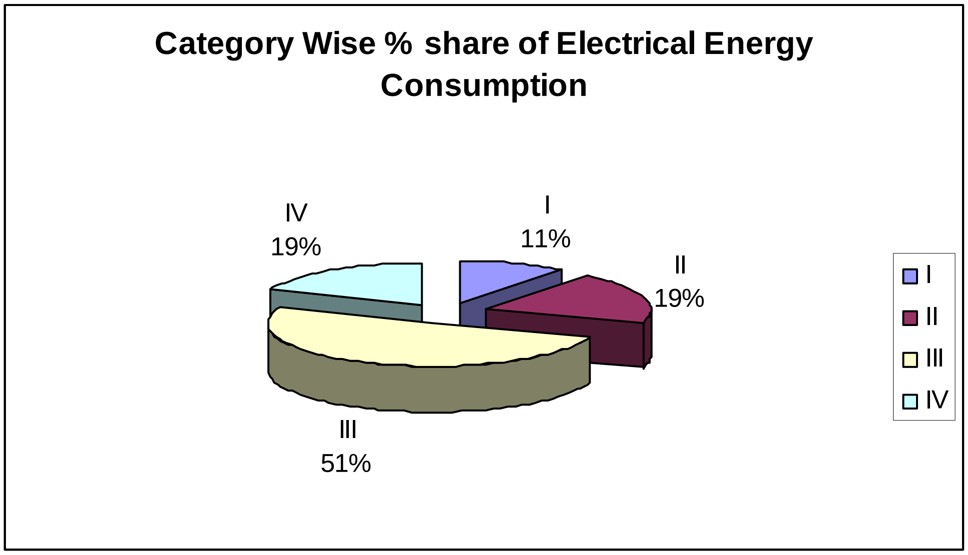
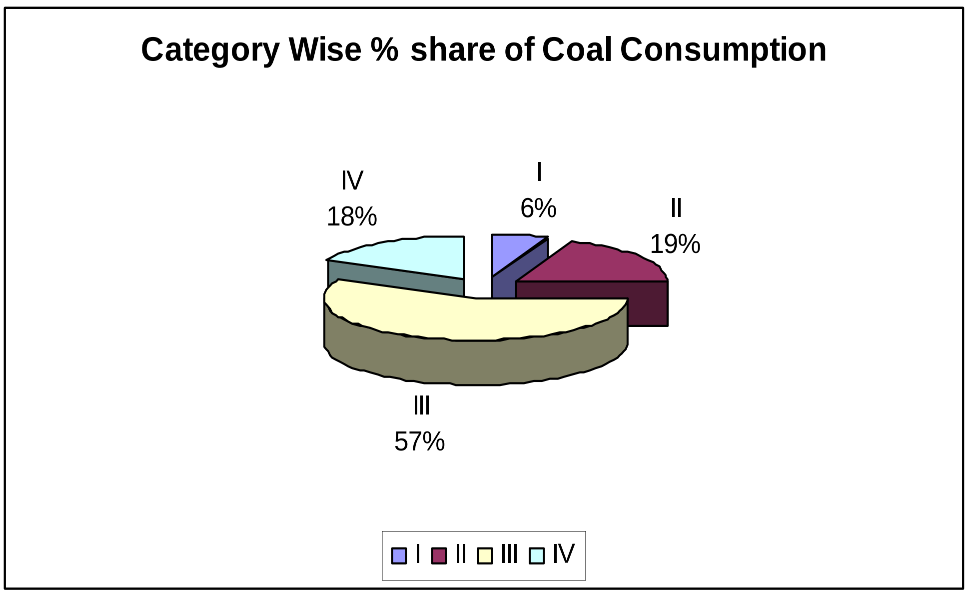


Fig No: 2.6 Category Wise Coal Consumption in Sponge Iron



From the above table and Fig it is observed that Category III plants i.e. above 100 TPD and up to 200 TPD kilns are consuming more electricity and coal consumption due to no higher no industries installed .

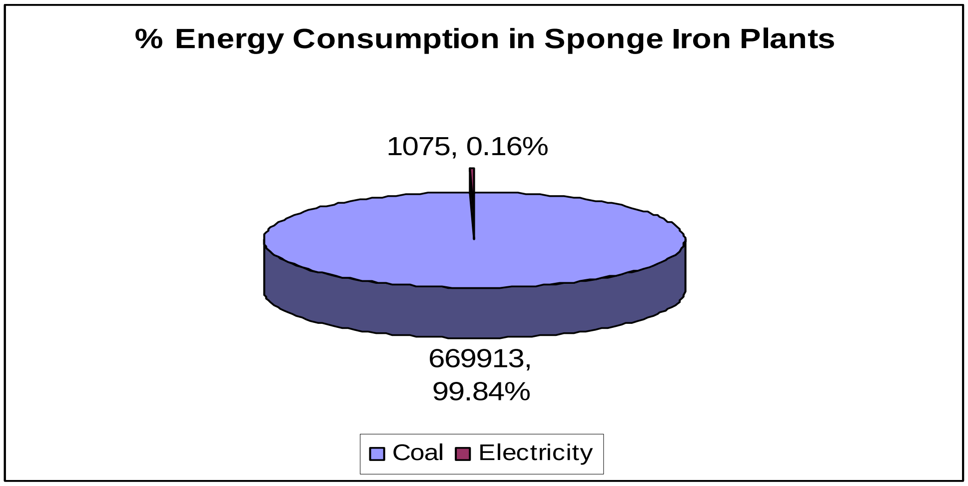
2.3.4 Energy Consumption Profile in Sponge Iron Cluster

The total Energy consumption in Sponge Iron Cluster at Orissa is presented below.

Table.2.8 Energy Consumption Profile in Sponge Iron Cluster

S. No	Energy Type	Unit	Quantity/ Year	TJ/Year	TOE	% Share
1	Coal	Tons	**2233044**	28029	669913	99.84
3	Electricity	Lakhs kWh/Year	**125.07**	45.02	1075	0.16
		Total		**28074.02**	**670988**	**100**

Fig No: 2.7Energy Consumption Profile in Sponge Iron Cluster



From the above table and fig, it is observed that total Energy consumption in Sponge Iron Cluster is 28074 TJ/Year where 0.16 % of electrical Energy and 99.84 % of coal energy is consumed in 30 Sponge Iron Industries located in Orissa.

2.4 Raw Materials

The raw materials required for sponge iron making in coal based plants are presented below. The details of raw material used and physical and chemical properties of raw material is presented below.

Iron Ore

Iron ore or Iron oxide is the source of iron in Sponge Iron making. High grade iron ore contain hematite (Fe_2O_3) mineral. These are associated with undesirable minerals containing Silica (SiO_2), Alumina (Al_2O_3) etc. Pure hematite has the chemical formula Fe_2O_3 and contains 69.94 % of iron balance 30.06% being oxygen. But in majority of Indian iron ore mines, iron ore contains 64% of iron.

The available iron ore from the mines are screened and up to 8-18mm size of iron ore is used for rotary kiln process. The chemical composition of available Iron ore in Indian Iron Ore mines is presented below.

Table 2.9 Chemical Composition of Iron Ore

S. No	Constituent	%
1	Total iron	65 - 67 %
2	Sio2 + Al2 O3	2 - 3 %
3	CaO + MgO	0.5 - 1 %
4	Sulphur	0.02 % max.
5	Phosphorous	0.04 % max.

The Iron content in iron Ore is varies from mine to mine. The Iron lumps with required quantity are feed along with suitable portion of Coal and Dolomite in to rotary kiln by conveyer belts and Volumetric Wave Feeders.

Coal

Coal is required to perform two vital functions inside the sponge iron rotary kiln. Firstly it coal is used to provide requisite heat for bringing the reactants to the reduction temperature. Secondly carbon in the char generated from the de volatilization of coal acts as a reductant for converting the iron oxide into metallic iron.

Of the irons oxides in iron ore, Fe O is the most difficult to reduce. If the coal is able to reduce Fe O into metallic iron under rotary conditions, then the coal is suitable for rotary kiln sponge iron making process. If the coal is found capable of reducing Fe O to metallic iron, it is automatically able to provide the necessary heat for the process. The coal must have adequate reactivity i.e. the ability of carbon in char to quickly react with CO_2 to form CO.

The following reactions are takes place while coal is used in sponge iron process.

FeO +CO←-------------→-Fe+CO2

CO2+C-----------------→-2CO

FeO +C-------------------→Fe +CO

Thus selection of coal should have the following indicators for selection

- Lower rank coal coals have high reactivity. All high volatile bituminous coals are suitable for sponge iron making
- A fuel ration (FC/VM) value should be lower than 1.5 and up to 1.8
- An increase in ash content by 1% reduces kiln productivity by 2%

The size of coal from free end is required to be roughly of 5 to 20 mm size and the coal from discharge end can be mixture of fine coal i.e.0-5m and lump coal up to 20 mm. The quantity of coal required for manufacturing of Sponge Iron is depend on Fe content in Iron ore and carbon content, ash and volatile matter in the coal.

Lime stone/dolomite

The third raw material is the flux, either dolomite or lime stone is required during the sponge iron process. These materials are used to de sulphurise iron ore and to prevent sulpher in coal from entering in sponge iron. Since flux is used in only minor quantities and its quantity has negligible influence on the process. The Dolomite a requirement is 0.03-0.05 MT for manufacture of 1 Ton of sponge iron from Iron Ore and varies depending up on Iron Ore and Coal.

2.5 Equipments and Machinery in sponge Iron manufacturing

The following major equipments/systems required for coal based sponge Iron plant for manufacturing of sponge iron from iron Ore.

2.5.1 Raw material preparation and handling system

The major raw materials required for the sponge iron production are iron ore, coal and dolomite/lime stone. The iron ore and coal are obtained mostly through the road transport from mines with different sizes. These materials are unloaded in stock yards and then are fed into the respective circuit for further processing. Each raw material has individual crushing circuit. But for the Lime stone which is only small quantity, is procured in the required size and fed to the stock bins through the iron ore circuit. The raw material Handling Equipments required are feeders, vibrating screen, impactors and crusher.

Ore Crushing Circuit

The size of iron ore procured for the suppliers are higher than the required size to feed into the kiln. So, the iron ore is required to crush in to required size, it is essential to install the ore crushing unit. The capacity of crushing unit is depends on the plant capacity. The required size of iron ore in the rotary kiln is in the range of 5-16mm. The Ore crushing unit has ground hopper, feeder, two iron ore crushers and one screen with the interconnected conveyors for handling the material. Dust suppression system is provided for pollution control system.

Coal Crushing Circuit

The size of coal procured for the suppliers are higher than the required size to feed into the kiln. So, the coal is required to crush in to required size, it is essential to install the coal crushing unit. The capacity of crushing unit is depends on the plant capacity. The required size of coal in the rotary kiln is in the range of 5-20mm and 0-5mm. The coal crushing unit has ground hopper, vibrating feeder, one coal crushers and one screen with the interconnected conveyors for handling the material to various bins. Bag filters for separation of dust particles is provided for pollution control.

2.5.2 Raw material Storage System and feeding

The raw material storage system is essential to stock the required raw material for uninterrupted production of the plant. The capacity of storage system is usually designed for one day ore more depending up on the plant requirements and operations. The raw material storage system is designed for iron ore, coal and dolomite with feeding systems for better process control. Weigh Feeders are provided under each bin to supply of the required quantity of raw material in each raw material to the kiln.

2.5.3 Reduction Unit.

In coal based sponge iron manufacturing reduction unit is heart of the plant where the actual reduction of iron ore is takes place. The reduction unit consists of rotary kiln and rotary cooler and details are presented below.

Rotary Kiln

The rotary kiln is longer in size and smaller in diameter (higher L/D ratio). This is due to heat transfer from flame to the solid charge in inside the kiln which is the main requirement during the process.

The oxide of Iron is reduced to its metallic form below the melting points of the metal and the oxide in the rotary kiln by supplying the adequate quality and quantity of coal. The entire process of reduction is takes place in the rotary kiln at higher temperature.

In this process coal will be used for producing reducer gas and the process will be carried out in a Horizontal Rotary Kiln.

The Rotary Kiln is operated and rotated with help of AC motor and gears. The speed of the rotation is used by gear box and the speed is controlled by Variable Drive System. The temperature and pressure measuring systems are required to install to measure the different temperatures zones and air flow velocity during the process of kiln. The sealing system is provided to prevent atmospheric air is enter in to the kiln. Raw material iron ore and coal, dolomite is enter in to the kiln in one side and powdered coal is enter in to the another side of the kiln. The gas generated in the kiln i.e. CO is passes opposite to the raw material pass during the operation.

The finished product from the rotary kiln is discharges and enters in to the cooler main drive after completion of the reactions.

Rotary Cooler

The Rotary Cooler is another rotary kiln in reduction units which is used to cool the high temperature metallic iron i.e. sponge iron cooled to around 250 C. The cooler main drive also similar to the rotary kiln but the operation is mainly to cool the finished product. The cooler main drive is driven by the motor with gear system. The cool water is circulated on the top of the kiln for heat exchange between product and water. Sufficient water is sprayed along the cooler main drive at top.

The cooler shell will be of 2.2 m diameter and 22 meters long and the shell plate will be 16 mm thick. The shell is supported by 4 numbers of roller assemblies. The other items include gear rim, spring plate system, pinion shaft system, thrust roller base frame for rollers, drive frame for cooler, thrust roller for frame, Transfer chutes, cooler hood, needle gate head for cooler outlet, spring ring carriage.

2.5.4 Product separation and Storage System

The finished product from the cooler drive is sent to the magnetic separators where metallic and non metallic is separated. The separated non metallic material is send to the dumping yard. The segregated metallic material i.e. sponge Iron is sent to vibrating screens for segregating the different sizes. Conveyor belts are used to transport the metallic and non metallic material.

The segregated material is stored in intermediate storage system provided in the plant. A Bag filter is provided for collecting the fine dust during the material transportation.

The Product Separation system has one screen and two magnetic separators positioned at various elevations. The product house bins have three to four bins with the higher volume of storage capacity. The four bins have the material discharge system with three bins for sponge iron and one for char + dolo char.

2.5.5 Waste Gas Cleaning System

The flue gasses are generated in the kiln during the sponge iron manufacturing. These gases are mainly contains CO, dust particles with higher temperature. The dust settling chamber (DSC) is provided where the higher particles are settle down and gases with fine particles are passes to After Burner Chamber (ABC).The water is sprayed in the ABC where the dust particles coagulate and further settle in the DSC tank. The hot gases from kiln have higher temperature and contain CO which cannot escape to environment.

The ABC system is provided to convert the CO in to CO2 by supply the atmospheric air. The higher temperature CO is converted in to CO2, and the temperature of the gas increased up to 1000 C. The gases from the ABC are required to cool which cannot be sent directly to atmosphere.

The hot gasses from after burner chamber (ABC) are passed through the Forced Draft Cooler (FDC)/Gas Cooled Terminal (GCT) to cool the hot gases from 1000 C to 250C. These gases are passes further through Electro-Static Precipitator (ESP) where fine dust particles in gasses were removed.

Induced draft (ID) fan is used to suck the gases from ESP and sent to atmosphere through chimney.

2.5.6 Auxiliary Facilities

The other equipments/machinery required for sponge iron plant is discussed which are directly/indirectly required for the operation of the plant.

Water supply system

Make up water and water circulating system is required for cooler main drive to cool the product. Pumps are used to supply the water in cooler main drive and makeup water in the ponds. The quantity of makeup water is required is depends up on the how much water is evaporated during the process. In some industries where Gas cooled Terminal is used for cool the waste gases are required water for cooling the gas.

Compressed air system

Compressors are used to for supply the compressed air required in the both rotary kiln and cooler main drive.

Shell Air Fans

Shell air fans are required to supply the air to the rotary kiln for combustion of coal. These fans are mounted in the across the rotary kiln. The quantity of air is depends upon the coal consumption and temperature in side the kiln. At least 5 to 7 shell air fans are provided in the rotary kiln across the kilns.

Instrumentation

The instrumentation has been designed to meet the continuous operation of the plant to meet the desired parameters in the kiln. Instrumentation is required for electrical and process operations in sponge iron plants due to continuous operations. During the process in the sponge iron many parameters i.e. temperatures, excess air, raw material feed are required to observe and maintain required values. To control the all the parameters it is require proper instrumentation system in the plant for smooth operation of plant.

2.6 Production /Manufacturing Process

The process of sponge iron manufacturing involves removal of oxygen from iron ore. Sponge Iron also called as Direct-Reduced Iron (DRI) is produced from direct reduction of iron ore (in the form of lumps, pellets or fines) by a reducing gas using fuel i.e. natural gas or coal. The reducing gas is a mixture majority of Hydrogen (H2) and Carbon Monoxide (CO) which acts as reducing agent. This process of directly reducing the iron ore in solid form by reducing gases is called direct reduction. In this process coal will be used for producing reducer gas and the process will be carried out in a Horizontal Rotary Kiln. The finished product i.e. sponge Iron observed under a microscope, resembles a honeycomb structure, which looks spongy in texture. Hence the name is called sponge iron.

The reduction of Iron Ore can be achieved by using either carbon bearing material, such as non-coking coal or a suitable reducing gas in the form of reformed natural gas. The processes employing coal are known as solid-reluctant of coal-based processes while those employing reducing gases are known as gas-based processes.

The basic reactions in this process are as follows:

$$C + O2 = CO2$$

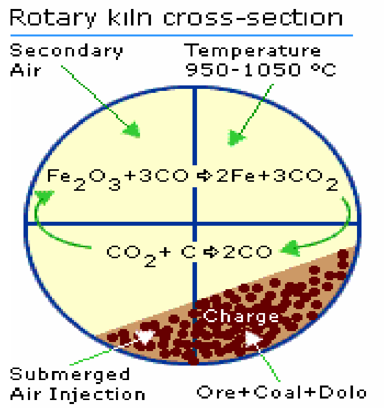
$$CO2 + C = 2CO$$

$$Fe2O3 + CO = Fe2O3 + CO2$$

$$Fe3O4 + CO = FeO + CO2$$

$$FeO + CO = Fe + CO2$$

Fig No 2.8 Rotary Kiln Cross Section and reactions



Process

Non-coking coal and iron ore along with limestone in the required size range and quantity are continuously fed into the feed – end of the inclined rotary kiln through a feed pipe. The materials move along the length of the kiln due to its inclination and rotation. Air is blown in through required number of air tubes suitably located along the length of the kiln. At the feed-end of the kiln air is blown in through nozzles for drying and pre heating of the charge. Initial heating of the kiln is carried through a central oil burner located at the discharge feed end. As the charge moves through the kiln, it is heated by the hot gases, which flow in the opposite direction to the charge (i.e. counter current flow). The initial part of the kiln (about 30%) is called the pre heating zone, where moisture in the charge and volatiles in the coal are removed / burnt off as waste gases. The required heat in this zone is provided by the combustion of the feed coal. The remaining portion of the kiln is called as the reduction zone. In this zone, oxygen in the iron ore is removed leaving metallic iron as per the following chemical reaction.

3FeO3 + CO --------------------→ 2 Fe204 + CO2

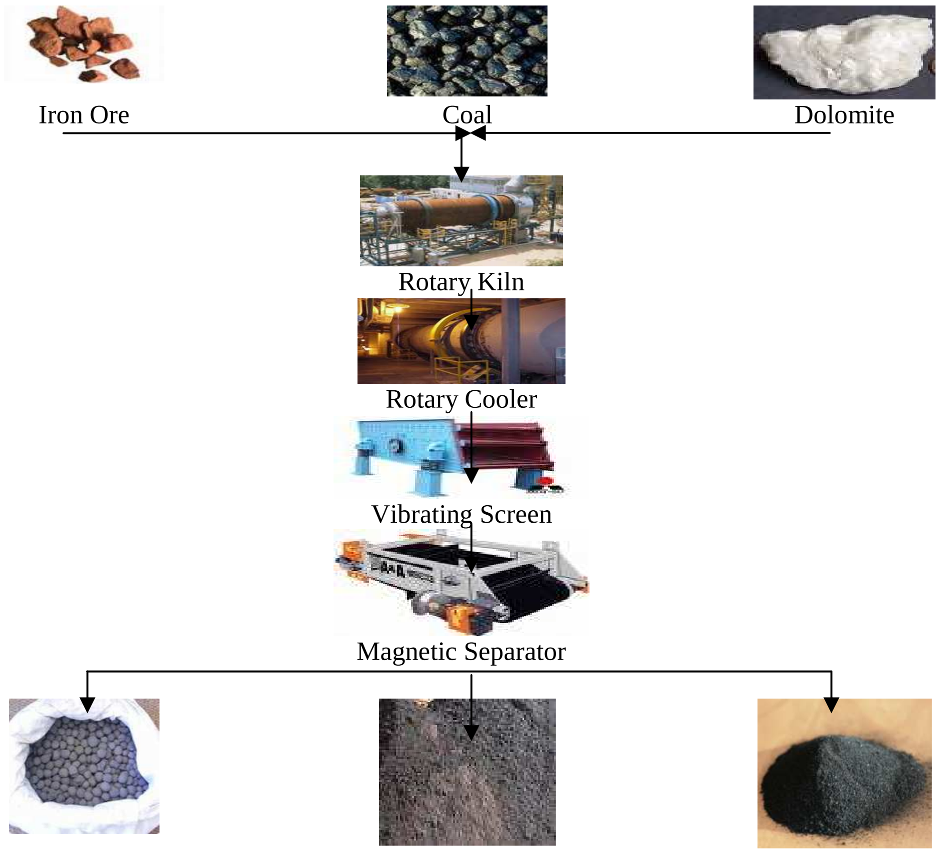
Fe2O4 + CO --------------------→ 3FeO + CO2

FeO + CO --------------------→ Fe + CO2

The CO is generated for the above reaction according to CO2 + C --→ 2CO, at temperature above 900 deg. C, carbon monoxide will combine with the oxygen in the iron ore forming carbon dioxide and thus reduce the ore to metallic state.

Higher the temperature, the faster would be the oxygen removal. After the removal of oxygen and grater is the metallization of sponge iron. Metallization levels can roughly be checked by density of the sponge iron. It can also be judged by the metallic luster if a sample is rubbed against a rough surface.

Fig No 2.9 Steps involved in Sponge Iron Manufacturing Process



After the iron ore has been metallic to the desired level, sponge iron and residual char are discharged from the kiln into a rotary drum type cooler. In the cooler sponge iron is cooled to below 250 deg. C before the material is discharged on to a belt conveyor. If the sponge iron were exposed to air at high temperatures (i.e. above 250 deg C) it would tend to re oxidize. It is therefore, necessary that the temperature of the product at the point of discharge from the cooler is as close as possible to the ambient temperature. The reduction process occurs in solid state. The crucial factor in this reduction process is the controlled combustion of coal and its conversion to carbon monoxide to remove oxygen from the iron ore.

