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Energy audit report
of
M/s Fluid Metals (India) Pvt. Ltd., Belgaum

Prepared for

Bureau of Energy Efficiency

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The Energy and Resources Institute

...towards global sustainable development

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It is well worthy to mention that the efforts being taken and the enthusiasm shown by all the plant personnel towards energy conservation and sustainable growth was really admirable. We found all the personnel keen to implement the possible energy conservation aspects.

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The Energy and Resources Institute (TERI)
New Delhi

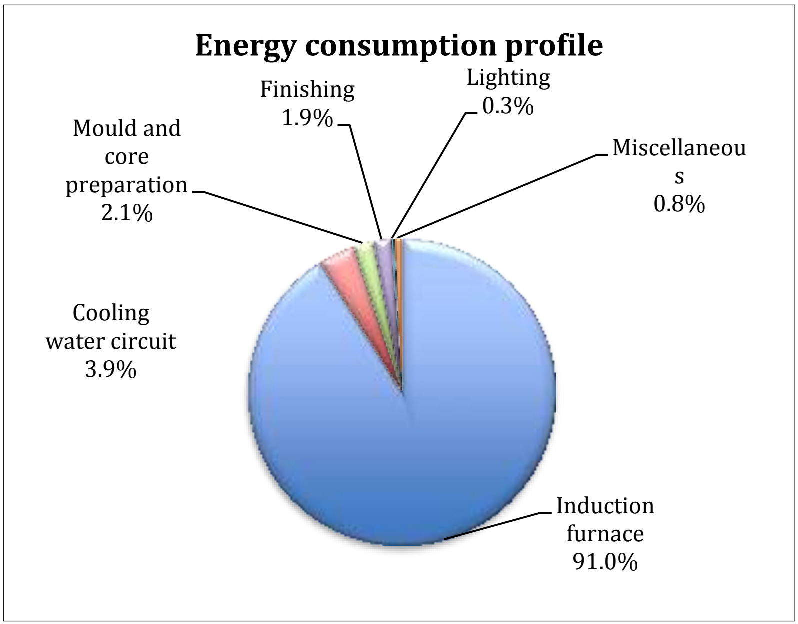
Executive summary

A detailed energy audit at M/s Fluid Metals (India) Pvt. Ltd. was conducted to identify the potential of energy savings. This report provides details of energy audit such as areas covered under the study, performance assessment of different equipment, potential areas for energy saving and estimated energy and cost savings along with investment required and payback periods. It provides insights to the plant for proper planning of investments on energy conservation recommendations.

Brief Introduction of the foundry unit

Name of the Unit	M/s Fluid Metals (India) Pvt Ltd
No. of years in operation	06
Factory address	S.No. 58/1 Navage Jamboti Road, Navage Belgaum – 590 018
Type of industry	Ductile iron and graded Cast Iron castings
Products Manufactured	Gears, Machine tools
Hours of operation per day	12
Number of days of operation per year	300
Energy used	Electricity

A detailed performance study was undertaken in the identified areas with the use of the sophisticated handheld instruments. Energy consumption pattern and production data were collected to estimate the specific energy consumption of the unit. The unit level baseline of the unit was also estimated using the historical data. The total energy consumption of the unit during FY 2014 – 15 was 81.8 toe (951,000 kWh) which is equivalent to 65.2 lakh rupees. The total CO_2 emission during this period is estimated to be 932 tonnes. Electricity was considered for CO_2 emission estimation.



The main source of the energy consumption in the plant is electricity used in induction melting furnace and to drive the process equipment and other auxiliaries, various utilities.

The unit manufactures ductile iron and graded CI castings which include gears and machine tools and supplies to various industries. The unit uses green sand and CO_2 sand moulding process. The total liquid melting production of the unit during 2014 – 15 was 1,451 tonnes and dispatched production was 921 tonnes. The plant has an installed capacity of 250 tonnes per month. With respect to production in financial year 2014 – 15 the capacity utilization factor for the unit is 48%. The net yield of unit is around 62%.

The energy consumption in the plant is mainly for following: induction furnace, cooling water circuit, mould and core preparation, finishing, lighting and miscellaneous. A pie chart depicting share of each area/section is given in figure.

Summary of energy conservation measures identified in unit

Key recommendations made in this energy audit report are summarised below.

S. No	Energy conservation measures	Annual energy savings Electricity (kWh)	Investment (Rs Lakh)	Savings Rs lakh/ year	Simple payback year
1	Power factor improvement	1,855	0.69	0.87	0.8
2	Lid mechanism for induction furnace	13,959	2.00	0.85	2.4
3	Remodeling layout of foundry to reduce poring distance	19,440	1.50	1.18	1.3
4	Reduction in rejection by improvement of process response study	23,020	2.50	1.40	1.8
5	Replacement of coil cooling pump of induction furnace	6,856	0.55	0.42	1.3
6	Replacement of raw water pump of induction furnace	3,553	0.55	0.22	2.5
7	Installation of timer for shot blast machine	1,305	0.05	0.08	0.6
8	Replacement of motor of sand muller in cupola section	798	0.19	0.05	3.9
9	Replacement of existing lighting system with energy efficient lighting system	2,354	0.76	0.14	5.3
	Overall	**73,141**	**8.8**	**5.21**	**1.7**

Total nine energy conservation measures are identified. Implementing then would attract a one-time investment of Rs 8.8 lakh; it would lead to annual savings of Rs 5.21 lakh. This would result in reduction in energy consumption by 7.7%. The specific energy consumption of entire foundry would improve from 1,033 kWh per tonne to 953 kWh per tonne.

1.0 Production and energy consumption

1.1 Introduction

M/s Fluid Metals (India) Pvt. Ltd is a steel casting unit set up in 2009. The unit manufactures ductile iron and graded CI castings which include gears and machine tools and supplies to various Industries. The unit has an installed capacity of 250 tonnes per month. Brief summary of unit is given in table 1.1.

Table 1.1: Brief description of unit

Name of the Unit	M/s Fluid Metals (India) Pvt Ltd
No. of years in operation	06
Factory address	S.No. 58/1 Navage Jamboti Road, Navage Belgaum – 590 018
Type of industry	Ductile iron and graded Cast Iron castings
Products Manufactured	Gears, Machine tools
Hours of operation per day	12
Number of days of operation per year	300
Energy used	Electricity

1.2 Process flow diagram

The major steps of process are mould sand preparation, charge preparation followed by melting, pouring, knockout and finishing. The uses green sand moulding and CO_2 moulding process. The process flow diagram is shows in figure 1.2.