The overall process extends to a period of 10 to 12 hours inside the kiln. During this time, iron ore is optimally reduced and the hot reduced sponge iron along with semi-burnt coal is discharged to a rotary cooler for indirect cooling to a temperature of around 120℃. Sponge iron being magnetic in nature, the discharge from cooler main drive consisting of sponge iron, chars & other contaminations are routed through electromagnetic separators, to separate other impurities from sponge iron. The product is then screened in size fractions of lump (+3mm) and fines (0-3 mm). Separate bins are installed to preserve its quality, reduce re oxidation and facilitate faster loading on to the trucks.

2.7 Current Policies and Initiatives of local Bodies

In any SME cluster, units are influenced by various institutions, associations and cluster actors. The financial Institutions, Government bodies and Industrial associations are playing a major role followed by Technical Institutions in the cluster.

2.7.1 Financial Institutions

Financial institutions are providing term loans and working capital to the industries. SBI is the lead bank in Rourkela, other banks have set up their branches.

2.7.2 District Industries Centre (DIC), Rourkela

The DIC helps the industry in getting provisional and permanent registrations to the established Industries and provides necessary assistance. It also guides new entrepreneurs to set up industries. The requirement of raw material like coal is allotted to the Industries based on the installed capacities.

2.7.3 National Small Industries Corporation Limited-NSIC

The prime aim of NSIC is to foster growth of small scale industries in India through various developmental activities such as hire-purchase and leasing, raw material assistance, marketing support, tender marketing, export development finance, composite term loan and single point registration scheme.

2.7.4 Orissa Industrial Infrastructure Development Corporation, IDCO

The IDCO provide and maintain existing infrastructure (Industrial estates) and have an office at Rourkela headed by a project manager. There are two industrial estates are located in Rourkela and majority of sponge Iron Units are set up their plants.

2.7.5 Industrial Associations

All Sponge Iron Industries in Orissa formed an association called **"Orissa Sponge Iron Manufacturers Association (OSIMA)"** to solve the issues in the cluster on Technical, Financial, man power and policy related matter. The details of associations in Sponge Iron Cluster; Orissa is presented below.

Table 2.10: Details of Associations in the Sponge Iron Cluster

S.No	Particulars	Details
1	Name of the Association	Orissa Sponge Iron Manufacturers Association (OSIMA)
2	Established Year	1983
3	Activities	• Organizing the Industry related Programs • Solving Industry related problems with respective to Government and Private agencies
4	Association Address	A/8, Palashpalli Bhubaneswar-20
5	Contact Person with details	B.K Burma Cell:09777173924 0674-2594875

2.8 Issues related to Energy Conservation and Technology up gradation

The following issues are identified while interacting with Owners and employees during Energy Use and Technology Audit in Sponge Iron Manufacturing Cluster, Orissa.

2.8.1 Energy Issues

All Sponge Iron Manufacturing Industries requires both thermal and electrical energy for manufacturing of Sponge Iron from Iron Ore. The required thermal energy is produced by using coal as fuel. The part of carbon is used for heating the Iron ore and remaining as use as reductant during the process. All Sponge Iron Industries are coal based and major energy consumption by these industries is thermal energy compare to electrical energy. Another form of energy i.e. electrical energy is used to operate installed equipments. All Industries draw electrical energy from WESCO by registering with contract maximum demand.

The availability of required quality of coal and quantity is one of major problems encountered in cluster. At present the coal quality is E/F grade with higher ash content and low fixed carbon content. Due to inferior quality of coal, the following problems are aroused during the operation of Sponge Iron units

- ✓ Higher coal consumption
- ✓ Higher ash content in coal leads to breakdown due to ring formation in kiln
- ✓ High rate of dola char generation

There is potential energy saving in both thermal as well as electrical energy by adopting the energy efficient technologies in Coal based Sponge Iron Industries.

- The flue gas generated during the process has higher temperature i.e. 900-1000. At present the higher temperature flue gas is cooled by FD fans/ GCT's with out utilizing the heat.
- At least 2.2 MW of power can be generated through the flue gases generated in 100 TPD kilns.
- The high temperature flue gases can be used for preheating of raw material i.e. Iron Ore, dolomite by adopting the preheated kiln which results the conserve in coal consumption
- VFD's are one of the technologies to conserve the electrical energy during part load condition. All industries are utilizing the VFD in Rotary kilns, but other areas like PH Bag filters, CD filters, pumps where part loads are exists during the process.

These two technologies are not implemented in many of the sponge iron plants due to lack of awareness on technology, energy conservation techniques and identification and approach towards implementation Technology. In general, Energy conservation awareness and conscious is required among all Sponge Iron Manufacturing Owners and Operator.

2.8.2 Technological Issues

Another major issue in Sponge Iron Manufacturing Cluster is identification of right technology and equipments to improve the efficiency plant.

Identification of energy efficient equipment/Technologies in Sponge Iron manufacturing industry is very difficult by the Owners. If any technology successfully implemented in one or two industries same is followed by other industries too. This is due to lack of technology information, financial constraints to invest and skilled manpower requirement. The technology service Providers, equipment suppliers are another issue in the cluster.

To overcome the situation in the cluster it is essential to generate awareness by organize /sensitize on relevant technologies with local service/ equipment suppliers with in the cluster.

2.8.3 Financial Issues

The Industry owners have good contacts with local banks to avail financial service from banks i.e. loans, salaries, and working capital requirements. Among all SME's, the larger units are capable of either financing themselves or get the finance from their banks. The smaller units will require loan at comfortable rates and other supports to raise the loan.

However, most of them have been able to invest for energy efficiency technologies which have good payback periods. If schemes like Energy Efficiency Financing is provided by SIDBI and through Government Schemes it shall play a catalytic role in implementation of identified energy conservation projects & technologies.

2.8.4 Skilled and Unskilled Manpower issues

All Sponge Iron Industries require skilled and unskilled manpower for the operation of plant. Skilled workers are required for operation of different process involved and electrical equipments. At present, availability of skilled workers are not from the technical back ground but experienced in sponge iron manufacturing operations. Even if the qualified staff joins for the sake of experience and jump to other industry after getting sufficient experience due to low salaries. There is gap between the no of skilled workers are available compare with no of industries due to fast growing of sponge Iron industries in the cluster. The skilled man power required training on operation and maintenance of kilns, prime movers for efficient use of machinery which leads to minimize the energy consumption in Industry.

Specialized and focused training to the skilled man power by the local service providers on better operation and maintenance of equipments, importance of energy, its use during the process and energy conservation measures among industry owners and workforce will result in efficient operation of plant resulting improving the productivity.

2.8.5 Issues related to Service Providers

Many of Energy Efficient technology providers have not shown keen interest in implementation of their new innovative technologies in the cluster due to higher price which cannot be implemented by the SME' s. Further several plant owners are reluctant to stop the production activities to carryout changes/modifications to the plant.

The Local service providers for Sponge Iron Industries are available with in radius of 100 km from the cluster and major technology providers are in metropolitan cities from where the required services are provided. The Cluster location is well connected by road, rail connection to reach these industries. Few of the service providers have their activities in Rourkela. The list of Service and Technology providers are presented in the Annexure. 2

3. ENERGY AUDIT AND TECHNOLOGY ASSESSMENT

3.1 Energy Audit & Technology Assessment in the Cluster

Energy audit is a systematic study or survey to identify how energy is being used in a plant and identify the energy saving opportunities. Using proper audit methods and equipments, an energy audit provides essential information on energy consumption pattern in every process and how energy being used with in a plant/ industry. The energy audit study is classified into two types

- Preliminary Energy Audit Study
- Detailed Energy Audit Study

During the detailed energy audit the energy consumption in each process is calculated and compares with bench marks standards. The identified energy losses in each area converted into energy conservation proposal where identification of technology /equipment is proposed to save energy. The energy audit report contains energy conservation opportunities and energy savings proposals comprising of techno economic analysis of projects. These energy conservation proposals are discussed with energy management team/management in the plant and implement on priority basis. Adopting this activity as routine or part of organizations culture gives life to energy management, and controlling the energy use.

3.1.1 Pre-Energy Use & Technology Audit Studies

The Methodology adopted for pre - energy audit activities is as follows:

- Based on situation analysis data provided by BEE in Sponge Iron Manufacturing units in Orissa, visited two to three units and observed energy issues in cluster
- Interacted with Association members regarding energy use, critical issues related to energy in various industries in the cluster and get their feedback and views
- Identify the high energy consuming equipments and analyzed latest technologies to modernize/ minimize energy consumption
- Prepared data sheet, units list to be audited to cover all installed capacities.
- Based on industry visits energy conservation areas are identified in Industries
- Exclusive allocation of team personnel (who can also speak local language) from our team to conduct preliminary audit in the plants

3.1.2 Preliminary Energy Audit Studies

The methodology adopted for Preliminary Energy Audit study in Sponge Iron Manufacturing Cluster as follows:

- Conducted preliminary study in 30 units
- Collection of past six month's both thermal and electrical energy consumption data
- Establishment of the energy consumption scenario at the plant
- Study and Identification of major energy consuming sections and equipments for further work for identification of energy conservation opportunities
- Detailing of no cost and low cost saving measures at the plant.
- Identification of the areas for detailed study and listing the measurements required
- Modified previous formats for data collection and measurements and finalized for detail energy audit study

3.1.3 Detailed Energy Audit Studies

The methodology adopted for No of detail Energy Audit study conducted in Sponge Iron manufacturing Cluster as follows:

- Conducted detailed energy study in 30 units
- Detail observations are made on all major equipments in terms of functions, energy requirements
- Thermal i.e. coal and electrical energy consumption is measured for 30 units
- Voltage, Current, kWh and PF are measured during the operation of each equipment/machinery using portable power analyzer for evaluation of specific energy consumption and identification of energy savings.
- Identified the energy conservation opportunities by verifying benchmarks
- Identified the technology requirements to save the energy losses in each process
- Prepare the Techno Economic feasibility to adopt the energy conservation technologies and Identify major constraints for installing energy efficient equipments
- The identified 15 technologies/energy conservation proposals are prioritized based on different capacities in the cluster and prepared Detailed Project Reports (DPRs)
- Identified the equipment suppliers locally/with in India and Identified the availability and accessibility of energy resources in the cluster
- Discussed with Industries management for adoption of New Technologies/Energy efficient equipments to their plants
- Discussed with the financial strength and investment to adopt the new technologies

3.1.4 Benefits of Energy Audit in Cluster

The Industrial clusters means where similar type of industries manufacturing same products in particular region/boundary. By conducting detailed energy audits in industrial cluster, there will be massive potential for energy savings with an average of 10 to 15 % of energy savings and depends up the type of energy used. The identified energy conservation proposals if implemented by one/two industries in cluster will replicate by all the units within the cluster. These results are creating a positive impact to the industries as well as national economy and the environment. It will result to reduce the emission of Green House Gases (GHG) into the atmosphere.

3.2 Observations made during Energy Use and Technology Audit

The following observations are identified during Energy use and technology audit conducted in sponge Iron manufacturing cluster.

3.2.1 Non Utilization of heat from Flue gases

All sponge Iron plants located in Orissa are coal based Industries. Flue gases are generated during the process having higher temperature. The higher heat content flue gases are cooled with out utilizing in the process. The temperature of flue gases is in the rage of 900-1000 C and cooled up to 250C by using the forced draft fans/ Gas cooled terminals.

3.2.2 Electrical Equipments

The electrical equipments installed in Sponge Iron plants are motors, compressors, blowers and pumps. These equipments are operated throughout the day and year long. These motors are standard and re winded and operated dusty environment. Due to re winding and lower efficiency and dusty operations the efficiency of motors decreases and power consumed by motors increases.

3.2.3 Skilled and UN Skilled Man Power

Majority of plant operators and helpers deployed in cluster units are non technical and illiterates and had been taken based on past experience in sponge iron units and do not have any technical skills and knowledge on energy conservation. This is also one of factor for inefficiency of the process and conscious of energy conservation.

3.3 Energy Consumption profile & Availability

The availability of energy resources in cluster level is assessed based on collected information from different sources and suppliers in the cluster. The details of energy consumption and availability are presented below in cluster level.

Table 3.1: Energy Consumption and Availability in Cluster

S. No	Type of Fuel	Units	Quantity /year	Availability
1	Electricity	Lakhs kWh	**6177**	Available from WESCO
2	Coal	MT	**9535612**	Available form Mahanadhi coal fields

The total Electrical energy consumption in 107 sponge iron Industries in Sponge Iron cluster, Orissa is 6177.13 lakhs kWh/ year and the power tariff is ₹3.30-3.75 /kWh depending up on the consumption. This power is supplied from WESCO Ltd.

The coal consumption by 107 sponge iron Industries in the cluster is 9535612 MT per year, which is available from near by located Mahanadhi Coal fields.

3.3.1 Availability of data and Information

The major energy consumption by Sponge Iron units is Coal followed by electricity. Majority of units are shared their electricity bills but not in coal consumption and production details.

3.4 Technology Gap Analysis in Sponge Iron Cluster

Various technological gaps were identified during energy use and Technology Audit in sponge Iron Cluster, Orissa due to lack of awareness on available technologies in the market, knowledge on tapping the potential energy saving and its monetary benefit, awareness among the workforce.

There is a tremendous need for the industry to modernize/upgrade its technology and adopt energy efficient technologies in some of the areas. There are many technologies and energy efficient equipments available in the market which can be sourced from local service providers dealing with these technologies. Further, as per the discussions made with the management, they are interested to adopt the Power generation form waste heat recovery, preheating the raw material and energy efficient motors etc for their sponge Iron Industries.

The following Technology Gaps are identified during the energy use and Technology Audit.

3.4.1 Energy Efficient Motors

The Motors installed in sponge Iron Industries is for operation of crushers, kilns, compressors, pumps etc. The efficiency of motors are found low compare to the energy efficient motors. By interacting with operators stated that many motors are re winded. Due to lower efficiency and re winded, the standard motors efficiency will decrease and power consumption will increase in continuous operation.

Now day's energy efficient motors are available at least above 90 % of efficiency in the market which can with stand even dusty operations. By implementing the energy efficient motors in crushers, compressors, pumps there will be tremendous electrical energy savings in Sponge Iron industries.

3.4.2 Power Generation from Waste Heat Recovery from flue gases

Power generation is one of the efficient ways of using heat from flue gas generated during the process. All sponge Iron manufacturing units are coal based units. Flue gases are generated during the process and have the temperature of 900 -1000 Deg C. This heat is niot utilized and simply cooled to 250 deg C before releasing it to atmosphere. This heat is enough to generate the power by adopting the waste heat recovery system and at least 2.2 MW power is generated form 100 TPD kiln.

3.4.3 Raw Material Pre heating from Waste Heat Recovery system

Another benefit of higher temperature flue gas is can be use for pre heating of raw material. In sponge Iron Industries coal is used in the kiln to heat the Iron ore and the reactant up to 700 C and reactant. So generated high temperature flue gas from the rotary kilns can used for preheating of raw material. Due to pre heating of raw material by flue gas at least 20% of coal is saved and productivity also increases up to 20%.

3.4.4 VFD' s for variable loads in process

In sponge iron plants motors are used to operate different equipments during the process applications. The loading of motors varies and from part load to full load in different applications. The variable load applications in the process are PH Bag filters, CD bag filters, kiln drives, pumps, compressors, ID and FD fans etc. Variable Frequency Drives (VFD) can be used in these motors to minimize the energy consumption and save at leas 15-20% energy is saved in these equipments.

3.5 Identified Energy Conservation measures

In Sponge Iron Cluster, it is essential to adopt energy efficient technologies and technology up gradation to reduce both thermal as well as electrical energy consumption. During the energy use and technology audit in 30 sponge Iron Industries located in Orissa, the following energy conservation measures are identified to reduce both electricity and coal consumption in Sponge Iron Industries.

3.5.1 Install Waste heat recovery system to generate Power

In Sponge Iron manufacturing, flue gases are generated with a temperature of 900-1000 C during the process. This heat is cooled with out utilizing heat by supplying the air by using FD fans. The heat content in the flue gas is enough to generate the power by installing the waste heat recovery system i.e. boiler. The high temperature flue gases are pass through the boiler for generate the steam and that can be used in turbine to generate the power.

Background

All sponge Iron Manufacturing Industries in Orissa are coal based industries and flue gases are generated during the process which have higher temperature i.e.900-1000 Deg C. These industries are operated throughout the year. At present all industries are not utilizing the heat from the flue gases and cooled by FD/GCT system before sending to ESP. Thus power generation using generated flue gases are one of energy conservation opportunities in sponge iron plants by installing waste heat recovery system.

Energy Conservation Potential

In 100 TPD coal based sponge iron plants, during the process at least 24000 m3/hr flue gases are generated and having the temperature of 900-1000C. The heat from the flue gas is recovered using Waste Heat recovery Boiler and generates at least 2.2 MW power. The total power generated in sponge iron plants are depends on installed capacity of sponge iron plants.

Technical Specifications

The waste gases generated from the Rotary kiln is passed through the boiler to generate the steam. The generated steam is used for generation of power. The temperature available in flue gasses is enough to generate the required steam for power generation through boilers. The boiler is a bi-drum, water tube boiler. The super heater in boiler is designed for an outlet temperature of 490 deg C. The gases leaving the kiln would enter a super heater. The gases leaving the super heater would enter a set of boiler bank tubes are expanded into the steam and water drums. The gases after passing across the boiler bank would enter a bare tube economizer. This is an inline counter flow economizer and heats up the feed water going to the drum.

The gases are reduced to around 180 Deg C for the economizer. After the economizer, the gases are let into a Bag Filter which is provided to reduce the dust emission level. An ID fan has been provided to take care of the gas draft losses in the system. The steam turbine is of multistage horizontal spindle condensing type turbine. The turbine is provided with gear unit capable of continuously transmitting the necessary power and designed for speed reduction ratios for the turbine. The AC Generator (alternator) is of 415V, 50HZ. 0.8 Power Factor, Salient Pole, Revolving \Field, Horizontal type Alternator, and producing required MW of power.

The technical specification of waste heat recovery system for generation of power from flue gases is presented below.

Table: 3.2 Technical Specifications of WHRS for Power Generation

S. No	Parameter	Unit	Value
1	Type of Boiler		➢Four pass, Horizontal ➢Water Tube ➢Natural Circulation ➢Single Drum Boiler
2	Steam Pressure	kg/cm2	66
3	Steam Temperature	C	485
4	Steam Flow	TPD	20
5	Flue Gas Temp	C	950
6	Installed Capacity of Sponge Iron Plant	TPD	200
7	Flue gas Flow	Nm3/hr	48000
8	Flue Gas Out Let Temperature	C	180
9	Feed Water Temperature inlet to Economizer	C	126
10	Cooling Water Temperature	C	40

Fig No 3.1 Power Generation from Waste heat recovery

Availability of Technology /Equipment

Power generation from waste heat gases Technology is proven in sponge Iron plants and operating successfully in many sponge Iron plants in India. The technology is available and manufacturing in India by few major companies. These companies are marketing their products through directly in India and Orissa. Majority suppliers for these equipments are located in capital cities in India. Sponge Iron Manufacturers can avail these equipments by ordering.

The details of manufacturers and suppliers of Power generation from Waste heat recovery from flue gas in India presented in Annexure-2.

Cost Benefit Analysis

Any Energy conservation/Efficiency Improvement proposal/project requires cost benefit analysis before implementation in industries. Based on observations and measurements taken from Sponge Iron Plants located in Orissa during Energy Use and Technology Audit, the cost benefit analysis was prepared for implementation of Power generation from Waste Heat Recovery in sponge Iron plants and presented below.

Table 3.3 Cost Benefit Analysis for Power Generation from Waste heat recovery

S.No	Parameter	Unit	Existing System	Proposed WHR Power Generation
1	Rotary kiln Capacity	TPD	100	100
2	No of kilns in the plant	No	2	2
3	Total Installed Capacity	TPD	200	200
4	Iron ore Consumption	Tons/hr	1.8	1.8
5	Iron ore Consumption	TPD	360	360
6	Coal Calorific Value	kcal/kg	3000	3000
7	Lump coal consumption	Tons/hr	1.08	1.08
8	fine coal consumption	Tons/hr	0.72	0.72
9	Total Coal Consumption	Tons/hr	1.8	1.8
10	Total Coal Consumption	TPD	360	360
11	Dolomite Consumption	Tons/hr	0.5	0.5
12	Flue gas generated by kiln	nm3/hr	24000	24000
13	Total flue gas generated at installed capacity	nm3/hr	48000	48000
14	Density of flue gas	kg/m3	1.3	1.3

S.No	Parameter	Unit	Existing System	Proposed WHR Power Generation
15	Actual gas flow	kg/hr	62400	62400
16	Flue Gas Temperature at out let of kiln	C	950	950
17	Enthalpy of flue gas at kiln out let @ 950C	kcal/kg	261.92	261.92
18	Enthalpy of gas at Boiler out let @ 170 C	kcal/kg	39.15	
19	Flue gas temperature at inlet of ESP	C	170	
20	Heat value available in flue gas	kcal/hr	13900848	
21	Radiation heat loss(1%)	kcal/hr	139008	
22	Blow down loss(2%)	kcal/hr	278017	
23	Actual heat available after loss	kcal/hr	13483823	
24	Steam enthalpy or total heat at 66kg/cm2, 490C	kcal/kg	800	
25	Feed water temperature	C	126	
26	Enthalpy of feed water	kcal/kg	127	
27	Generated steam @66 kg/cm2, 485 C	kg/hr	20035	
28	Power generation by generated steam	MW	4.4	
29	Power generation	kwh/day	105600	
30	Auxiliary power consumption	kwh/day	10560	
31	Power available for grid	kwh/day	95040	
32	Power Consumption in Industry	kWh/day	18000	
33	Power available for grid	kwh/year	26964000	
34	Power Cost	Rs./kWh	3.3	
35	Energy cost due to power generation using flue gases	Rs.lakhs/ year	1098	
36	Investment cost of power plant	Rs. Lakhs	2200	
37	O& M cost	Rs. Lakhs	110	
38	Manpower Cost	Rs. Lakhs	3.95	
39	Total investment Cost including O&M, Manpower	Rs. Lakhs	2314	
40	Pay back period	years	2.11	

From the above table, it is observed that the power generated using the flue gases from 2x100 TPD plant is 4.4 MW and investment required for power generation is Rs. 2200 lakhs. The payback for the technology is 2.11 years.

Life Cycle Cost

The Life Cycle Cost of Waste heat recovery power plant using flue gases in sponge iron plant is calculated based on operating cost, equipment life and maintenance etc. The detail of life cycle cost is presented below.

Table 3.4 Life Cycle Cost of Power Generation from Waste heat recovery

S.No	Particulars	Units	Value
1	Waste heat recovery potential	kcal/hr	13900848
2	Power generation by flue gas	MW/hr	4.4
3	Quantity of flue gas	Nm3/hr	48000
4	Capital Cost	Rs. In lakhs	2200
5	Replacement of components	Rs. In lakhs	44
6	Annual Maintenance	Rs. In lakhs	110
7	Manpower cost	Rs. In lakhs	3.95
8	Life of pre heated kilns	Years	20
9	Interest rate	%	10
10	LCC at the end of life	Rs. In lakhs	2345

The life cycle cost of Waste heat recovery power plant using flue gases in sponge iron plant is estimated at Rs.2345 lakhs

Implementation Cost

The implementation cost of Waste heat recovery power plant is calculated based on machinery, erection, civil works and retrofitting costs etc. The detail of implementation cost is presented below.

Table 3.5 Implementation Cost for Power Generation from Waste heat recovery

S.No	Parameter	Cost in Rs.lakhs
1	Civil Works	22.00
2	Plant and Machinery	2200.00
3	Electrical works	44.00
4	Erection and Commissioning	22.00
5	Miscellaneous costs	40.00
6	**Total Cost**	**2328**

The implementation cost of Waste heat recovery power plant using flue gases in sponge iron plant is estimated at Rs.2328 lakhs

Recommendations

All Sponge Iron plant having minimum 200 TPD installed capacity can install the waste heat recovery power plant which is technically and financially viable.

Benefits

The following benefits are expected by Installing waste heat recovery Power plant using flue gases during the process in sponge iron plants.

- Heat from flue gases is used for power generation. No other raw material is required for power generation
- Reduction in environment Pollution
- Generated power can be used in sponge iron plants. This will save the energy cost.
- Reduce the GHG emissions

Limitations

The coal based sponge iron plants with minimum 200 TPD installed capacities and required water facilities available are advised to implement the waste heat recovery power plants.

3.5.2 Installing Preheating Rotary kiln for Raw material heating using Waste heat gases

In Sponge Iron manufacturing, flue gases are generated during the process is about 900-1000 C temperature. This heat is cooled with out use before sending to environment. If the heat content in the flue gas can be used for preheat the raw material used in sponge iron plant i.e. Iron Ore. Due to pre heating of the raw material input coal required for the sponge iron plant is reduced and production cost is reduced.

Background

All sponge Iron Manufacturing Industries in Orissa are coal based industries. The coal is used as heat the raw material and as a reductant for converting the iron oxide into metallic iron during the process. In sponge iron plants, the actual quantity of heat required to heat up the iron ore in kiln up to 700 Deg C is 140000 kcal per tone of material.

The flue gases are generated during the process of rotary kiln and having higher temperature i.e.900-1000 Deg C. The heat content in the flue gas is not utilized in the plants and cooled by supplying the air/water.

If sponge iron industries utilize the heat in flue gas by adopting the preheating kiln, considerable coal is saved and the coal consumption is reduced in the plant. The pre heating kiln system will improve the efficiency of existing kiln and increase the productivity.

Energy Conservation Potential

By adopting the Raw material preheating system in Sponge Iron plant for utilizing heat from the flue gases, the coal consumption will reduce by 20-25% by comparing with present coal consumption in the plant. The energy consumed for cooling the flue gases are reduced by adopting the raw material pre heating system.

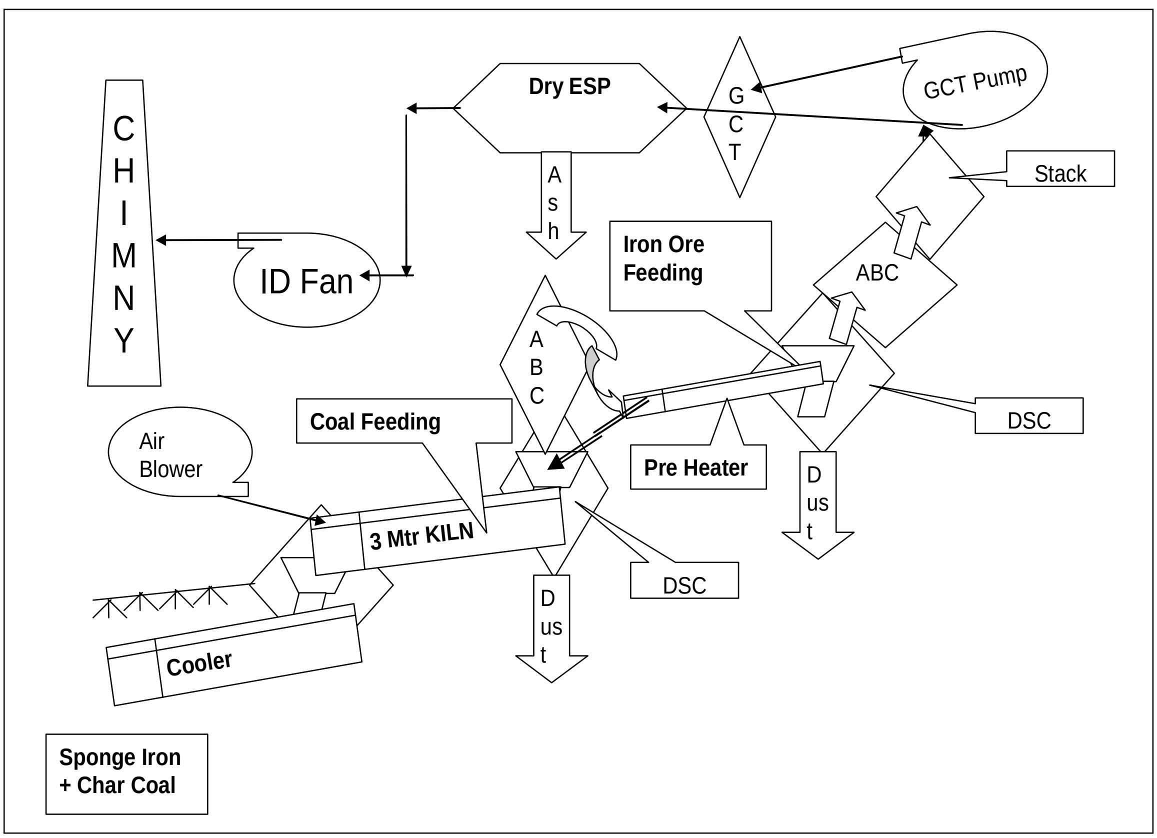
Technical Specifications

The Technical specification of suggested preheating rotary kiln system for using the heat from flue gas in 100 TPD Plant is presented below.

Table: 3.6 Technical Specification of Preheating Rotary kiln of Raw material heating

S. No	Parameter	Unit	Value
1	Type of Equipment		Rotary kiln
2	Pre heating kiln Capacity	TPD	100
3	Quantity of Flue gas Flow	Nm3/hr	24000
4	Temperature of Flue gas (In)	C	900-1000
5	Temperature of Flue Gas(Out)	C	250
6	Raw material temperature after pre heated	C	800—850
7	Gas flow		Counter flow

Fig.3.2 Preheating Rotary Kiln of Raw material heating



Availability of technology /equipment

The suggested technology is proven in at least 10 to 15 sponge iron plants in India and the suppliers are from Indian based companies. The details of manufacturers and suppliers of preheating Rotary kilns for Raw material pre heating using flue gases generated in sponge Iron plants is presented in Annexure-2

Cost Benefit Analysis

The cost benefit analysis of suggested pre heating kiln technology for implementing in sponge Iron plants for 100 TPD is presented below.

Table 3.7 Cost Benefit Analysis of Preheating of Raw material using Waste heat

S.No	Particulars	Units	Existing kiln	Pre heated kiln Tech
1	Installed Capacity of kiln	TPD	100	100
2	Iron Ore Consumption	TPD	180	180
3	Coal Calorific Value	kcal/kg	3000	3000
4	Coal Consumption	TPD	180	180
5	Dolomite	TPD	5	5
6	Total Flue Gas Generated per kiln	Nm3/Hr	24000	24000
7	Density of flue gas	kg/m3	1.31	1.31
8	Actual Gas flow	kg/hr	31483	31483
9	Flue gas Temperature at kiln out let	oC	950	
10	Flue gas temperature at inlet to ESP	oC	250	
11	Sp. heat of flue gas	kcal/kg C	0.312	
12	Heat available from flue gas	kcal/hr	6875931	
13	Equivalent Coal Savings	kg/hr	2292	
14	No of hours operation	hrs/day	24	
15	No of Days operation	Days/year	350	
16	Total coal savings	Tons/year	19253	
17	Total monetary savings	Rs.Lakhs/year	578	
18	Electrical energy Consumption	kWh/Day	816	
19	Electrical energy cost for preheating kiln	Rs.Lakhs/year	9.4	
20	Total monetary savings	Rs.Lakhs/year	568.2	
21	Cost of preheating kiln including civil, equipment etc	Rs.Lakhs	341	
22	Total investment required	Rs. Lakhs	350.4	
23	Payback period	Years	0.62	

From the above table it is observed that the total coal savings due to installation of preheating rotary kiln for raw material heating is 19253 Tons/year and monetary savings is

Rs.568.2 lakhs/year. The total investment required for the pre heating kiln is Rs.350.4.Lakhs and payback period is 0.62 years.

Life Cycle Cost

The Life Cycle Cost of preheating rotary kiln for pre heating of raw material in sponge iron plans is estimated based on the life, maintenance cost, and operating parameters and presented below.

Table 3.8 Life Cycle Cost of Preheating Rotary kiln for Raw material Pre heating

S.No	Particulars	Units	Value
1	Waste heat recovery potential	kcal/hr	6875931
2	Equivalent coal savings	TPY	19253
3	Quantity of flue gas	Nm3/hr	24000
4	Capital Cost	Rs. In lakhs	341
5	Replacement of components	Rs. In lakhs	6.82
6	Annual Maintenance	Rs. In lakhs	3.41
7	Life of pre heated kilns	Years	25
8	Interest rate	%	10
9	LCC at the end of life	Rs. In lakhs	351.23

It is observed that life cycle cost of Preheating Rotary kiln for pre heating of raw material in Sponge Iron plants is estimated at Rs.351.23 Lakhs.

Implementation Cost

The implementation cost of Pre Heat Rotary kiln in sponge iron plants for pre heating of raw material using flue gases is estimated based on erection, civil works and retrofitting cost etc.

Table 3.9 Implementation Cost of Preheating Rotary kiln for Raw material Pre heating

S.No	Parameter	Cost in Rs.lakhs
1	Civil Works	124.29
2	Plant and Machinery	186.15
3	Electrical works	20.57
4	Erection and Commissioning	3.72
5	Miscellaneous costs	10.00
6	**Total Cost**	**344.73**

The implementation cost of pre heating rotary kilns in sponge iron plants for raw material pre heating using flue gases is estimated at Rs344.73 Lakhs

Recommendations

All Sponge Iron pants more than 50 TPD can be used this technology.

Benefits

The following benefits are expected by installing pre heating kiln in sponge iron plants using flue gases for pre heating of raw material. They are

- Increase the productivity
- Reduced Process time
- Reduction in Electricity cost
- Reduce the coal consumption in process
- Improved plant Efficiency
- Reduction in GHG emissions

Limitations

There is no limitation to Install Pre Heating Rotary kiln for raw material pre heating using waste heat gases in Sponge Iron Industries irrespective of Installed Capacities and existing plants.

3.5.3 Installing Fuel Economizer i.e. Raw material preheating System

In Sponge Iron manufacturing, flue gases are generated during the process is about 900-1000 C temperature. This heat is cooled with out use before sending to environment. If the heat content in the flue gas can be used for preheat the raw material used in sponge iron plant i.e. Iron Ore. Due to pre heating of the raw material input coal required for the sponge iron plant is reduced and production cost is reduced.

Background

All sponge Iron Manufacturing Industries in Orissa are coal based industries. The coal is used as heat the raw material and as a reductant for converting the iron oxide into metallic iron during the process. In sponge iron plants, the quantity of heat required to heat up the iron ore in kiln up to 700 Deg C is 140000 kcal per tone of material.

The flue gases are generated during the process of rotary kiln and having higher temperature i.e.900-1000 Deg C. The heat content in the flue gas is not utilized in the plants and cooled by supplying the air/water.

Fuel economizer is one of technologies for sponge iron plant for effective utilization of flue gas heat. In this technology, the heat from flue gas is used for raw material pre heating. At least 20-25% of coal is saved during the implementation of the fuel economizer.

Energy Conservation Potential

By adopting fuel economizer in sponge iron plants where heat from flue gases is used to pre heat the raw material, at least 20-25% of coal consumption is saved

Technical Specifications

The Technical specification of fuel economizer for 100 TPD sponge iron plant is presented below.

Table: 3.10 Technical Specifications of Fuel Economizer

S. No	Parameter	Unit	Value
1	Type of Fuel Economizer	Model	AAG 3336
2	Bed Depth	mm	100
3	Material Stroke	Stroke/min	3-4 recommended
4	Hot Gas Required	m3/hr	5200
5	Temperature of air discharged	C	254

Availability of technology /equipment

The suggested technology is available and near by the sponge iron cluster, Orissa. The details of technology suppliers for fuel economizer which is raw material pre heating using flue gases generated in sponge Iron plants is presented in Annexure-2

Cost Benefit Analysis

The cost benefit analysis for implementation of fuel economizer in 100 TPD sponge iron plants is presented below.

Table 3.11 Cost Benefit Analysis of Raw material preheating System Fuel Economizer

S.No	Particulars	Units	Values
1	Capacity of kiln	TPD	100
2	Total Iron ore required for production of sponge Iron	TPH	7.50
3	coal Consumption	TPH	7.50
4	calorific Value of coal	kcal/kg	3500
5	Total heat supplied	kcal/hr	26250000
6	Quantity of flue gas available from kiln	nm3/hr	24000
7	Density of hot air	kg/m3	1.164

S.No	Particulars	Units	Values
8	Sp. heat of hot gases	kcal/kg C	0.31
9	Flue gas Temperature from kiln outlet	C	1000
10	Heat available from flue gas	kcal/hr	8660160
11	Initial temperature of Iron Ore	C	30
12	Temperature of Iron ore required in process	C	700
13	Sp. heat of Iron Ore	kcal/kg	0.22
14	Actual heat required to heat the Iron Ore	kcal/hr	1105500
15	Flue gas supplied to pre heat the iron ore by 700 C	kcal/hr	1105500
16	Quantity of coal saved	kg/hr	315.86
17	Total quantity of Coal savings due to pre heating	T/hr.	0.32
18	No of hours of operation	hrs/day	24
19	No of Days operation	days/year	350
20	Total coal Savings	Tons/year	2653
21	Monetary savings	Rs. In lakhs/year	92.86
22	Investment required	Rs.in lakhs	150.00
23	Payback period	Years	1.62

From the above table it is observed the total coal saved during the implementation of fuel economizer in existing sponge iron plants is 2653 tons/year and monetary savings is 92.86 lakhs/year. The investment required for technology is Rs.150 lakhs and payback period is calculated based on monetary savings to be 1.62 years.

Life Cycle Cost

The Life Cycle Cost of fuel economizer in sponge iron plans is estimated based on the life, maintenance cost, and operating parameters and presented below.

Table 3.12 Life Cycle Cost of Raw material preheating System using Waste heat gases

S.No	Particulars	Units	Value
1	Fuel Economizer	kcal/day	8716032
2	Quantity of flue gas	Nm3/Hr	24000
3	Capital Cost	Rs. In lakhs	150
4	Annual Maintenance	Rs. In lakhs	1.5
5	Life of WHR	Years	15
6	Interest rate	%	10
7	LCC at the end of life	Rs. In lakhs	167.25

It is observed that life cycle cost of fuel economizer for pre heating of raw material in Sponge Iron plants is estimated at Rs.167.25 Lakhs.

Implementation Cost

The implementation cost of fuel economizer in sponge iron plants for pre heating of raw material using flue gases is estimated based on erection, civil works and retrofitting cost etc.

Table 3.13 Implementation Cost of Fuel Economizer using Waste heat gases

S.No	Parameter	Cost in Rs.lakhs
1	Plant and Machinery	150
2	Civil Works	1.5
3	Electrical works	0.75
4	Erection and Commissioning	1.5
5	Miscellaneous costs	0.75
6	**Total Cost**	**154.5**

The implementation cost of fuel economizer in sponge iron plants for raw material pre heating using flue gases is estimated at Rs.154.5 Lakhs

Recommendations

All Sponge Iron pants more than 50 TPD can be used this technology.

Benefits

The following benefits are expected by installing pre heating kiln in sponge iron plants using flue gases for pre heating of raw material. They are

- Increase the productivity
- Reduced Process time
- Reduction in Electricity cost
- Reduce the coal consumption in process
- Improved plant Efficiency
- Reduction in GHG emissions

Limitations

There is no limitation to Install Pre Heating Rotary kiln for raw material pre heating using waste heat gases in Sponge Iron Industries irrespective of Installed Capacities and existing plants.

3.5.4 Install Energy Efficient Motor for Crushers

Background

All Sponge Iron plants required iron ore and coal for production of sponge iron. The size of iron ore and coal from the mines are available in the form of lumps. It is essential to reduce the size up to 8-18mm size of iron ore and coal of size 5-18mm which is required for the reduction in rotary kilns. Coal and iron ore crushers are installed in all plants to reduce the required size of raw materials. The crushers are operated by motors and the capacity of motor depends on the capacity of raw material process. The operation of crusher depends on the rate of production in the plant and operated around 10- 12 hours in a day. During the energy use and technology audit conducted in sponge iron plants located in Orissa it is observed that all plants utilizing standard motors in crushers. The efficiency of the standard motors is lower than energy efficient motors available now a day. It is also observed that some of the plants are using several times re-winded motors.

Energy Conservation Potential

Power consumption in crushers is increased due to lower efficiency and several times re-winded motors. The Energy Efficient Motor (EEF1) has higher efficiency while operating in part & full load conditions and dusty operating comparing with standard motor. The efficiency of EEF1 i.e.93.3% is more than the existing standard motors. If efficiency of motor increases, power consumption will be reduce at both part and full load conditions. By replacing energy efficient motor with standard motors in sponge Iron Industries at least 8-10% energy savings is obtainable.

Technical Specifications

The Technical Specification of 40HP energy efficient motor presented below.

Table: 3.14 Technical Specifications of Energy Efficient Motor

S.No	Parameter	Unit	Value
1	Capacity of Motor	HP	40
2	Type of Motor	Name	Induction
3	Motor power	kW	40
4	Rated Current	A	60
5	Voltage	V	415
6	PF	%	0.8
7	Frequency	Hz	50
8	Efficiency at full load	%	93.3

Fig 3.3Energy Efficient Motors

It is observed that the efficiency of the energy efficient motor has higher efficiency compared to the existing motor in Sponge Iron Manufacturing units.

Availability of Technology /Equipment

The Energy Efficient Motors are available and manufacturing in India by the many companies. These companies are marketing their products through directly or dealers with in Orissa. Majority dealers/ suppliers for these equipments are located in Rourkela, Bhubaneswar. Owners from Sponge Iron Industries can avail these equipments by placing order from near by places. The details of manufacturers and suppliers marketing these energy efficient motors are presented in Annexure-2.

Cost Benefit Analysis

The Cost benefit analysis for installing energy efficient motors in crushers is presented below. Based on observations and measurements taken from sponge Iron Industries in crushers, the cost benefit analysis is calculated and presented below.

Table 3.15 Cost Benefit Analysis of Energy Efficient Motor

S. No	Parameter	Unit	Existing motor	EEF1 motors
1	Connected Load	HP	40	40
2	Connected Load	kW	29.84	29.84
3	motor Efficiency	%	80	93.3
4	Input power	kW	37.3	31.98
5	Measured power	kW	27.5	23.58
6	Loading	%	73.73	73.73

S. No	Parameter	Unit	Existing motor	EEF1 motors
7	Working hours	hr/Day	10	10
9	Working Days	Days/year	350	350
10	Annual Power consumption	kWh	96250	82529
11	Power tariff	Rs./kWh	3.3	3.3
12	Total Energy cost	Rs	2655180	2276682
13	Energy Savings Due to EE	kWh/Year	13721	
14	Cost of Energy savings	Rs.in lkahs/Year	3.78	
15	Investment Cost	Rs. In lakhs	0.87	
16	Payback Period	Years	0.230	

From the above table it is observed that by installing energy efficient motors in crushers leads to save 13721 kWh/Year of electrical energy and the monetary savings is of Rs. 3.78 lakhs per year. The investment required for energy efficient motor is Rs. 0.87 lakhs and payback period is 0.23 years.

Life Cycle Cost

The Life Cycle Cost of Energy Efficient Motor for crusher is estimated based on the life, maintenance cost, and operating parameters. The detail of life cycle cost of EE motors is presented below.

Table 3.16 Life Cycle Cost of Energy Efficient Motor for ID fan

S.No	Particulars	Units	Value
1	Capacity of Motor	HP	40
2	Efficiency of motor	%	93.3
3	No of Working hours	Hr/day	10
4	No of Days	Days/Year	350
5	Capital Cost	Rs	0.87
6	Annual Maintenance	Rs	0.0174
7	Life of Motor	Years	25
8	Interest rate	%	10
9	LCC at the end of life	Rs	0.91

From the above table it is observed that the life cycle cost of 40 HP energy efficient motors in sponge iron plant is estimated at Rs.0.91 lakhs.

Implementation Cost

The implementation cost of Energy efficient motors in crushers is estimated based on installation, retrofitting and electrification cost etc. The details of implementation cost for installing EE motors is presented below.

Table 3.17 Implementation Cost of Energy Efficient Motor

S.No	Parameter	Cost in Rs.lakhs
1	Capacity of motor	40
2	Cost of Equipment	0.87
3	Civil Works	0.01
4	Electrical works	0.01
5	Erection and Commissioning	0.00
6	Miscellaneous costs	0.01
7	**Total Cost**	**0.90**

From the above table it is observed that the implementation of 40 HP energy efficient motors in sponge iron plant is estimated at Rs.0.90 lakhs

Recommendations

All Sponge Iron Industries in Orissa where standard motors are using in both coal andiron ore crushing units can adopt energy efficient motor for the same operation The capacity of Energy Efficient Motor (EEF1) is depends upon the capacity of the crushing circuit.

Benefits

The following benefits are expected while installing Energy Efficient Motor in crushers.

- Less Maintenance Cost
- Low Running Cost
- Reduction in Energy consumption
- Less break downs
- Reduction in energy consumption leads to reduce the GHG emissions

Limitations

There is no limitation in installing energy efficient motors in crushers except capacity of the motors.

Subsidy from Government of India

The Development commissioner, Ministry of Small and Medium Enterprises ,Government of India providing a subsidy for implementation of Energy Efficient technologies for registered SME' s under a scheme of National Manufacturing Competitiveness Program (NMCP) Under XI Plan. The subsidy component will be 25% of project cost and up to 10.00 lacks per project.

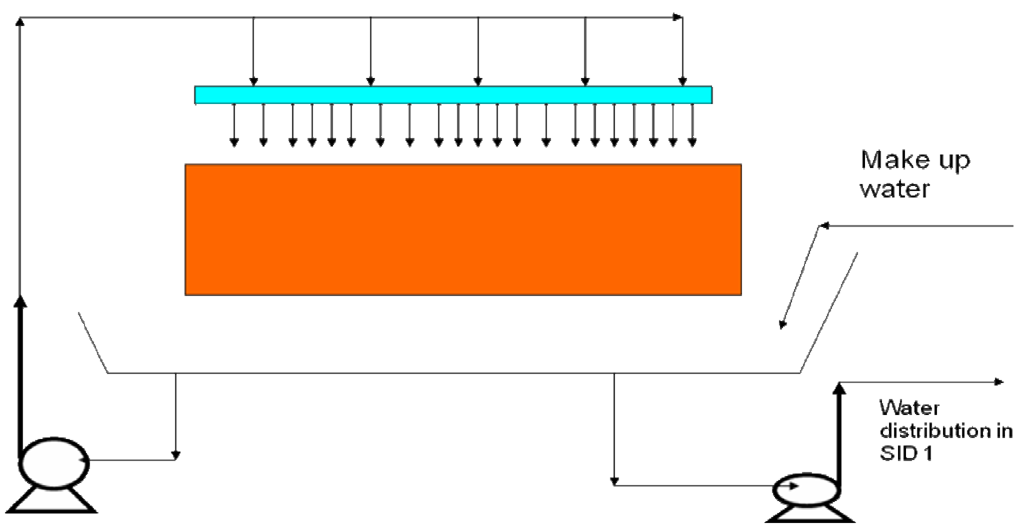
3.6 Other Energy Conservation measures

Following are the other energy conservation measures that are identified during the Energy Use and Technology Audit.

3.6.1 Optimize The Water Spray To The Rotary Cooler

During the detailed energy audit conducted in sponge iron units located in Orissa, it is observed that all units supply the water from the sump and sprayed over the surface of the cooler kiln, from where it drops and collects in the sump below the kiln and collected in sump. Again the hot water is mixed with raw water and cooled naturally/coolers and again re-circulated to the surface of the cooler kiln. Indirect heat exchange takes place and the product gets cooled to less than 120^{o}C before exiting the cooler. The make up water is added to the sump according to its level due to evaporation takes place during rotary cooler operation. This make up water is pumped from source and added into the sump to mixes with the water in the hot well sump and result the sump water temperature is higher than the make up water.

Fig 3.4 Optimize the Water Spray to the Rotary Cooler



So it is recommend to add make up water to the spray header (preferably towards the product end of the cooler), instead of the hot well. This will have the following advantages.

- Lower temperature of water gives better cooling for the sponge iron exiting the cooler
- Reduced water circulation load for the water spraying pump

Benefits

The annual saving potential of Rs. 0.50 Lakh shall be achieved by implementing this project. This will not require a significant investment.

3.6.2 Avoid Damper Loss In Identified Dust Collector Fan By Changing Speed Of Fan

Back Ground

All Sponge Iron fans are required to install Dust collectors, Bag filers due to high pollution generated during the process and raw material preparation. Dust collector fan (DE – 6) is operating for removing the dust generated during material loading operation into the truck and for hopper filling. During the observations made in sponge Iron plants located in Orissa all plants are installed bag filters and operated by adjusting the dampers manually. The pressure measurements were carried out in all the auxiliary bag filters to identity the damper loss.

Energy Conservation Potential

Dust collector fan is having a pressure drop of 73 mmWC across the damper. The observed pressure drop across the damper is due to the partial closing of the damper (90% opening). This increase in pressure drop across the damper increases the power consumption of the fan. The pressure drop across the damper alone accounts for 22.26% of the total power consumed by the fan. The present head requirement is 0.78 times the head developed by the fan. The practical measurements are given below:

Table 3.18 Energy Conservation in Dust Controller

S. No	Identity	Unit	Dust Collector Fan
1	Before Damper	mm WC	-290
2	After Damper	mm WC	-363
3	Pr. drop across damper	mm WC	73
4	Damper opening	%	90
5	Head developed by the fan	mm WC	328
6	Motor power consumption	kW	50
7	Damper loss	%	22.26
8	Savings	kW	10

Damper control in fan is an energy inefficient method of capacity control, as a part of the energy supplied to the fan is lost across the damper. Good potential by avoid damper loss by opening the damper by reducing the speed by 5% by changing the v pulley.

Recommendation

The following recommendations are made during the observations in Dust Collectors.

- Change the v pulley and reduce the fan speed by 5% Reducing the speed by 5% will reduce the power consumption by 14%
- Open the damper fully and maintain the same flow

Benefits

Reducing the speed by 5% by changing the pulley and avoiding damper loss for the above fan would result in an annual savings of Rs. 2.0 Lakhs. This requires an investment of Rs. 0.2 Lakhs with simple pay back period of 2 months.

3.7 Identified Technologies for DPR Preparation

The Justification for technologies/equipments identified for DPR preparation (e.g. potential, reliability, etc. in the cluster) is based on the detailed studies carried out and considerable potential in all cluster units for energy Efficiency Improvement and conservation.

All the Sponge Iron Industries the manufacturing products and equipments in their industries are similar except the installed capacities, due to the reason if any identified technology/equipment can be replicated in other industries also. The following technologies/equipments were considered for preparation of detailed project report.

Table 3.19: Proposed Technologies/Equipments for Detailed Project Report:

S.No	Name of DPR	No	Capacities
1	Energy Efficient Motors	4	25 HP 40 HP 50 HP 60 HP
2	Power Generation from Waste Heat Recovery System	4	100 TPD 200 TPD 300 TPD 400 TPD
3	Fuel Economizer for Raw material preheating	4	50 TPD 100 TPD 200 TPD 300 TPD
4	Preheating kiln for Raw material preheating	3	50 TPD 100 TPD 200 TPD
	Total	15	

The identified 15 energy conservation proposals are considered for preparation of bankable DPRs.

4. SMALL GROUP ACTIVITIES / TOTAL ENERGY MANAGEMENT

4.1 Introduction

Energy is one of the most important resources to sustain our lives. At present we still depend a lot on fossil fuels and other kinds of non-renewable energy. The extensive use of renewable energy including solar energy needs more time for technology development.

4.2 Systematic Approach for Energy Conservation by TEM/SGA

In this situation Energy Conservation (EC) is the critical needs in any countries in the world. Of special importance of Energy Conservation are the following two aspects:

1. Economic factors
2. Environmental impacts

4.2.1 Economic factors of Energy Conservation

Energy saving is important and effective at all levels of human organizations – in the whole world, as a nation, as companies or individuals. Energy Conservation reduces the energy costs and improves the profitability.

Notably, the wave of energy conservation had struck the Indian intelligentsia 3 years earlier when a Fuel Policy Committee was set up by the Government of India in 1970, which finally bore fruits three decades hence in the form of enactment of the much awaited Energy Conservation Act, 2001 by the Government of India. This Act made provisions for setting up of the Bureau of Energy Efficiency, a body corporate incorporated under the Act, for supervising and monitoring the efforts on energy conservation in India. Brief History of energy efficiency movement in India and associated major milestones are as follows

- 1974: setting up of fuel efficiency team by IOC, NPC and DGTD (focus still on industry)
- 1975: setting up of PCAG (NPC main support provider) : focus expanded to include agriculture, domestic and transport
- 1978:Energy Policy Report of GOI : for the first time, EE as an integral part of national energy policy–provided detailed investigation into options for promoting EE
- Post 1980, several organizations started working in EC area on specific programs (conduct of audits, training, promotion, awareness creation, demonstration projects, films, booklets, awareness campaigns, consultant/product directories)
- Some line Ministries and organizations like BICP, BIS, NPC, PCRA, REC, Ministry of Agriculture, TERI, IGIDR, CSIR, PETS (NPTI)

- State energy development agencies
- Industry associations
- All India financial institutions

The Government of India set up Bureau of Energy Efficiency (BEE) on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The mission of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy. This will be achieved with active participation of all stakeholders, resulting in accelerated and sustained adoption of energy efficiency in all sectors

Private companies are also sensitive to energy costs, which directly affects their profitability and even their viability in many cases. Especially factories in the industrial sectors are of much concern, because reduced costs by Energy Conservation mean the more competitive product prices in the world markets and that is good for the national trade balance, too.

4.2.2 Environmental impacts of Energy Conservation

Energy Conservation is closely related also to the environmental issues. The problem of global warming or climate change is caused by emission of carbon dioxide and other Green House Gases (GHG). Energy Conservation, especially saving use of fossil fuels, shall be the first among the various countermeasures of the problem, with due considerations of the aforementioned economic factors.

4.3 Total Energy Management (TEM)

Every point in factories has potential for Energy Conservation. Total Energy Management is implemented, by all the people's participation, step by step utilizing "Key Step Approach" in a systematic manner, as shown below:

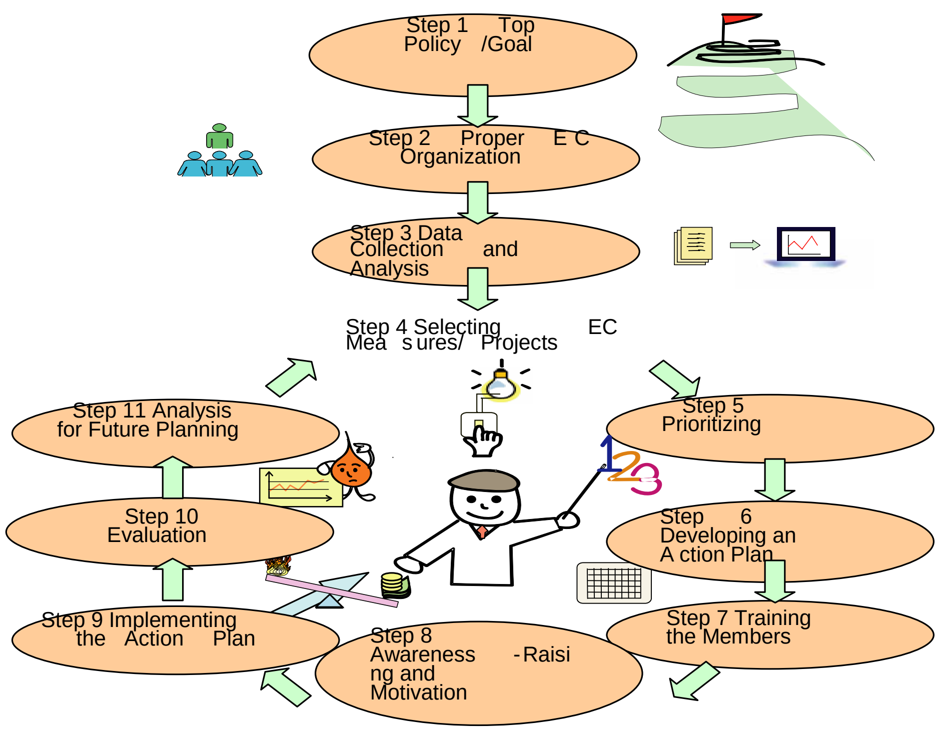
1. Top management policy/Goal
   - Develop a policy statement
   - Set targets
2. Proper EC Organization including Assignment of Energy Manager
   - Establish proper EC organization (utilizing SGA)
   - Assignment of Energy Manager
3. Data collection and Analysis
   - Collect data on current energy use
   - Analyze the collected data
   - Identify management strength and weakness

- Analyze stakeholders' needs
- Anticipate barriers to implement
- Estimate the future trend

4. Selecting EC Measures/Projects
    - Selecting EC Measures
    - Selecting EC Projects
    - Make out a plan/program
5. Prioritizing
6. Developing an Action Plan
7. Training the related members
8. Awareness-raising and Motivation
9. Implementing the Action Plan (including monitoring and controlling)
10. Evaluation (Management review)
11. Analysis for future planning (Standardization and Dissemination)

The following figure shows these Key Steps for implementing Energy Conservation activities.

Fig No 4.1: Key Step Approach



Each step is explained in this order as below:

Step 1: Top Management policy/Goal

It is the most important for the success of Energy Conservation activities within companies or factories to have clear and official commitment of top management – either the corporate top (senior) management or factory managers. The top (senior) management shall announce explicit commitment to the Energy Management (or Energy Conservation) and behave along this line – for example, participate in EC (Energy Conservation) events and encourage the people there for EC promotion.

This Handbook is primarily meant for Energy Managers for the use of EC promotion within factories, on the assumption that top management has already committed to that. However, there may be cases where top management would learn about Energy Management (or Energy Conservation) by this Handbook, or Energy Managers would make efforts to persuade top management to support or commit to Energy Management (or Energy Conservation) with the help of this Handbook.

1. Develop a policy statement

It is desired that the top (senior) management announces the “Energy Policy Statement”. This is very effective to let people inside and outside the company clearly knows the management’s commitment to Energy Management (or Energy Conservation). The format of the energy policy statement is various, but it usually includes the goal or objective of the company and the more concrete targets in the field of Energy Management (or Energy Conservation). It often shows the major measures and timetables. The statement shall match the company’s mission statement or overall management strategy plan.

2. Set targets

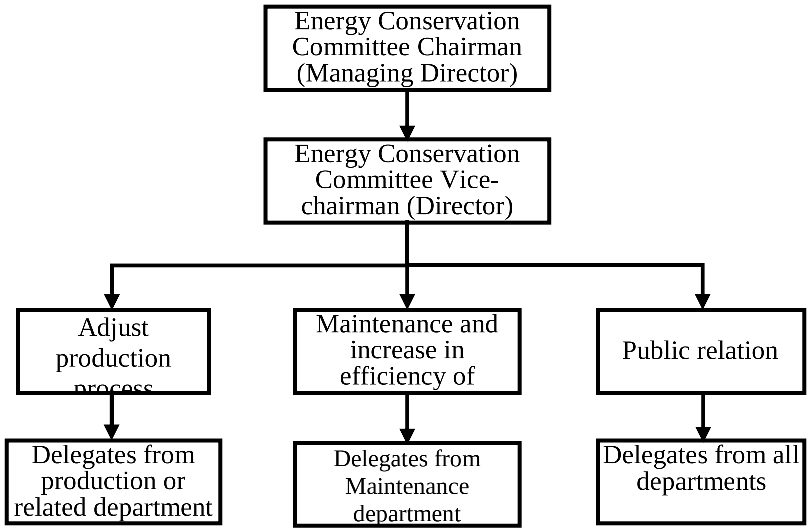
The targets shall be concrete and specific so that everyone can understand it.

Step 2 : Proper EC Organization including Assignment of Energy Manager

In some countries, where the EC Promotion Act is in force, the designated factories have obligation of assigning Energy Managers. In relation to Energy Management, however, the word “Energy Managers” is here used as a Manager or a Coordinator, separate from the above-said legal obligation, who works exclusively for Energy Management (or Energy Conservation) purposes, ranging from gathering energy-related information to drafting EC plans/programs and promoting or coordinating during implementation. To the proper Energy Management, this type of Energy Manager is indispensable. How to position this Energy

Manager within the company organization is also an important issue and needs careful decision. In some cases, Energy Committee, with members from the major departments, may be formed to assure the company-wide or factory-wide cooperation, as shown in the following figure.

Fig No. 4.2: Example of energy conservation committee's Organization



Actually there are many ways of forming EC organization, depending on the situation of factories or institutions, such as the size, kind of business, etc. In any case, it is very effective to utilize SGA (Small Group Activities) and there are also many ways to do that. The important thing is to design and make out the organization carefully to meet the purpose. In practical sense to do that, there may be the following five widely applicable ways of establishing the organization.

- Utilize Line (Formal) Job-related Organization for TEM purpose
- Use TPM Organization for TEM purpose
- Use TQM Organization for TEM purpose
- Add Employee Suggestion System to Energy Conservation Organization for TEM purpose
- Utilize another organization for TEM purpose

The easy and practical way may be starting from easy form of TQM, or QCC (Quality Control Circle) activities. Furthermore, because TPM is closely related to job-related organization, (1) and (2) may be often give the same kind of results. (An example of this form is shown in Part 3, 2 "How is SGA related to Energy Conservation?" (page 21).

Step 3 : Data collection and Analysis

Before trying to make out any future programs or action plans, it is essential for the company or factory management to understand the current situation in a proper and accurate manner. This includes not only the status of their own operation but also other relevant information such as competitors' operation, circumstances around the company and their trend in future, positioning the company itself in the local and global markets, and so on. The key steps for this purpose are shown below:

1. Collect data on current energy use and analyze them

The current data of energy consumption shall be obtained by measurement, calculation or estimation for the individual operation units (energy cost centers) with classification of kinds of energy (fuels types, utility types, etc.). The data shall be gathered regularly and arranged/summarized daily, weekly, monthly, by seasons or annually. Then the data shall be checked for the past historical trend and interpreted with relation to operational modes and production scales. That shall also be utilized for the forecast of future trends.

2. Identify Management Strength and Weakness

Then the data shall be compared with the best practice data or benchmarks in the industry. If such reference data are hardly available, the historical data of their own operation and estimated data for the competitors would be utilized for this purpose. At the same time, the strength and the weakness of the company shall be evaluated considering the competitors' situations in the local and global markets. This would serve the purpose of making out a realistic Energy Management plan later.

3. Analyze stakeholders' needs

Stakeholders are top (and senior) management, middle managers, staff/engineers and workers/operators. Other stakeholders in the normal business sense, such as the shareholders and lenders, need not be considered here for the moment. The needs and intention of those stakeholders shall be summarized and taken into consideration.

4. Anticipate barriers to implement

Making out a realistic and practical program also needs consideration of anticipated barriers for the implementation of Energy Management program or action plan. Some possible examples of such barriers are:

-Insufficient understanding and support by top management
-Insufficient understanding and cooperation of managers within factories
-Insufficient awareness of people to get successful results
-Insufficient capability of people due to lack of training
-Insufficient available technology due to lack of information
-Insufficient availability of manpower for EC activities within factories
-Insufficient budget for EC activities due to the company's financial status

5. Estimate the future trend

The future trend of energy supply-demand balance is estimated based on checking and analysis of the historical data. That data of future trend would also be a basis of the program of excellent Energy Management.

In analyzing the collected data and developing ideas of Energy Conservation, it is very often useful to think of the following techniques of finding problems and solutions:

Suppress: Using during the time in which it is not necessary to use. Examples include using electricity before or after working hours or when there is no one working.

Stop: Using equipment when it is not necessary. Examples include using all lightings during break time.

Reduce: Amount, pressure, temperature, speed, or brightness, or quality that exceed requirement. Examples include reducing intensity of lighting if not necessary.

Prevent: Prevent leakage or loss of energy. Examples include reducing space that leads to outside in order to prevent the leakage of heat into air.

Improve: Improve or repair machines to increase efficiency or modify manufacturing process to the one which enables us to conserve energy more. Examples include changing transparent sheet over the roof.

Store: Re-use the discarded energy. Examples include re-using heat from exhaust fume in order to reduce use of electric heater to warm heavy oil.

Change: Change how to use, type of energy, or energy sources to a suitable one from technical or economic point of view. Examples include changing the grade of heavy oil to an appropriate one or changing furnace systems or welding machines to the ones that use gas.

Increase production: Examples include improving production process. This will lead to the reduction of energy usage per production amount.

Step 4 : Selecting EC Measures/Projects

Based on the aforesaid understanding of the current status and position of the company (factory), various EC measures are studied and many EC Projects are proposed. Comparison among these measures and projects are made with consideration of a lot of factors, such as technical, economic, intangible, and so on.

Then a plan/program is developed based on these study results. To do this, it is very important to consider the following issues:

The plan/program shall be realistic, practical and attainable with due consideration of many related elements and management resources of the company or factory. It also shall be expressed in terms of the measurable or quantifiable parameters, including Fuel Usage Index, Electricity Usage Index, Energy Usage Index, etc. It usually includes a lot of managerial measures of Energy Management (or Energy Conservation) promotion activities such as motivation techniques, means to improve awareness, training, and so on. In other words, the following items are often useful in comparing and selecting alternative plans:

1. Effects of energy conservation: Activities that can conserve energy more than others are more promising.
2. Investment amount: Activities that require less investment are more promising.
3. Pay-back period: Activities with short pay-back period for investment amount in equipment are more promising because all energy conservation will be profits after pay-back period.
4. Length of implementation: Activities that can be performed in a short period are more promising because they do not influence production process of the factory.
5. Number of personnel required: Activities that require a large number of personnel tend to be burdensome.
6. Importance to executives and reputation of the company: Some activities provide

little financial benefit but cause good image or reputation.

7. Risk of the project: Some activities bring about big financial benefits but involve high risk from various factors. In this case projects have less importance.

Step 5 : Prioritizing

Many EC measures and projects are prioritized based on the internal studies including comparison among their alternatives, in the manner explained in the above.

Step 6 : Developing an Action Plan

The priority consideration then gives birth to the Action Plan. The plan shall be clear, practical and comprehensive with proper schedule and budgeting. Shown below is an example of such a plan.

Table No 4.1: Example of energy saving plan

S. No	Detail of the plan	Length (Months)						Person in -charge	Budget	Inspect by
1	Turn off electricity when there is no one around	◄	─	─	─	─	►	Mr.Prayat		
2	Turn off air-conditioner 30 minutes before stop working	◄	─	─	─	─	►	Miss Aom		
3	Reduce welding machine's current according to the specification of the metal used for welding	◄	─	─	─	─	►	Mr. Matthayas		
4	Close welding machine after working	◄	─	─	─	─	►	Miss Thanom		

Step 7 : Training the related members

This issue is very important to secure the success of project Implementation, because the people are the most important resources that determine the success of the plan.

Step 8: Awareness-raising and Motivation

To have the total power of "all members' participation" combined together, it is also very crucial how to raise awareness and motivation of related people within the company (or factory). Shown below is an example of awareness raising plan.

Table No 4.2: Example of awareness raising campaign

S. No	Detail of the plan	Length (Months)						Person in charge	Budget	Inspected by
1	Display the results of energy conservation every month							Mr.Prayat	-	Mr. Laaied
2	Evaluate every month							Miss Aom	-	Mr. Laaied
3	Perform energy conservation activity every 6 months							Mr. Matthayas	-	Mr. Laaied
4	Perform “Finding measures” activity in order to make energy conservation plan							Miss Thanom	-	Mr. Laaied
5	Provide rewards to sections that have achieved high efficiency								-	

Step 9: Implementing the Action Plan (including monitoring and controlling)

The organizational force established in the said planning step shall be utilized fully to ensure smooth implementation of the program. Energy Manager and/or the committee shall continue working to promote the activities and report to top management on the status quo.

The actual records of implementation shall be closely watched and monitored. If some problems arise, or some variance between the planned figures and the actual record is observed, then necessary actions shall be taken immediately.

Step 10: Evaluation (Management Review)

After the program is completed, the report shall be submitted to the top (senior) management. The results shall be assessed and analyzed for any good and bad points. The lesson shall be utilized as a feedback in the subsequent plan/program.

Thus the activities are repeated to form a cyclic movement. The result of evaluation must be announced on the board in order to inform employees, so that they will be given motivation for the next activities. Evaluation can be divided into 2 types as follows.

- Short-term evaluation for the follow-up of the performance
- Long-term evaluation for the evaluation of the whole project that will be used for the future planning

Evaluation can be made in the following 3 levels.

1. Self Audit: Self evaluation that is made in a small group or a department based on the predefined form. (Inspection may be made every month.)
2. Upper Manager Audit: Evaluation that is made by the section/department manager intended to raise performance of the activity. (Inspection may be made every 3 month.)
3. Top Management Audit: Evaluation made by the executives of the organization that will be used for the evaluation of annual bonus. (Inspection may be made every 6 month.)

In some cases, top management could think of adopting external people (outside consultants) to evaluate the results of Energy Conservation activities. Even in those cases, internal evaluation should be made to gain the fruits as much as possible.

Step 11: Analysis for future planning (Standardization and Dissemination)

The successful results and the lessons learned are to be analyzed and arranged into the standard form which can be easily utilized by anyone in the factory. The standardized documents or information are to be disseminated all over the company.

Moreover, Energy Conservation should be incorporated as part of daily jobs and performed continuously in systematic manner. For this purpose, activities for energy conservation must be incorporated as a part of company's basic or business plan. If a problem is found as a result of evaluation, improvement or modification will be done and the objectives will be achieved. If the results reach or exceed the objective, information must be gathered in order to set it as a "Work Standard," which will be used in setting a new activity plan.

4.4 Small Group Activities (SGA)

Small Group Activity (SGA) gives employees the problem solving tools they need to eliminate obstacles to Total Productivity, the cumination of zero break-downs, zero defects, and zero waste. Enterprising employees identify the problem, be it in "man, material, method, or machine," and develop cost-effective and practical methods for solving the problem.

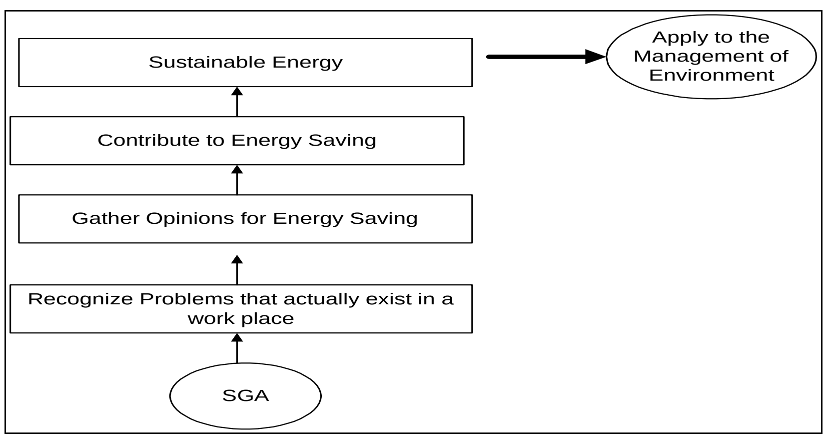
4.4.1 Importance of SGA

SGA are activities by group of employees at operator (working Group) level. They aim to solve problems that occur at the place taken care of by each employee and put emphasis on participation and team work. Factories can apply small group activities to many kinds of work along with normal work or other measures that are already underway. The burden on employees will not increase because of small group activities. They are not only bringing benefits to factories but also boosting the knowledge and ability in performing jobs of employees, improving communication among employees, increasing creativity, and make it possible to express their own proposal with less hesitation to management. As a result, employees will start to think "This is our problem." This SGA can be applied to Energy Conservation, too, with successful results, as shown in Figure 13.

4.4.2 How SGA leads to Energy Conservation? :

An excellent example of organizational structure that promotes energy management emphasizing participation is that they form overlapping small groups as in figure 14. The feature of this structure is that a small group for energy management is distributed to various sections as in figure 15, which is a recipe for success of Total Energy Management (TEM) and makes various communications and management of activities more efficient and effective.

Fig.No 4.3 Relationship of SGA and Energy savings



Small group activities for total energy management (TEM) are the activities in which employees of all levels in production or management, starting from the top to the bottom, participate in order to reduce loss related to their own job by improving their job. In order for the activities to succeed, management of all levels must provide support in necessary training and equipment, communication of policies, and the setting of problems to solve.

Small group activities for TEM can be divided into 4 or 5 levels depending on the scale of the organization. This division is in order to emphasize the fact that everyone must improve in their job under the responsibility to each other. It also enables us to make improvement without overlapping. The following example shows utilizing the existing job-related organization as much as possible.

Fig. No 4.4 Example of Organizational Structure with Overlapping

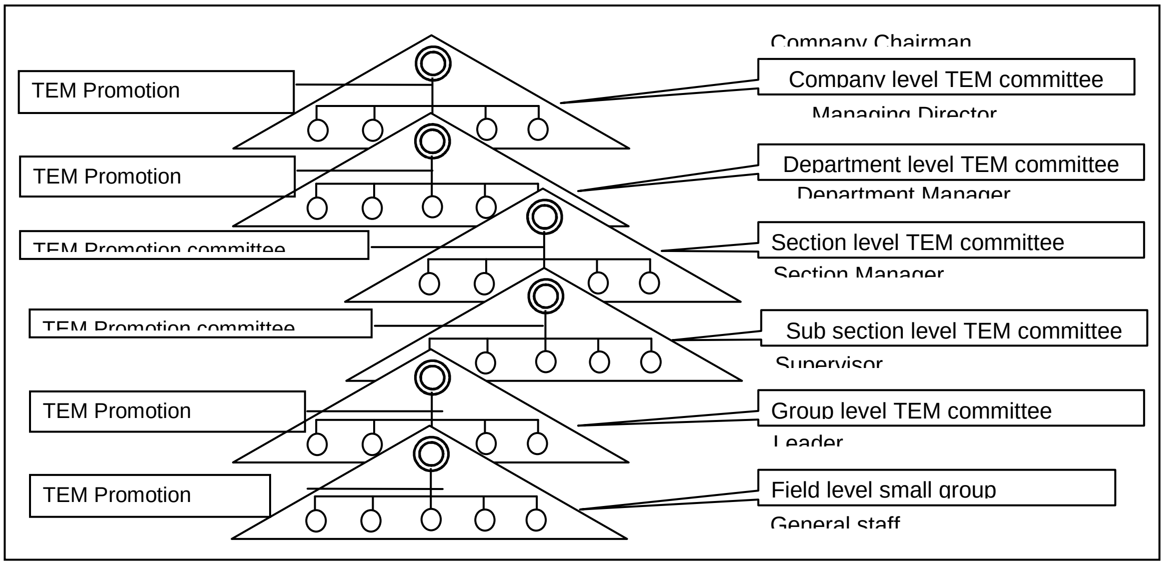
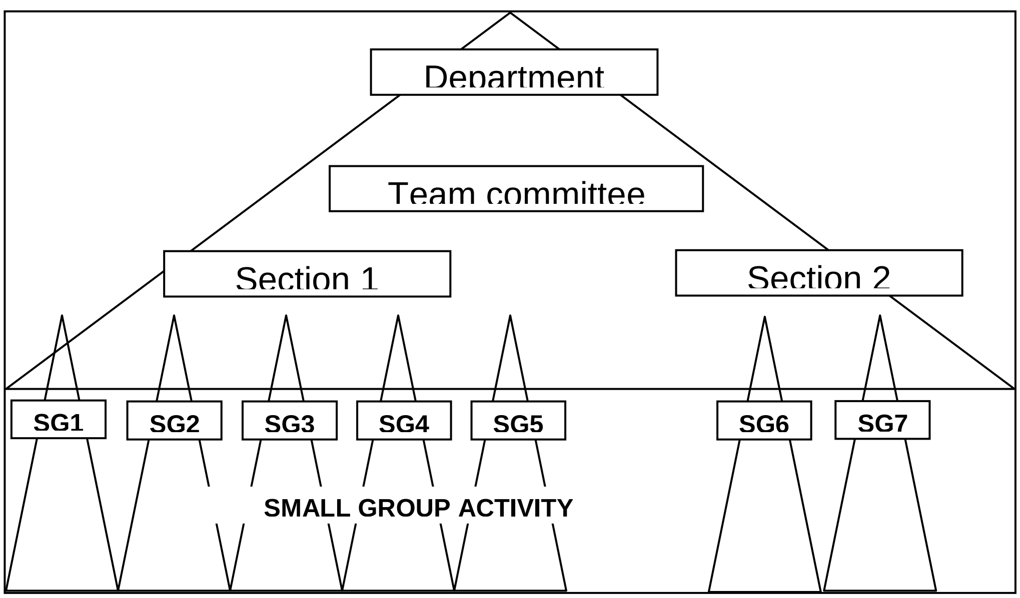


Fig.No 4.5 Positioning of SGA in Main Job Structure



4.4.2.1 Executives level

- Define the policy and target for Total Energy Management
- Follow-up and manage activities to make sure that activities are implemented according to the policy
- Consider opinions and suggestions from the promotion office
- Consider reports from promotion committee from various levels

4.4.2.2 Level of Total Energy Management promotion office

- Make sure that whole activities are done in the correct direction, without delay and smoothly
- Find a suitable method that makes it possible to implement activities continuously and without slowdown
- Listen to opinions and suggestions from small groups in order to use for improving
- Provide advice for Total Energy Management to various groups
- Persons in charge of the office must be those with good personal relationship, friendly, and with spirit of good service

4.4.2.3 Medium level

- Define the policies of each department that are consistent with the policy of the Total Energy Management and the target of the company
- Define numerical targets to sub-groups apart from the target of the company as a whole
- Follow-up the progress in order to provide to sub-groups
- Report the progress along with suggestions and opinions to upper level committee periodically

4.4.2.4 Workers/Operators level

- Implement small group activities with various themes and achieve target
- Report progress and problems encountered during implementation to upper level committee periodically
- Ask for support, suggestions, and opinions from upper level committee

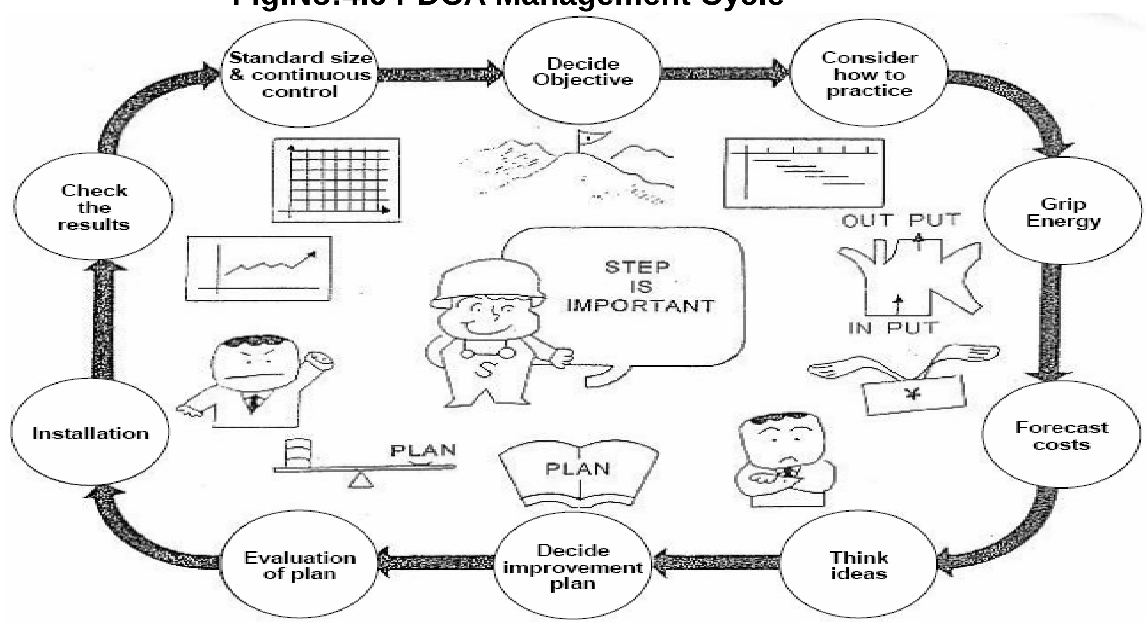
4.4.2.5 Responsibility of Energy Conservation committee

- Gather and analyze information on costs related to energy every month
- Analyze and solve problems related to energy
- Find a method for energy conservation
- Prepare energy conservation plan
- Follow-up the result of implementing the plan
- Perform activities such as public relationship for encouraging employees to participate
- Offer training to small group in each department

4.5 Steps of Small Group Activities for Energy Conservation

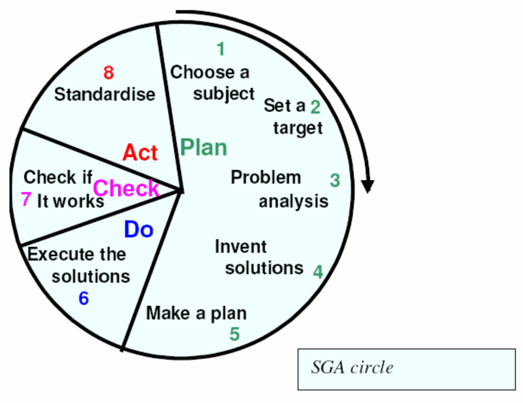
Small group activities for Energy Conservation can be done by using "10 Stages for Success", based on "PDCA Management Cycle", as shown below and in pictorial forms

Fig.No:4.6 PDCA Management Cycle



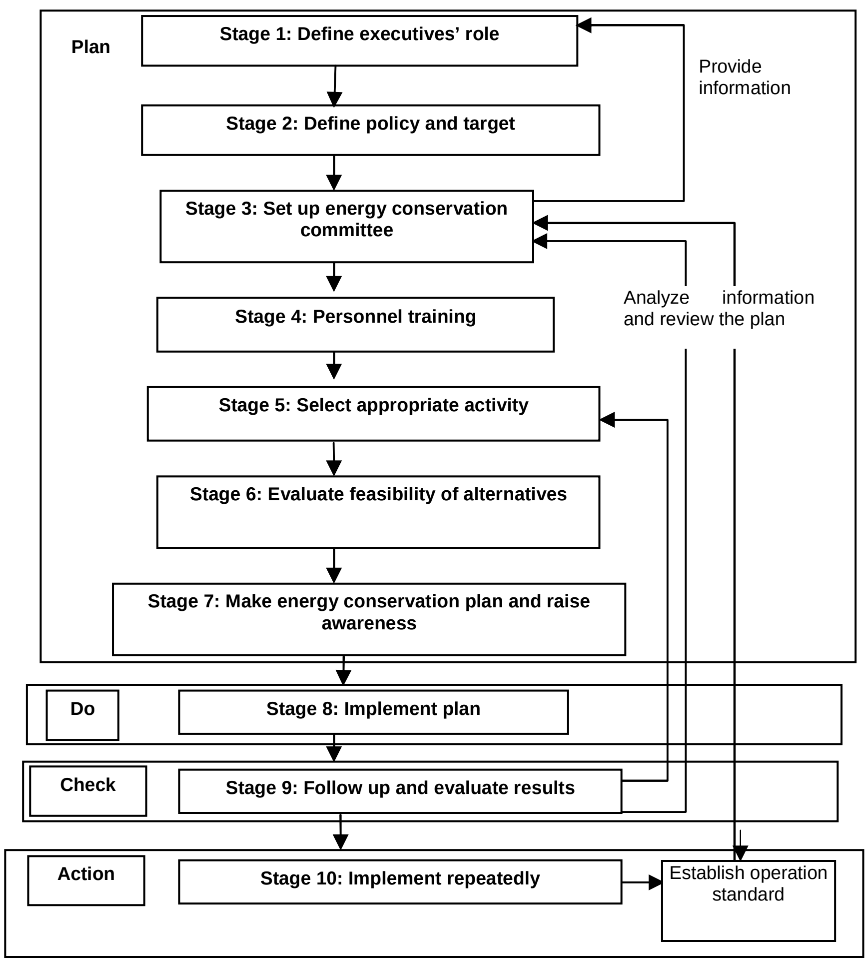
- Plan: Make an efficient plan in order to improve operation
- Do: Implement according to the plan
- Check: Check if implementation was according to the plan
- Act: Judge what to improve, what to learn and what to do from what we have checked

Fig No: 4.7 SGA Circle



Please note that these stages are substantially the same as "Key Steps" explained earlier, but put more stress on utilization of SGA. So readers could read and use either method up to their preference.

Fig:4.8 Ten Stages for Success



4.5.1 Stage 1: Define Executive's Role:

In promoting small group activities, support must be provided such as basic environmental support. Therefore, executives must provide follow up support to employees of their companies.

- Establish a special unit that provides support to small group activities
- Prepare a system for managing small group activities in the company
- Prepare annual plan for small group activities
- Prepare a venue for meeting, consultation, advice or suggestion
- Establish a system for giving rewards to high achieving employees
- Establish a reporting system starting from informing what to do until reporting of the results
- Establish a fair system for evaluating results
- Establish a system for providing support and training to employees

4.5.2 Stage 2: Define Policy and Target

- Executives must announce a policy of supporting small group activities.
- Energy conservation committee must act as an advisor in order to set a numerical target that is consistent with total energy management (TEM) policy and the target of the organization. Specific targets must be set for each group.

We can see that responsibilities in stages 1 and 2 are mainly those of executives and committee. Responsibility of employees will become clearer from stage 3 and afterwards.

4.5.3 Stage 3: Set up Energy Conservation Committee:

The principle of small group activities (SGA) is to divide into groups based on the scope of responsibility. The size of the group will depend on the size of organization. However, size of the group should not be too large. Usually a size of 5 to 10 persons is considered appropriate. It is important to define responsibilities clearly so that every member of the group can have their responsibility and participate in the activities.

4.5.4 Stage 4: Personnel Training:

This stage will help employees to have more knowledge and understanding, have new ideas, and have more belief in their own responsibility.

4.5.5 Stage 5: Select Appropriate Activity

In doing small group activities, each member must be able to think, express their own ideas, and make decisions based on reality and by investigating electrical equipment, machines, and office equipment that exist in the area of their responsibility. Items to consider include size, number, where to use, situation of usage, current situation, and the number of hour's usage per day. By this we can evaluate the current situation of energy usage. Also by judging if there are more machines than needed, we can choose suitable activities and real problems for the organization.

4.5.6 Stage 6: Evaluate feasibility of alternatives (Analyze problems and decide on the measures and activities in each point):

Each group will gather ideas on the reasons for the problems, obstacles, and how to solve problems in order to decide on the problems, measures, and importance of activities and thus evaluate on the feasibility of activities to do based on advice from department manager. Basically, the following activities are not suitable for small group activities.

- Highly technical issues
- Issues that require a long time or many people to implement

We have identified the following problems through small group activities.

- Issues on material quality or production that influence energy usage
- Behavior on energy usage
- Efficiency of machines or equipment that uses energy
- Awareness toward environment and energy usage
- Safety costs for energy conservation

4.5.7 Stage 7: Make Energy Conservation Plan and Raise Awareness

Each group must prepare its activity plan. Generally, implementation for small group activities takes 6 months to 1 year. Activities to be implemented should correspond to the objectives of each group. Besides, it might help to listen to opinions of all organizations in order to receive support from all other organizations.

4.5.8 Stage 8: Implement Plan

Implement according to the plan of each group.

4.5.9 Stage 9: Follow Up and Evaluate Results

After implementing the plan, each member of small groups will follow up and evaluate the result by analyzing result, search for strong and weak points of activities, find a way to improve the activities and report on general achievement.

4.5.10 Stage 10: Implement Repeatedly

Energy conservation is an activity that must be implemented repeatedly. Therefore, it is necessary to implement each activity repeated and make improvement to each activity. If we are satisfied with the results, by achieving the objectives of activities, we should provide rewards in order to give motivation for continuing the small group activities and implement creative activities.

Dos and Don'ts in Energy Conservation

- Don't emphasize the mistakes in the past. It is better to talk about the present.
- Don't be worried about the theory or principles. Don't spend too much time in discussion or analysis of problems in meeting rooms.
- Don't think that an activity can be done perfectly from the beginning. It is necessary to do the job continuously by having experiences and judging by ourselves.
- Do start with an activity that requires small amount of investment.
- Do Raise awareness so that all employees understand the necessity and importance of energy conservation and participate in it.
- Do start the activity now without postponing to tomorrow.

4.6 Used Often for Small Group Activities for Energy Conservation

4.6.1 5S:

5S is a contraction derived from the Japanese words **Seiri, Seito, Seiso, Seiketsu,** and **Shitsuke**. It is simple methodology that is also extremely useful in practical and realistic life. 5S is a set of actions to be followed through every day activities to advance the operational surroundings and circumstances. 5S is made in order to provide fortification to every personage in diverse profitable and industrialized fields. 5S is an extremely practical contrivance and skill set for anyone who wants to generate a more prolific environment within the workplace or who wants to make it their profession to make other people's businesses more proficient and productive. 5S occupy a list of products including eyewear,

ear protectors and safety gears. Look into these different products that make up the significance of an industrialized security supply. Lean Six Sigma experts promise or guarantee for the efficiency of 5S as an enlightening enhancement to better working surroundings in an association. If you dig up Six Sigma guidance that is paid for by your company, you will be in a position to work for your company and make things better for you as well as for everyone. 5S is very useful in lots of industries and job markets, but can often fail simply because of the lack of recognition concerning changes in the office.

Fig No:4.9 Five S's

5S consists of five steps that are crucial for the completion of 5S. The 5S steps are described as follows-

1. **Seiri / Sort**- This is very logical term in, which identification of the contents take place, data base of the products have been created and, then any kind of sorting take place just to arrange the products and removal of unwanted items. Classification of the products is necessary, which is called Red Tagging. It is important just to identify factors, right from whether it is needed, existing amount obligatory amount, occurrence of necessity, and so on.

2. **Seito / Systemize**- This step in 5S process consists of removal of unwanted items permanently and one more task that to be take place is decision that means you have to decide that what is required to be in what place. Place the items in such manner that you could retrieve them within 30 seconds of requirement.

3. **Seiso / Brush away/ Sweep-** Examine al the items on the daily basis. The process is not that much time consuming, but essential to clean up your workplace and most required in 5S. The conscientiousness to keep the office clean should be circulated between everyone in the group.

4. **Seiketsu / Homogenize-** This important step of 5S involves the visual control, which is important to keep your organization well- organized and clean. It is a complete evaluation to improve the working conditions.

5. **Shitsuke / Self Control-** This step is quite essential, but critical because it involves all the discipline to ensure the 5S standards, it also takes charge of dedication and commitment.

4.6.2 QCC (Quality control circle):

QCC (Quality control circle) means controlling quality through group activities. For this, it is necessary to work hand in hand and achieve objective quality or customers' request. With this, we can find weak points, find the cause of problems, gather ideas for problem solving and systematically prepare quality and thus, solve problems such as material loss, production costs, working hours, or productivity. This is also a very useful tool to tackle with Energy Conservation problem. So many factories or institutions are encouraged to utilize this tool.

5. CONCLUSION

5.1 Issues/barrier for implementation of Energy Conservation proposals

The following major barriers identified for implementation of the energy savings proposals in Sponge Iron Cluster in Orissa. They are:

- Lack of awareness and information among cluster owners on energy losses during the process, EE technologies and energy conservation measuring in Sponge Iron manufacturing Industries
- Majority of SMEs and doesn't have financial linkages to implement the energy savings proposals to their industries
- The SMEs Owners of Sponge Iron Units interested to implement to power generation and raw material pre heating systems using waste heat gases and EE motors

5.2 Availability of LSPs for Implementation Energy Conservation Proposals

The availability of Local Service Providers for implementation of identified energy saving proposals is furnished below:

Table 5.1: Availability of LSP's for implementation of Energy Savings Proposals

S.No	Technology	Local Service Providers	
		Orissa	India
1	Energy Efficient Motors	Available	Available
2	Power Generation from Waste Heat Recovery	Available	Available
3	Fuel Economizer for Preheating of Raw material	Not available	Available
4	Preheating kiln for raw material preheating	Not Available	Available

5.3 Awareness on Energy Conservation and Energy Efficiency technologies

The Owners and operators in sponge iron plants do not have awareness on energy conservation concepts and energy efficiency improvement in the plants towards reduction in energy consumption.

Though the clusters units are in operation since last 2-3 decades, awareness programs on Energy conservation and efficiency improvement in Sponge Iron Manufacturing Industries are not conducted regularly either from local bodies or central government in the cluster.

5.4 Summary of Energy savings proposals and total savings

The summary of energy saving proposal identified during the Energy use and Technology Audit conducted in Sponge Iron Cluster, Orissa for different technology options are presented below.

Table 5.2 Summary of Energy savings proposals and total savings

S. No	Technology	Capacity	Energy Savings		Investment Cost (Rs.in lakhs)	Expe-cted Units	Total Energy Savings		Total Investment (In lakhs)	Pay back (Yrs)
			Electrical (lakhs kWh/yr)	Coal (MT/Yr)			Electrical (kWh/Yr)	Coal (MT/Yr)		
1	Preheating Kiln	50 TPD	0	9626	139	2	0.0	19253	279	0.4
2	Preheating Kiln	100TPD	0	19253	341	5	0.0	96263	1705	0.5
3	Preheating Kiln	200TPD	0	38505	547	2	0.0	77010	1093	0.4
4	Power From Waste Heat Recovery System	2.2 MW	63	0	1100	3	189	0.0	3300	5.3
5	Power From Waste Heat Recovery System	4.4 MW	126	0	1870	4	504	0.0	7480	4.5
6	Power From Waste Heat Recovery System	6.6 MW	189	0	2310	5	945	0.0	11550	3.7
7	Power From Waste Heat Recovery System	8.8 MW	252	0	3927	2	504	0.0	7854	4.7
8	Fuel Economizer for Pre heating of Raw material	50 TPD	0	1327	110	2	0.0	2653	220	2.4
9	Fuel Economizer for Pre heating of Raw material	100TPD	0	2653	150	3	0.0	7960	450	1.6
10	Fuel Economizer for Pre heating of Raw material	200TPD	0	5306	300	2	0.0	10613	600	1.6
11	Fuel Economizer for Pre heating of Raw material	300 TPD	0	7960	425	2	0.0	15919	850	1.5
12	Energy Efficient motors	25 HP	0.0898	0	0.5	8	0.7	0.0	3.6	1.5
13	Energy Efficient motors	40HP	0.1347	0	0.9	15	2.0	0.0	13.1	2.0
14	Energy Efficient motors	50HP	0.1996	0	1.1	10	2.0	0.0	11.1	1.7
15	Energy Efficient motors	60 HP	0.253	0	1.4	5	1.3	0.0	6.9	1.7
	Total		**631**	**84630**	**11223**	**70**	**2148**	**229671**	**35416**	**3.79**

From the above table it is observed that the total electrical energy saving from 15 Energy savings proposals identified in the cluster is 631 Lakhs kWh/year and total coal savings is 84630 Tons/Year and investment for 15 energy savings proposals are 11223 Lakhs.

The expected Industries to implement the different energy saving proposals identified in the cluster are 70. The total electrical energy savings in the cluster is 2148 lakhs kWh/Year and total coal savings is 229671 MT/Year. The payback period for these energy savings proposals are lies in between 0.5 to 3.0 years depending up on energy savings and investment cost.

Annexure 1
Technical Calculations

1. PUMP CALCULATIONS

Step 1: Calculation of the Hydraulic power of pump

Flow of the pump: Q m^3/hr
Head of the pump: H m
Acceleration due to gravity: 9.81 m/s^2

Hydraulic power of pump $= \frac{[Q \times H \times 9.81]}{3600}$

Step 2: Calculate the Efficiency of Pump Set.

Motor Power: Pm kW
Efficiency of Pumps set (Over all Efficiency) =η

I.e. Over all efficiency η $= \frac{[Q \times H \times 9.81]}{[3600 \times Pm]}$

Note: over all efficiency of pump set = motor efficiency x pump efficiency

$$\eta_{Pset} = \eta_{motor} \times \eta_{Pump}$$

Step 3: Saving calculation for Pump Set.

Measured input power of the old pump set = $P_{old\ pump\ input}$ kW
Measured input power of the new energy efficient pump set = P new pump input kW
Annual energy saved in kWh= (P old pump input kW - P new pump input kW) x Working hour x Annual working days

2. CALCULATIONS FOR MOTOR

Step1: Calculation of Motor Loading.

Rated power of the motor = P'_m hp
Rated power of motor = $P'_m \times 0.746$
= P_m kW
Rated Efficiency of motor = $\eta_{motor\ rated}$
Rated Input Power of the motor = P_m kW ÷ $\eta_{motor\ rated}$
= $P_{m\ input}$ kW
Measured input power = $P_{m\ measured}$ kW

Percentage loading of motor $L_M = \frac{Pm\ measured}{Pm\ input}$ %

Step 2: Calculation of motor efficiency.

Approximate Output hp = % loading x Rated hp
= L_M x P'_m hp

Motor efficiency $\eta_{\text{motor measured}} = \dfrac{\%\ \text{Loading x P'm hp}}{\text{Pm measured kW}}$

Step3: Saving Calculation by replacing EE motor.

Measured input power of old motor = $P_{\text{oldm measured}}$ kW
Rated power of EE Motor = P'new motor hp
Rated power in kW = P' new motor x 0.746
= P new motor kW
Rated Efficiency = η new motor rated
Rated Input power of the EE motor = Pi/p new motor
= P new motor kW ÷ η new motor rated
Actual input power of EE motor = Pi/p new motor x loading%
= PA i/p new motor

Annual saving in kWh
= ($P_{\text{oldm measured}}$ kW - PA i/p new motor) working Hr x no.of working days

Annexure – 2
Local Service Providers

.No	Machinery / Equipment	Name of the Manufacturer / Supplier	Contact Address	Telephone
1	**ENERGY EFFICIENT MOTORS**	NSPL	Station Road, Barbil, Orissa India	91-6767-276834
2		Krishna Engineers & Consultants	4723, laxmi vihar, sainik school, Bhubaneswar, Orissa India	91-674-6533717
3		Crompton Greaves	Bhubaneshwar Janpath Tower, 3rd Floor, Ashok Nagar Unit II Bhubaneshwar – 751009 India	Tel : +91 674 2531 128, 2531 429 Fax : +91 674 2533 521 e-mail : satish.mohanty@cgglobal.com
4	**Waste Heat Recovery Plant Power from Sponge Iron**	Lloyds Group	Chaterjee International Centre, 16th floor, Room No. A-8, 33-A, Chowrangee, Kolkata – 700 071	Tel. Nos. +91-033-22175903 Fax:033-22260928 Email: cal_verma@yahoo.co.in
5		Articulated Vessels & Utility Engineers (p) Ltd	Hyderabad, India	Paramirvir Singh : 09391372723 Anup Gupta : 9246361191
6		Godawari Power & Ispat Ltd.	428/2, Phase-I, Industrial Area, Siltara - 493111 Dist. Raipur, Chhattisgarh, India	Tel: 0771-4082333, 4082235, 07721-406130, 31, 407130, 9893059181 Fax : 0771-4082234, 07721-403701
7		AVANT-GARDE ENGINEERS AND CONSULTANTS PVT. LTD.,	No. 68A, Porur Kundrathur High Road, Porur, Chennai - 600 116.	Ph. nos.: +91-44-2482 7843, 2482 8532, 2482 8717 Fax: +91-44-2482 8531. E-mail : avantgarde@vsnl.com
8		Thermax	D-13, MIDC Industrial Area R D Aga Road, Chinchwad, Pune 411019	Phone : 020 - 66122100/ 27475941-42 Fax : 020 - 27472049
9		VISA Steeel	VISA House 8/10 Alipore Road Kolkata 700027 West Bengal	Tel: + 91 33 3011 9000 Fax: + 91 33 3011 9002
10		Shree **Satya Sai Technical Services**		**John Reddy** Mob. 08805751113

.No	Machinery / Equipment	Name of the Manufacturer / Supplier	Contact Address	Telephone
11	**Preheating Kiln For Raw material heating in Sponge Iron Plant**	EICS Group Of Companies	Flat No: 101, 1st Floor, Block A, Akashara Whispering Willows, Salut, Rajarhat, Kolkata-700136	Web: www.eicsgroup.in
12		Mid India Power and Steel Ltd.(MIPSL)	401, Mahakosh House, 7/5 South Tukoganj, Nath Mandir Road, Indore. 452 001 MP, INDIA	, Phone: +91-731-2518167 - 9, 2528133; Fax: 91-731-2516714, 2527250;
13	**Fuel Economizer In Sponge Iron Plant**	Spongy Tech Consulting Engineers Pvt. Ltd	"Dream-Villa" MIG-9/A, CGHB Kota Colony Raipur, Pin 492010 (C.G.) INDIA	+91-771-2575101

Annexure 3
Quotations

1. Motors

QUOTATION

SLR ENTERPRISES

Ph : (O) 66568120
Telefax : 66338262
Mobile : 9849006201

AUTHORISED DEALER FOR :
FINOLEX CABLES LTD, ROTOMOTIVE - MOTORS & WORM GEAR BOXES
D. No. 3464, (4-3-1 to 6) 3rd Floor, "Dundoo Vihar", R.P. Road, Secunderabad - 500 003.

M/s. APITCO LTD,
Balkeerbagh,
Hyd Bad

Qtn. No. : 359 Date : 24/12/10.

Ref. No. :

S.No.	DESCRIPTION	Qty.	Unit Price	Amount Rs.	Ps.
	SIEMENS MAKE 1500 RPM FOOT MOUNTING MOTOR EFFI				
1	60 HP 1SE0 223 - 4YL80		198,400/-		
2.	75 HP 1SE0 254 - 4YA80		252500/-		
3	100 HP 1SE0 281 - 4YA80		323150/-		
4	120 HP 1SE0 284 - 4YA80		374910/-		
5	150 HP 1SE0 311 - 4YA80		453900/-		
	LESS DISCOUNT : 45%				
	EXCISE DUTY : extra @	10.3%			

TIN : 28630156311
APGST No. SEC/10/1/2734/96-97 Valid from : 1-4-1996
CST No. : SEC/10/1/2352/2000-2001 w.e.f. : 1-8-2000

Terms & Conditions :

1) Prices : Vat @ 14.5% extra
2) Delivery : Ex-Stock
3) F.O.R. : Sec Bad
4) Payment : 25% advance balance against delivery.
5) Validity : One week.

for **SLR ENTERPRISES**

QUOTATION

Ph : (O) 66568120
Telefax : 66338262
Mobile : 9849006201

SLR ENTERPRISES

AUTHORISED DEALER FOR :
FINOLEX CABLES LTD, ROTOMOTIVE - MOTORS & WORM GEAR BOXES
D. No. 3464, (4-3-1 to 6) 3rd Floor, "Dundoo Vihar", R.P. Road, Secunderabad - 500 003.

M/s. APITCO LTD,
Bartheerbagh,
[illegible] Road.

Qtn. No. : 358 Date 24/12/10.

Ref. No. :

S.No.	DESCRIPTION	Qty.	Unit Price	Amount Rs. Ps.
4)	SIEMENS Make 1500 RPM FOOT MOUNTING MOTOR EFF1			
1)	5 HP 1SE0 113-4YA80		19935=00	
2.	7.5 HP 1SE0 130-4YA80		27470=00	
3.	10 HP 1SE0 133-4YA80		31995=00	
4	12.5 HP 1SE0 163-4YA80		51480=00	
5	15 HP 1SE0 163-4YA80		52900=00	
6	20 HP 1SE0 166-4YA80		65750=00	
7	25 HP 1SE0 183-4YA80		86830=00	
8	30 HP 1SE0 186-4YL80		91680=00	
9	40 HP 1SE0 207-4YL80		123780=00	
10	50 HP 1SE0 221 4YK80		160500=00	
	Discount : 45% Extra @ 10.3% Excise duty			

TIN : 28630156311
APGST No. SEC/10/1/2734/96-97 Valid from : 1-4-1996
CST No. : SEC/10/1/2352/2000-2001 w.e.f. : 1-8-2000

Terms & Conditions :
1) Prices : Vat @ 4% extra for SL No 1 to 3 & 14.5% extra for others
2) Delivery : Ex-Stock
3) F.O.R. : Sec'bad
4) Payment : 25% advance balance against delivery
5) Validity : One week

for **SLR** ENTERPRISES

2. Fuel Economizer

SELECTION CHART

AAG Model	Bed depth (mm)	Capacity (M³/hr.)							
		1	2	3	4	5	6	7	← stroke/min.
3334	100	1.08	2.16	3.24	4.32	5.40	6.48	7.56	
	150	1.62	3.24	4.86	6.48	8.10	9.72	11.34	
	200	2.16	4.32	6.48	8.64	10.80	12.96	15.12	
3336	100	1.62	3.24	4.86	6.48	8.10	9.72	11.34	
	150	2.43	4.86	7.29	9.72	12.15	14.58	17.01	
	200	3.24	6.48	9.72	12.96	16.2	19.44	22.68	
3338	100	2.16	4.32	6.48	8.64	10.8	12.96	15.12	
	150	3.24	4.86	7.29	9.72	12.15	14.58	17.01	
	200	4.32	8.64	12.96	17.28	21.6	25.92	30.24	

COMMERCIAL FACTORS

500 & 350TPD	190 Lacs
100TPD	150 Lacs
50TPD	110 Lacs

Please Note: Manufacturing of Equipments, designs, research & development charges, supervision charges, installation, commissioning charges & deputation of process experts with 07 days trial production. (Taxes & duties are not included) contractor to be decided by the customer. Transportation cost borne by the customer.

B) COAL

SIZE: 4 to 18 mm

In addition – 4mm size is to be used in restricted quantity.
M.P.S. should be nearly equal to the M.P.S. of Iron ore for better mixing / combination inside the kiln.
Ash around 25% is preferable (every 1% increase will reduce productivity by about 2 to 3% in the ash range 30%).
V.M. = 28 to 32% (Coal with very high V.M. are difficult to use as they increase the gas volume which creates problem in the A.B.C.
Reactivity = 1.75 CC of CO / gm carbon / sec (min).
Reactivity index = 3000 CC / minute (min).
Caking Index = < 3.
Swelling Index = < 1.
GCV = > 5500 K. Cal / Kg.
Ash softening temperature = > 1150^{0}C.
Ash fusion temperature = > 1225^{0}C.
Ash Flow point = > 1275^{0}C.

CALCULATION FOR SAVING OF COAL AFTER INTRODUCING "AAG" FUEL ECONOMIZER

Annexure - 1

ASSUMPTIONS

1. Daily Production of sponge iron

100TPD	-	120 TPD (min.)
50TPD	-	60 TPD (min.)

2. Total quantity of hot gases discharged from reduction kiln

100TPD plant	-	24000 NM^3/hr.
50TPD plant	-	14000 NM^3/hr.

Temperature of hot gases at the Outlet of reduction kiln	-	1000^{0}C (Average)
4. Temperature of preheated iron ore	-	700^{0}C (Average)
5. Ambient temperature	-	30^{0}C
6. Density of air at 30^{0}C	-	1.164 Kg. / M^3
7. Useful heat value of coal	-	4500 K.cal/kg.
8. Sp. Heat of iron ore	-	0.22 K. Cal / kg. ^{0}C
9. Sp. Heat of hot gas	-	0.312 K. Cal / kg. ^{0}C
10. 'Fe' percentage in iron ore	-	65%
11. 'FC' percentage in coal	-	45%
12. Landed cost of Iron Ore	-	Rs. 3600 / MT
13. Landed cost of Coal	-	Rs. 3000 / MT
14. Selling price of sponge iron	-	Rs. 11500 / MT

DETAILED CALCULATION

(Quantity of Heat Required)

(A) Heat required for heating the mixture of iron ore and dolomite from 30^0C to 700^0C

CASE – I (100TPD)

Plant capacity = 100TPD

Expected increase in output rate = 20%

(i) Quantity of iron ore to be heated

$$= \frac{(100 + 20\% \text{ of } 100) \times 1.65}{22 \text{ hrs.}} \text{ TPH}$$

= 9 MT/hr. or 9,000 Kg/Hr.

(ii) Quantity of heat

= 9,000 x 0.22 (700-30)

= 13,26,500 K. Cal. / hr.

Say = 14,00,000 K. Cal. / hr.

CASE – II (50TPD)

Plant capacity = 50TPD

Expected increase in output rate = 20%

(i) Quantity of iron ore to be heated

$$= \frac{(50 + 20\% \text{ of } 50) \times 1.65}{22 \text{ hrs.}} \text{ TPH}$$

= 4.5 MT/hr. or 4500 Kg/Hr.

(ii) Quantity of heat

= 4,500 x 0.22 (700-30)

= 6,63,300 K. Cal. / hr.

Say = 7,00,000 K. Cal. / hr.

Annexure -2

DETAILED CALCULATION

- (Hot Air Quantity & Temperature of Air discharged)

(B) Quantity of hot air required to heat the mixture from 30⁰C to 700⁰C

CASE – I (100TPD) Plant

(i) Heat available in the hot air discharged from the system
= Mass x Specific Heat x Temp
= (24,000 M³/hr. x 1.164 kg. / M³) x .31 K.Cal./kg. x 1,000⁰C K. Cal/kg.
= 86,60,160 K Cal./hr.

Say 86,60,000 K. Cal./hr.

Therefore quantity of hot air required
= $\frac{24,000 \times 14,00,000}{86,60,000}$ M³/hr.
= 3,880 M³/hr.

(ii) Considering the heat transfer efficiency of the system to be 85% and other losses as 10% -
The hot air quantity required = $\frac{3880}{.75}$ M³/hr.
= 5,173 M³/hr.

Say 5,200M³/hr.

(iii) Temperature of cold gas leaving "AAG" Fuel Economizer model 3336 after heating the mixture to 700⁰C –
= (5,200 x 1.164 x .31 x 1,000) – 14,00,000
= 4,76,368 K. Cal/hr.
Heat lost = Heat gained
4,76,368 K. Cal/hr. = 5,200 x 1.164 x 0.31 x ΔT
= 1,876.4 ΔT
There fore $\Delta T = \frac{4,76,368}{1,876.4}$ = 254⁰C

Say 5,200M³/hr.

(iv) Temperature of total air reaching to waste heat recovery boiler circuit –
Let hot air from system, X = 18,800 M³/hr.
And cold air from "AAG" – 3336, Y = 5,200 M³/hr.
Heat available in hot air = 86,60,000 K. Cal/hr.
(a) Hot air from Kiln -
18,800 x 1.164 x0.31 x1,000 = 67,83,792 K.Cal/hr.
(b) Hot air entering "AAG"
5,200 x1.164x0.31x1,000 = 18,73,368 K.Cal/hr.
Heat available in cold air from "AAG"
= 5,200 x 1.164 x 0.31 x (250-30) = 4,13,000 K.Cal/hr.
Say 4,13,000 K.Cal/hr.

Total heat in mixture i.e. (X+Y)
= 67,83,792 + (18,73,368-4,13,000) = 82,47,160 K.Cal/hr.
Total quantity of air (18,800 + 5,200) = 24,000 M³/hr.
Heat lost = Heat gained
24,000 x 1.164 x 0.31 x ΔT = 82,47,160

There fore $\Delta T = \frac{82,47,160}{24,000 \times 1.164 \times 0.31}$ = 952⁰C

CASE – II (50TPD) Plant

(i) Heat available in the hot air discharged from the system
= Mass x Specific Heat x Temp
= (14,000 M^3/hr. x 1.164 kg. / M^3) x .31K.Cal./kg. x 1,000°C K. Cal/kg.
= 50,51,760 K. Cal./hr.

Say 50,50,000 K. Cal./hr.

Therefore quantity of hot air required

$$= \frac{14{,}000 \times 7{,}00{,}000}{50{,}50{,}000} \ M^3/hr.$$

= 1,940.59 M^3/hr.

(ii) Considering the heat transfer efficiency of the system to be 85% and other losses as 10% -

The hot air quantity required $= \frac{1{,}940.59}{0.75}$ M^3/hr.

= 2,587.46 M^3/hr.

Say 2,600M^3/hr.

(iii) Temperature of cold gas leaving "AAG" Fuel Economizer model 3334 after heating the mixture to 700°C –
= (2,600 x 1.164 x .31 x 1,000) – 7,00,000
= 2,38,184 K. Cal/hr.

Heat lost = Heat gained

2,38,184 K. Cal/hr. = 2,600 x 1.164 x 0.31 x ΔT
= 938.2 ΔT

Therefore $\Delta T = \frac{2{,}38{,}184}{938.2}$ = 254°C

(iv) Temperature of total air reaching to waste heat recovery boiler circuit –

Let hot air from system, X = 11,400 M^3/hr.
And cold air from "AAG" – 3336, Y = 2,600 M^3/hr.

Heat available in hot air

(a) Hot air from kiln
11,400x1.164x0.31x1,000 = 41,13,576 K.Cal/hr.

(b) Hot air entering "AAG"
2,600x1.164x0.31x1,000 = 9,38,184 K.Cal/hr.

Heat available in cold air from "AAG"
= 2,600 x 1.164 x 0.31 x (250-30) = 2,06,400 K.Cal/hr.
Say 2,06,000 K.Cal/hr.

Total heat in mixture i.e. (X+Y)
= 41,13,576 + (9,38,184-2,06,000) = 48,45,760 K.Cal/hr.

Total quantity of air (11,400 + 2,600) = 14,000 M^3/hr.

Heat lost = Heat gained

14,000 x 1.164 x 0.31 x ΔT = 48,45,760

There fore $\Delta T = \frac{48{,}45{,}760}{14{,}000 \times 1.164 \times 0.31}$ = 959°C

Annexure - 3

DETAILED CALCULATION
- (Coal Consumption)
C. Saving in coal consumption

CASE – I (500TPD)

(i) Coal consumed in conventional kiln producing 600TPD will be
= 600 x 1.2 = 720 MT/day or 720/24 = 30 MT/hr

(ii) Heat taken out from hot air = 67,00,000 K.Cal/hr.
Calorific value of coal = 4,500 K.Cal/kg.
Therefore equivalent coal = $\frac{67,00,000}{4,500}$ Kg. of coal/hr.
= 1,488.89 kg./hr.
Say 1,489 kg/hr. or 1.489 MT/hr.

Therefore saving in coal consumption = $\frac{1.489}{30}$ x100 = 4.96%

Say 4.5%

CASE – II (350TPD)

(i) Coal consumed in conventional kiln producing 420TPD will be
= 420 x 1.2 = 504 MT/day or 504/24 = 21 MT/hr

(ii) Heat taken out from hot air = 47,00,000 K.Cal/hr.
Calorific value of coal = 4,500 K.Cal/kg.
Therefore equivalent coal = $\frac{47,00,000}{4,500}$ Kg. of coal/hr.
= 1,044.44 kg./hr.
Say 1,044 kg/hr. or 1.044 MT/hr.

Therefore saving in coal consumption = $\frac{1.044}{21}$ x100 = 4.97%

Say 4.5%

Annexure - 3

DETAILED CALCULATION
- (Coal Consumption)
C. Saving in coal consumption

CASE – I (100TPD)

(i) Coal consumed in conventional kiln producing 120TPD will be
= 120 x 1.2 = 144 MT/day or 144/24 = 6 MT/hr

(ii) Heat taken out from hot air = 14,00,000 K.Cal/hr.
Calorific value of coal = 4,500 K.Cal/kg.
Therefore equivalent coal = $\frac{14,00,000}{4,500}$ Kg. of coal/hr.
= 311 kg./hr. or 0.311 MT/hr.

Therefore saving in coal consumption = $\frac{0.311}{6}$ x100 = 5.18%

Say 5%

CASE – II (50TPD)

(i) Coal consumed in conventional kiln producing 60TPD will be
= 60 x 1.2 = 72 MT/day or 72/24 = 3 MT/hr

(ii) Heat taken out from hot air = 7,00,000 K.Cal/hr.
Calorific value of coal = 4,500 K.Cal/kg.
Therefore equivalent coal = $\frac{7,00,000}{4,500}$ Kg. of coal/hr.
= 155.56 kg./hr. or 0.1556 MT/hr.

Therefore saving in coal consumption = $\frac{0.1556}{3}$ x100 =5.18%

Say 5%

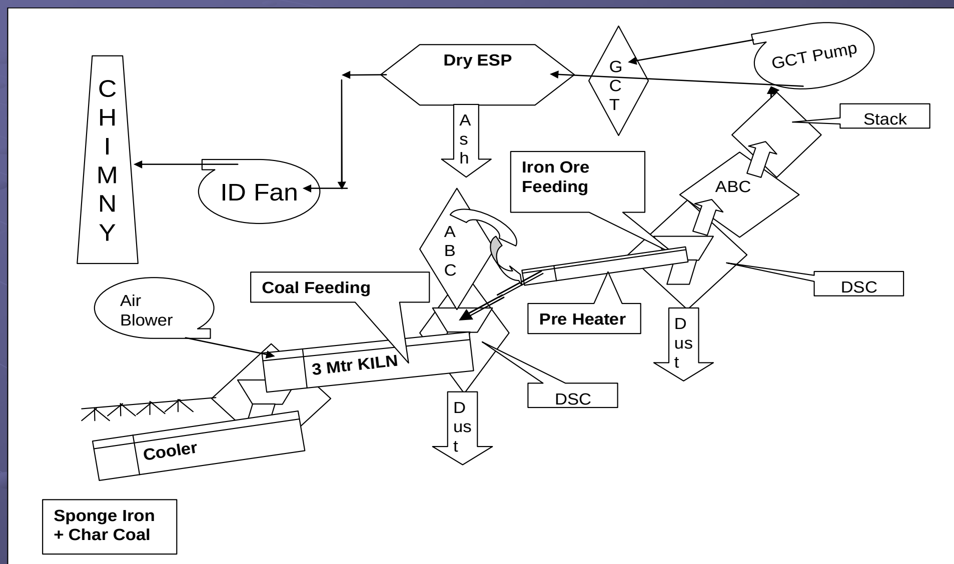
3. Pre heating Kiln

Project Report for Pre Heating Kiln Arrangement in the existing system

INTRODUCTION

- India has been the largest producer of Sponge Iron in the world since last few years.
- Local conditions here favored coal based rotary kiln units, but rotary kiln sponge iron has low energy efficiency.
- In present units 6 Gcal energy is spending to produce one MT of Sponge Iron.
- Where as 1.7 Gcal is utilized in sponge iron process.
- About 2 to 2.5 Gcal per metric ton of sponge iron is going in waste gasses.
- Most of the units cooling these gasses by spraying water in GCT.
- To recover this waste gas energy even through power generation is one of feasible option.
- **It is always preferable to plough as much of this energy back in to the process as possible.**
- Heating of iron ore in another rotary kiln without coal burning and by using only waste gas heat is an attractive possibility.
- This is called **Pre Heating Kiln System.**

Flow Diagram for Iron Ore Pre Heating with Kiln Exit Gasses



Pre Heating Kiln Working Principle

- In the pre heater system sized iron ore is continuously fed into the pre heater and where as coal fed into the main kiln.
- The waste gas librated through reduction process is passes through the pre heater kiln.
- The pre heating kiln is so designed as to heat the iron ore to about 800 to 850 ^{0}C by utilizing the waste heat from main kiln exit gasses.
- The discharge end of the pre heating kiln is connected to the main kiln ABC top end by the ducting to draw the waste gasses into the pre heating kiln.
- Where the waste gasses enter in counter current fashion and the combustibles are burn with pre heated air and Iron Ore get Pre Heated.
- The rest of the pre heating kiln effectively act as a cooler for gasses and the temperature will come down to 500 ^{0}C.
- By which we can reduce water consumption in GCT.

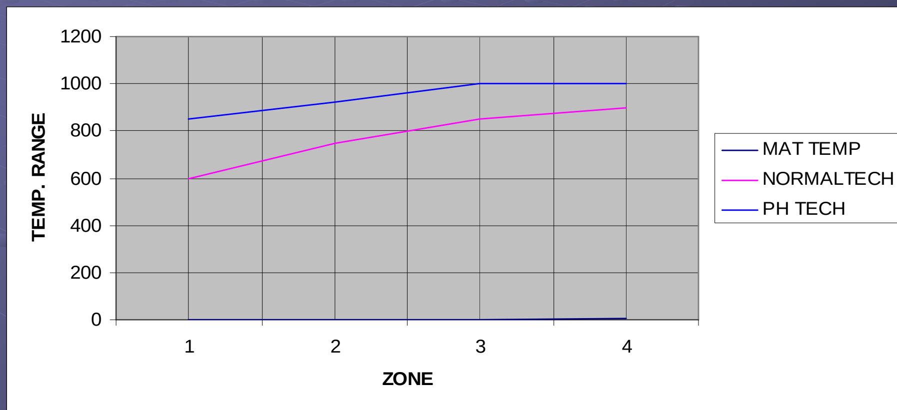
SILENT FEATURE OF THE TECHNOLOGY

- **Usage of waste heat with lower project cost**
- **The cost of production reduces.**
- **Reduction in coal consumption by 20-25%**
- **Total coal burning per day is reduced 20 to 25% compare to the present consumption.**
- **Total coal handling in the unit is reduces to 25%.**
- **This is directly reducing the pollution level in the unit.**
- **Lower solid waste generation due to reduced coal consumption**
- **As the solid waste qty reduces cooling water consumption also reduces.**
- **Environment Friendly :** The carbon particles, volatile dust, and left over CO is being fully burnt in the kiln by proving excess air.
- **Safer Technology :** The burning of carbon particles and lowering the temp. at after burning chamber is being done in pre heater so the risk of high temp. handling is reduce.

COMPARISION OF THE CONVETIONAL KILN AND PRE HEATER SYSTEM

Process Parameters	Conventional Kiln	Pre Heater System
Energy Consumption	5.5 to 6.0 Gcal/MT-DRI	4.1 to 4.5 Gcal/MT-DRI
Coal Consumption [Coal of 10% Moisture, 25 % Ash; Wet basis]	1100 – 1200 Kg/MT-DRI	825 – 900 Kg/MT-DRI
Loss of energy in waste gasses	2.0 to 2.5 Gcal/MT-DRI	1.8 to 1.9 Gcal/MT-DRI
Sensible energy loss in solid product	0.28 to 0.32 Gcal/MT-DRI	0.2 to 0.22 Gcal/MT-DRI
CO_2 emission	2.1 to 2.3 MT/MT-DRI	1.05 to 1.15 MT/MT-DRI

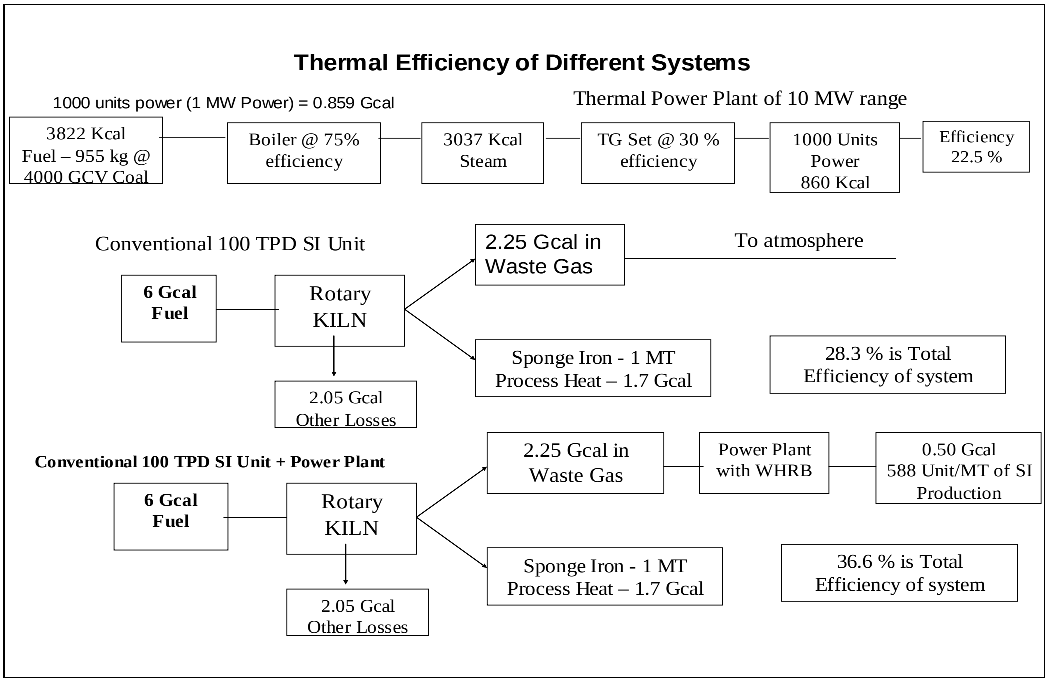
MATERIAL TEMP COMPARISON IN CONVENTIONAL KILN & PRE HEATER SYSTEM

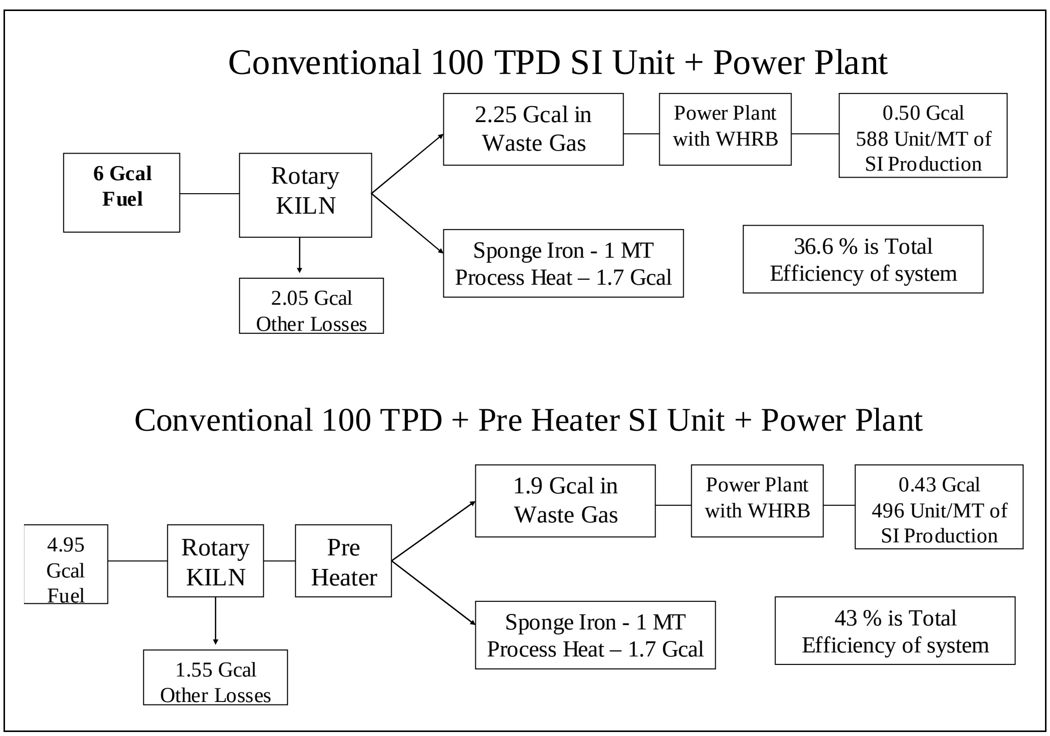


ESTIMATION FOR THE MODIFICATION OF 100 TPD X 1 NO SPONGE IRON KILN WITH NEW PRE-HEATING TECHNOLOGY

SR. No.	DESCRIPTION	VALUE IN LACS
1	CIVIL AND STRUCTURAL	124.29
2	PLANT AND MACHINERY	186.15
3	ELECTRICAL INSTALLATION	20.57
4	CONSULTANCY CHARGES	10.00
	TOTAL	**341.01**

SAY AS **350 LACS**


Thermal Efficiency of Different Systems
1000 units power (1 MW Power) = 0.859 Gcal
Thermal Power Plant of 10 MW range
3822 Kcal
Fuel – 955 kg @
4000 GCV Coal
Boiler @ 75%
efficiency
3037 Kcal
Steam
TG Set @ 30 %
efficiency
1000 Units
Power
860 Kcal
Efficiency
22.5 %
Conventional 100 TPD SI Unit
6 Gcal
Fuel
Rotary
KILN
2.25 Gcal in
Waste Gas
To atmosphere
Sponge Iron - 1 MT
Process Heat – 1.7 Gcal
2.05 Gcal
Other Losses
28.3 % is Total
Efficiency of system
Conventional 100 TPD SI Unit + Power Plant
6 Gcal
Fuel
Rotary
KILN
2.25 Gcal in
Waste Gas
Power Plant
with WHRB
0.50 Gcal
588 Unit/MT of SI
Production
Sponge Iron - 1 MT
Process Heat – 1.7 Gcal
2.05 Gcal
Other Losses
36.6 % is Total
Efficiency of system


Conventional 100 TPD SI Unit + Power Plant
6 Gcal
Fuel
Rotary
KILN
2.25 Gcal in
Waste Gas
Power Plant
with WHRB
0.50 Gcal
588 Unit/MT of
SI Production
Sponge Iron - 1 MT
Process Heat – 1.7 Gcal
2.05 Gcal
Other Losses
36.6 % is Total
Efficiency of system
Conventional 100 TPD + Pre Heater SI Unit + Power Plant
4.95
Gcal
Fuel
Rotary
KILN
Pre
Heater
1.9 Gcal in
Waste Gas
Power Plant
with WHRB
0.43 Gcal
496 Unit/MT of
SI Production
Sponge Iron - 1 MT
Process Heat – 1.7 Gcal
1.55 Gcal
Other Losses
43 % is Total
Efficiency of system

4. Waste Hear Recovery Power Plant

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AV-UE/WHRS /Q/11-12:08A **Date: 21-04-2011**

To,

Kind Attn: Mr. Gopala Rao

Dear Sir,

Sub: Technical Proposal for Supply of Common 1 x 20 TPH Waste heat recovery System for 2 x 100 TPD Sponge Iron plant.

We thank you very much for showing interest in AV-UE for your boilers. As required by you, We are pleased to submit herewith our Technical Proposal for the Supply 1 x 20 TPH Waste heat recovery System for 2 x 100 TPD Sponge Iron plant at 66 Kg/cm2(g) Pressure and 485±5 ºC Superheated Steam.

AV&UE supplies boilers designed and manufactured to several national & international standards like IBR, ASME Sec VIII Div 1 & BS 113.

We trust the above is in line with your requirement & in the meantime, if you need any further clarifications to evaluate our proposal please feel free to contact us.

Assuring you of our best attention, always.

Thanking you,

Yours faithfully,
For ARTICULATED VESSELS & UTILITY ENGINEERS PVT. LTD.

PARAMVIR SINGH
MANAGING DIRECTOR

Our Protofilo :
- MSW Based Power Plants
- AFBC Boilers
- Sulphuric Acid Plants (SCDA & DCDA)
- Heat Exchangers
- Waste Heat Recovery Systems
- CFBC Boilers
- Travelling Grate Boilers
- Pressure Vessels

Need Based Fabrication

ARTICULATED VESSELS & UTILITY ENGINEERS PVT. LTD.,

Office: H. No. 155, 1st Floor, Medchal Highway, Opp. Cineplanet, Kompally, Hyderabad - 500 014, Andhra Pradesh, INDIA. Ph: 040-6581 0418, Fax: 040-6581 0419

Works: Survey No. 10&13, Gundla Pochampally Village, Medchal Mandal, R R District, Andhra Pradesh, India. Ph: 040-6581 0423

E-mail: info@avuboilers.com, website: www.avuboilers.com

ENERGY IS LIFE B E E CONSERVE IT

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INDEX

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iv). The equipments will be constructed in modules; this modular construction ensures easy transportation and easy maintenance.

v) Upper and Lower Headers of the Membrane Wall and the Evaporator are connected to the Steam Drum by Risers & Down Comers.

vi) Thermal Expansion joints are provided to absorb Thermal Expansion impact of the Boiler.

vii). Feed Water Control Valve is located down Stream of the Economizer to avoid steaming in the Economizer.

viii). Superheated Steam Temperature is controlled through Intermittent Spray Type Desuperheater located between primary & secondary super heater banks.

ix). Equipped with High Quality Standard Valves, Mountings & Instruments.

x). The Internal Trays and the Column Shell of the Deaerator shall be made of SS-304 material to eliminate rust formation due to Oxidation.

xi). The system ensures arresting of total dust through 3-Stage trapping system.

a. At the Furnace Entry, the primary heavy dust is collected/ removed through Dust Hopper, provided at the bottom of the Furnace, by rotating valve.

b. The Carry-Over dust particles from the Furnace chamber are removed in the Super heater and collected at Dust Hopper at the bottom of the Super heater Chamber.

c. Finally the dust particles will be removed in the dust collectors provided at the bottom of the economizer hopper.

xii). Please appreciate that the Dust particles carried by the flue gases from the Sponge Iron plant are just not Dust particles, but also has appreciable heat content in it. So removal of the dust from the Kiln exhaust flue gases, before entering Boiler chamber would result in loss of heat content, which ultimately hampers the over-all Thermal efficiency of W.H.R. System. Therefore, the 3-stage dust removal system suggested and incorporated in design (as above in Sl.No.11) is the most efficient and appropriate solution to maintain high Thermal Efficiency of the system and render the overall system dust free.

xiii). Most efficient, reliable, dependable and performance based system.

xiv). Since we have already supplied, Erected and Commissioned a number of WHR Systems, we assure you that the Erection & Commissioning of the WHRS, at your site, shall be within the stipulated schedules exhibiting a superior quality of workmanship.

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2.2.4. EVAPORATOR MODULES:

The Evaporator section consists of bare tubes arranged to form a tube bundle. The tubes are arranged in such a manner that they face the gas flow directly. The top and bottom ends of the tubes are duly welded to headers, which in turn are connected to the steam drum / water circuits respectively.

2.2.5. ECONOMISER MODULES:

The Economiser section consists of bare tubes arranged to form a tube bundle. The tubes are arranged in such a manner that they face the gas flow directly. The top and bottom ends of the tubes are duly welded to headers, which in turn are connected to the steam drum / water circuits respectively.
In this zone consists of economizer, the heat is recovered to preheat the Boiler Feed Water is preheated. Feed Water Control Valve is located before Economizer.

2.3. GAS CIRCUIT:

Exhaust gas from 2 x 100 TPD Plant ABC (After Burning Chamber) of kiln enters the radiant chamber where it gets cooled sufficiently before entering into second and third chamber. The gas then passes through the two stage Superheater section, evaporator section and Economiser section and let into the ESP. ID Fan draws the cooled exhaust gas and lets into atmosphere through the chimney.

2.4. BLOW DOWN TANK:

We have considered one no. common blowdown tank (Common for CBD & IBD for each boiler) to which the boiler blowdown, boiler drain lines from various systems will be connected.

2.5. WATER AND STEAM CIRCUIT:

Deaerated water enters economiser and gets heated. The heated water then enters the steam drum and then circulated (Natural Circulation) in evaporator sections and water wall. Saturated steam is collected in the steam drum. Saturated steam is then superheated in convection superheaters and taken out to turbine. Inter stage desuperheater is provided to control the steam temperature.

2.6. SOOT BLOWING SYSTEM:

Soot Blowing system consists of retractable and rotary soot blowers which uses steam as blowing media. Retractable soot blowers are provided in the superheater zone. Rotary type soot blowers are provided in the evaporator and economiser zones. Piping to individual soot blowers are adequately sized and properly routed to prevent the entry of water droplets into the soot blowers. Steam traps are provided in the pipeline to remove the condensate from the system.

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2.7. DEAERATOR CUM STORAGE TANK:

This system consists of Deaerator in which the oxygen content in the feed water is reduced to the required level by spraying water as droplets in the presence of steam. There will be a storage tank below the Deaerator to store deaerated water.

2.8. CHEMICAL DOSING SYSTEM

2.8.1 LP CHEMICAL DOSING SYSTEM

The feed water contains traces of oxygen due to the incomplete mechanical / Thermal deaeration. These traces of oxygen are scavenged by chemical deaeration. Chemicals like sodium sulphite or hydrazine is dosed to the suction pipe of feed pump by LP dosing. In LP dosing sodium sulphite react with oxygen and forms sodium sulphate or Hydrazine React with O2 and forms water & nitrogen.

2.8.2 HP CHEMICAL DOSING SYSTEM

Scale formation is limited by converting hardness salts to a free flowing sludge. HP dosing is done by carbonate control and phosphate control by addition of sodium carbonate / or Trisodium phosphate respectively. Other chemicals such as sodium hydroxide carbonate or calcium oxyphosphate can also be added. Best result of calcium carbonate or magnesium hydroxide or calcium silicate, magnesium silicate will be available as free flowing sludges where caustic alkalinity is 10 to 15% of the dis-solved solids. OH alkalinity leads to prevention of magnesium phosphate as bad scale by converting magnesium to magnesium hydroxide. Sludge conditioner can also be used, if there is no effective means of blowdown is available it is better not to concentrate on internal treatment.

4.0 THERMAL DESIGN DATA:

4.1. Heating Surface Areas:

S.No	Description	Area, Sq.m.
1	Water walls	
2	Screens	41
3	Evaporator -I	436
4	Primary Super heater	133
5	Secondary Super heater	114
6	Economiser	882
	Total	

*** The Heating Surface Areas may be changed during detailed engineering.**

4.2. Flue Gas Pressure Profile:

S.No	Description	Pressure mmWC
1	Radiation chamber	15
2	Superheater 1 & 2	40
3	Evaporator	15
4	Economiser	20
5	Ducting	20
6	ESP (Not in our scope)	35
	Total	145

4.3. Flue Gas Velocity Profile:

S.No	Component	Velocity, m/s
1	Radiation chamber	10-8
2	Superheater -II	8-6
3	Superheater -I	8-6
4	Evaporator	7-5
5	Economiser	7-5

4.4. Steam & Water Pressure Profile:

S.No	Description	Pressure, Kg/cm2(g)
1	At the outlet of MSSV	66
2	Drum working Pressure	68
3	Economiser inlet pressure	70
4	Super heater S.V. Set Pressure	69
5	Drum S.V.1 Set Pressure	71.5
6	Drum S.V.2 Set Pressure	72.5

4.5. Flue Gas Temperature Profile:

S.No	Component	Deg C
1	Radiation chamber inlet	950
2	Inlet to Superheater -II	740 -730
3	Inlet to Superheater -I	660-650
4	Inlet to Evaporator	560-550
5	Inlet to Economiser	365-355
6	Outlet of ESP	180 ± 10

4.6. Water/ Steam Temperature:

S.No	Component	Deg C
1	Inlet to Economiser	126
2	Economiser Outlet	266
3	Inlet of Super heater -I	281
4	Outlet of Super heater-I	405
5	Inlet of Super heater -II	385
6	Outlet of Super heater-II	485± 5

Note: Thermal Design Data May vary during detailed engineering

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5.0 GUARANTEED PARAMETERS:

Following are the guaranteed parameters for WHRSG:

Steam output at SH outlet	Kg/h	20000
Steam pressure at SH outlet	Kg/cm^2 (g)	66 ± 0.5
Steam temperature at SHO	°C	485 ± 5
Design pressure	Kg/cm^2 (g)	75
Hydro test pressure	Kg/cm^2 (g)	112.5
Gas Flow from two Kiln	Nm^3/hr	48000
Gas side pressure Drop	mm WC	145
Gas Inlet Temperature	°C	950
Gas outlet Temperature	°C	180 ± 10
Blow down losses (considered)	%	2.0
Radiation losses (considered)	%	2.0

6.0 EQUIPMENT TECHNICAL DATA:

6.1. Specification of Radiation chamber:

S.No	Description	Value
1	Design code	IBR 1950 with its latest amendments
2	Design pressure	75 kg/cm² g
3	Design temperature	317 °C
4	Hydro test pressure	112.5 kg/cm² g
5	Type	Vertical
6	Type of tubes	Bare
7	Tube outer diameter	50.8 mm
8	Tube thickness	4.47 mm
9	MOC of tubes	BS 3059 Seamless
10	MOC of headers	SA 106 Gr B

6.2. Specification of Secondary Superheater:

S.No	Description	Value
1	Design code	IBR 1950 with its latest amendments
2	Design pressure	75 kg/cm² g
3	Design temperature	524 °C
4	Working temperature	485 °C
5	Hydrotest pressure	112.5 kg/cm² g
6	Type	Horizontal
7	Type of tubes	Bare
8	Tube outer diameter	38.1 mm
9	Tube thickness	4.06 mm
10	MOC of tubes	SA 213 T11
11	MOC of headers	SA 335 P11

6.3. Specification of Primary Superheater:

S.No	Description	Value
1	Design code	IBR 1950 with its latest amendments
2	Design pressure	75 kg/cm^2 g
3	Design temperature	444 °C
4	Working temperature	405 °C
5	Hydrotest pressure	112.5 kg/cm^2 g
6	Type	Horizontal
7	Type of tubes	Bare
8	Tube outer diameter	38.1 mm
9	Tube thickness	4.06 mm
10	MOC of tubes	SA 210 Gr A1
11	MOC of headers	SA 106 Gr B

6.4. Specification of Evaporator:

S.No	Description	Value
1	Design code	IBR 1950 with its latest amendments
2	Design pressure	75 kg/cm^2 g
3	Design temperature	317 °C
4	Working temperature	289 °C
5	Hydro test pressure	112.5 kg/cm^2 g
6	Type	Flag
7	Type of tubes	Bare
8	Tube outer diameter	44.5 mm
9	Tube thickness	4.06 mm
10	MOC of tubes	BS 3059 Seamless
11	MOC of headers	SA 106 Gr B

6.5. **Specification of Economiser:**

S.No	Description	Value
1	Design code	IBR 1950 with its latest amendments
2	Design pressure	75 kg/cm² g
3	Design temperature	300 °C
4	Working temperature	289 °C
5	Hydrotest pressure	112.5 kg/cm² g
6	Type	Horizontal
7	Type of tubes	Bare
8	Tube outer diameter	38.1 mm
9	Tube thickness	3.66 mm
10	MOC of tubes	BS 3059 Seamless
11	MOC of headers	SA 106 Gr B

6.6. **Specification of Attemperator:**

S.No	Description	Value
1	Type	Fixed Nozzle spray type Attemperator
2	Nos	one
3	Location	Between primary & secondary SH
4	MOC of headers	SA 516 Gr 70
5	Header outer diameter mm	Dished
6	Header thickness mm	As per IBR

6.7. **Specification of Soot Blowers:**

S.No	Description	Long Retractable	Rotary soot blower
1	Location	Super heater	Evaporator & Economiser zones
2	Qty	2	4
3	Steam temperature ºC	Super-heated steam	
4	Steam pressure kg/cm^2(g)	20-30	
5	Source of Steam	Super heater steam from Steam line	
6	Drive	Motorized	

6.8. Specification of HP Dosing System:

S.No	Description	Value
1	Major Parts	Storage Tank – 1 No., Stirrer – 1 No., Dosing Pumps – 2 Nos.
Storage Tank Details		
1	Size of Storage Tank	600 mm x 500 mm
2	Tank Capacity	150 liters
3	MOC of Tank	SS
4	MOC of Chemical Basket	SS 304
Dosing Pump Details		
1	Pump Capacity	6 LPH
2	Pump Type	Reciprocating Plunger Type
Stirrer Details		
1	Type of Operation	Motorised

6.9. Specification of LP Dosing System (Common for WHRS & AFBC Boilers):

S.No	Description	Value
1	Major Parts	Storage Tank – 1 No., Stirrer – 1 No., Dosing Pumps – 2 Nos.
Storage Tank Details		
1	Size of Storage Tank	600 mm x 500 mm
2	Tank Capacity	150 liters
3	MOC of Tank	SS
4	MOC of Chemical Basket	SS 304
Dosing Pump Details		
1	Pump Capacity	6 LPH
2	Pump Type	Reciprocating Plunger Type
Stirrer Details		
1	Type of Operation	Motorized

6.10. **Steam Drum specification:**

S.No	Description	Value
1	Design code	IBR 1950 with its latest amendments
2	Design pressure	75 kg/cm² g
3	Design temperature	317 °C
4	Hydrotest pressure	112.5 kg/cm² g
5	Length	7000 mm
6	Inner diameter	1200 mm
7	Thickness	As per IBR
8	Material of construction	SA 516 Gr 70
9	Quantity per boiler	1 no.
10	Corrosion allowance	As per IBR
11	Internals	Demister pad
12	Quantity of safety valves	2 nos.
13	Drum S.V.1 Set Pressure	72.5 kg/cm² g
14	Drum S.V.2 Set Pressure	73.5 kg/cm² g

6.11. **Specifications of Blow down tank (2 Nos):**

S.No	Description	Value
1	Design code	IBR
2	Tank height	1000 mm
3	Tank OD	960 mm
4	Shell thickness	10mm
5	Type of ends	Dished
6	Material of construction	SA 516 Gr 70

6.12. **Deaerator cum Storage Tank:**

1.	Design Code	As per IBR 1950 with Latest Amendments & Good Engineering Practice
2.	Outside Diameter	1500mm
3.	Length of shell (tan to tan)	5000 mm
4.	Thickness of shell	12 mm
5.	Type of dish end	2: 1 Ellipsoidal with straight face
6.	Thickness of dished end	12 mm
7.	Operating pressure	0.1 kg/cm² g
8.	Design Pressure	1.5 kg/cm² g
9.	Operating temperature	126 °C
10.	Design Temperature	150 °C
11	Outlet feed water capacity	23 m3/hr
12	Corrosion allowance	3.2 mm over & above design code requirement
13	Condensate Oxygen content (at DA inlet)	Design = 300 ppb / Normal = 42 ppb
14	Condensate Oxygen content (at DA outlet)	0.005 ml/Ltr (7PPB)
15	Storage capacity	10 m3

6.13. **Specifications of Sample Coolers:**

S.No	Description	
1	Type	Shell & Coil type
2	Sampling Points	Feed water line(Common for Three Boilers), Blow down line, Saturated steam line & Superheated Steam line
3	Material of construction	
	Shell	Carbon Steel
	Coils	Stainless Steel

6.14. ID FAN:

Description	Specification
Flow m3/sec	27
Developed head, mmWC	150
Temperature, °C	180 ± 10
Motor rating, KW	60
Speed, RPM	2900
Quantity	1 no
Type of Fan	Centrifugal
Medium	Ambient
Motor Voltage, V	415
Type of control	Pneumatically generated power cylinder actuated regulating damper control with VFD

6.15. Boiler feed water pumps 2 nos (1 W +1 S):

S.No	Description	Value
	Type	Centrifugal multy stage
1	Design water flow	24 m3 /hr
2	Pressure head	865 mmWC
3	Temperature	126 ºC
4	Speed	2900 RPM
5	Type	Centrifugal, Multi Stage

Notes:

All the measurements of feed water shall be made at high-pressure heater outlet or economiser inlet.

1 Morpholine or any other volatile amine may be used to elevate the pH. The concentration of volatile chemical in feed water shall not exceed 1 ppm. (Expressed as ammonia)

2 Sodium sulphite shall be dosed in the feed water, after the tapping point for desuperheater spray so that it does not get contaminated.

3 The phosphate and pH shall be maintained in accordance with coordinated phosphate pH curve, to prevent the presence of free hydroxide in boiler water.

4 If the feed water is used for desuperheating spray, for all pressures

4.1 Hardness shall be nil.

4.2 SiO2 shall not exceed 0.02 ppm.

4.3 Conductivity at 25 deg C measured after cation exchanger in H+ form after CO2 removal not to exceed 2 micromho / cm.

5 Total alkalinity in boiler water shall not exceed 20% TDS.

6 Presence of oil or organic matter is not allowed in feed water which will induce foaminess and cause carry over of impurities in to steam.

7 The phosphate and pH are recommended in accordance with coordinated phosphate curve to prevent presence of free hydroxide in boiler water. If the recommended pH is consistently obtained phosphate residual can be maintained near lower limits.

14.0 LIST OF PRINCIPAL VENDORS FOR BOUGHT OUT COMPONENTS:

PRESSURE PARTS ENDOR LIST:

- Plates (Boiler quality) : SAIL / Imported
- Tubes & Pipes (Boiler quality) : MSL / JINDAL / Imported

INSTRUMENT VENDOR LIST:

A. Air Filter Regulator:

- Shavo Norgen (India) Pvt Ltd, Placka, Veljan, SMC Pnematic

B. Flow Nozzle / Orifice:

- AV&UE(Orifice), Star Mech, JN Marshall, Hydro Pneumatics, GIC, Eureka Industrial Equipment ltd

C. Instrumentation & Ext. Cables:

- Finolex, Finecab

D. I/P Converters:

- Watson Smith (Mtl), H&B / Rosemount, Moore, Anirudh Engineers, Forbes Marshall, Fischer, ABB, MIL, Imported

E. Level Gauges & Level Switches:

- Levcon instruments Pvt Ltd, Protolona Instruments, Yarway, Hitech, Becon pvt. Ltd (Solatron Make), Chemtrol (level switch), Pune Techtrol, Imported

F. Pressure, DP, Flow & Level Transmitter:

- ABB, Emerson, Yokogawa, Fuji, Rosemount, Siemens, H&B, Imported

G. Pressure & Temperature Gauges:

- General Instruments Co., Radix Electro Systems, H.Guru, Pyro electric, Wika, Waaree instruments, Forbes Marshall, Radix Micro Systems

H. Pressure Switch & Temperature Switches:

- Indfoss, Switzer, AN Instruments

I. RTD and Thermocouples:

- Tempsen, Radix Electro Systems, Pyroelectric, GIC, Nutech Engineers, Detriv, Thermal instruments, Waree

J. PLC:

- Allen Bradely, LSS, Schneider Electric, Siemens, Tata Honeywell, ABB, GE Fanuc, Rockwell automation

K. EWLI:

- Level State, Radix Electro Systems, Yarway, Solatron

L. O2 Flue Gas Analyser (In Situ Tpe):

- Ametek, Chemtrol, Enotech, ABB Kent, Land Combustion, Emerson, Forbes marshall, YBL

M. Flue Gas Analyser

- Codel, Chemtrol, Ametek, ABB Kent, Land CCombustion, Emerson, Forbes marshall, YBL

N. VFD:

- ABB, Siemens, GE, Allan Bradley, L&T, Dan Foss, Schneider, Eurotham Automation, Vacon, Fuji Electric-VFD

O. Desuperheater / PRDS:

- Forbes marshall, Yarway, Fisher Sanmar, AV&UE (De-Super heater), Mazda, JN Marshall, Dewrence, Chemtrols

P. Single Loop Controller:

- Bells Controls, Siemens ltd, Tat Honeywell Ltd, Yokogawa Blue Star ltd

Q. SWAS:

- AV&UE, Forbes Marshal, Swan, Rosemount, Chemtrol, Yokogawa, VJ Engineering, ABB

<u>ELECTRICAL VENDOR LIST:</u>

A. Motor Control Centers:

- AV&UE, Seimens, L& T

B. Motors –LT

- Kirloskar, BHEL, Siemens, BNGEF, Bharat Bijlee, ABB, Rotomotive, Alstom

C. Power Control Cables:

- Cable Corporation of India, Polycab, UCI, NICCO, Fort Closter, TCL

D. Transducers:

- BABB, Siemens, AE, Alstom, Minilee

E. LT Switch Gear Components:

- Siemens, L&T, ABB, Alstom , LG -LS

F. CTs & PTs:

- Precise, Kappa, Indcoil, Alstom, Areva

G. Push Button Station:

- GEPC, Standard Gold, Technic, Vaishnov

H. Selector Switches:

- Kavcee, SCI, GEPC

I. Digital Meters:

- Enercon, Neptune, HPL, IMP

J. Protection Relays:

- Alstom, LG - LS

K. Auxiliary Relays:

- Alstom, LG – LS, Siemens

L. Cable Trays & Accessories:

- APT Engineering, Premier, Jamuna metals, Globe

M. Air Circuit Breaker / MCCB:

- Seimens, L&T, GE power, Schneider Electric

N. Analog Meters:

- AE, Rishabh

O. Motor Protection Relays:

- Alstom, LG -LS

P. Contractor:

- Siemen, L&T, GE power, Schneider Electric, BCH, Telmechanique, LG -LS

Q. Ac Switches:

- Seimens, L&T, GE power, Schneider Electric, LG -LS

R. DC Switches:

- Kaycee

S. VFD panels:

- ASEA Brown Boveri Limited, Danfoss industries Private Limited, Eurotherm Del India Limited, L&T, Siemens L:imited, TB Wood,s India PCT Limited, Amtech, HI Rel, AV&UE

T. Junction boxes:

- AV&UE, SAI-BEE , Mithsagar, Baliga

MECHANICAL VENDOR LIST:

A. Feed Water Pumps:

- KSB, Sulzer, Kirlosker

B. Insulation:

i. Mineral Wool insulation:

- Llyod Rock Fibres, Rock Wool Industries, Orient, Mine wool , Thermo wool

ii. Aluminium Caldding:

- Balco, Indal, Hindlaco, Anish Metals, Alluminium India

iii. Refractory & insulation Bricks:

- ACC, Dalmia Refractory, Tata Refractories, Pacific Refractories, Castwell

C. Fans & Accessiroes:

- Air Flow, Ritz, CB Doctor, imported

D. Chemical Dosing System:

- AV&UE, Metapow, Positive Metering Systems

E. **Pipe work, Valves & Fittings:**

i. **Safety valves:**

- TYCO Sanmar, MH Valves, Fainger & Lesser, Diaton China, BHEL, Mazda

ii. **Blow down valves:**

- Levcon, BHEL, Fluid Line, Diaton China, MH Valves

iii. **Control Valves:**

- MIL, Fisher Xomox, Imported, Mascot Valves, Samson Controls

iv. **Solenoid Valves:**

- Rotex, ASCO

v. **Manual Valves**

- BHEL, KSB, Alsa, Prime, Fluidline, Daiton

F. **Paints:**

- Asian paints , Berger paints India Limited

Annexure-IV

Financial Schemes

The various schemes from Ministry of Micro Small and Medium Enterprises (MSME), Government of Orissa and Small Industrial Development Bank of India (SIDBI) are available to Install SMEs, install or upgrade Energy Efficient technologies and marketing. These schemes are availed and implemented through the District Industries Center (DIC), Commissioner of Industries and District Collector and Financial Institutions. The unit's holders are taken the benefits of various schemes from time to time. The details of different financial schemes are

1 .Small Industrial Bank of India (SIDBI)

SIDBI was established in 1990 as a Principal Development Financial Institution for Promotion, Financing, Development of Industries in the small scale sector and for coordinating the functions of other institutions engaged in similar activities. SIDBI has many products and schemes which can be fine tuned to meet the requirements of SMEs. List of some of such products & schemes is as follows.

a. Technology up gradation Fund:

TUFS has been launched with a view to sustaining as well as improving the competitiveness and overall long term viability of the SSI sector. The scheme intends to provide timely and adequate capital at internationally comparable rates of interest in order to upgrade the industry's technology level.

b. Marketing Support for SMEs:

To finance corporate entities to enable them to provide support services and/or infrastructural facilities to small scale sector to improve its marketing capabilities

c. Direct Credit Scheme:

To finance SSIs & Service sector units with project cost upto Rs.25 crore, Medium Sector Enterprises (MSE) and Service sector units with project cost above Rs.25 crore and upto Rs.250 crore.

d. Bills Financing Scheme:

Bills Finance Scheme seeks to provide finance, to manufacturers of indigenous machinery, capital equipment, components sub-assemblies etc.

e. Refinancing Scheme:

SIDBI grants refinance against term loans granted by the eligible PLIs to industrial concerns for setting up industrial projects in the small scale sector as also for their expansion / modernization / diversification.

f. Scheme for Development of Industrial Infrastructure:

The Scheme purpose is to strengthening of existing industrial clusters / estates by providing increased amenities for smooth working of the industrial units. The scheme is to avail setting up of warehousing facilities for SSI products / units and Providing support services viz., common utility centers such as convention halls, trade centers, raw material depots, warehousing, tool rooms / testing centers, housing for industrial workers, etc.

On the basis of experiences of above mentioned schemes it is advisable to devise and implement schemes of similar characteristics through SIDBI for the sustainable development of SMEs.

2 Ministry of Small and Medium Enterprises (MSME)

Ministry of Small and Medium Enterprises (MSME), Government of India implementing various schemes for promote the SME sector towards its growth. The following schemes are available for implementation of Energy Efficient Technologies in SMEs.

a. **Technology Up gradation:** Government of India will provide financial support to the extent of 25% of the project cost for implementation of Energy Efficient Technologies (EET), as per the approved DPR. The maximum amount of assistance will be Rs. 10 Lakh. About 390 units will be supported for implementing EETs in MSMEs.

b. **Quality Up gradation:** Under this activity, MSME manufacturing units will be provided subsidy to the extent of 75% of actual expenditure, towards licensing of product to National/International Standards. The maximum assistance allowed per MSME is Rs. 1.5 Lakh (Average Rs. 0.75 Lakh) for obtaining product licensing/marking to national standards and Rs. 2 Lakh (Average Rs. 1.50 Lakh) for obtaining product licensing/marking to international standards. One MSME unit can apply only once under the scheme. Total 3000 product certification on national standards and 1000 on international standards are proposed to be reimbursed under the scheme. This scheme will include the star rating certification by BEE. All the applications for the star rating will be reimbursed the application processing fees directly to the entrepreneur after the successfully certification from BEE.

3 Government of Orissa

Government of Orissa providing SSI Certificate and Subsidy through the District Industries Center (DIC) to promote industrial activity in the district. The DIC will issue the SSI to the Industries based on the capacity. It has schemes and other related activities for the SSI unit's i.e. marketing assistance etc., to promote the self-employment schemes with assistance from the local banks.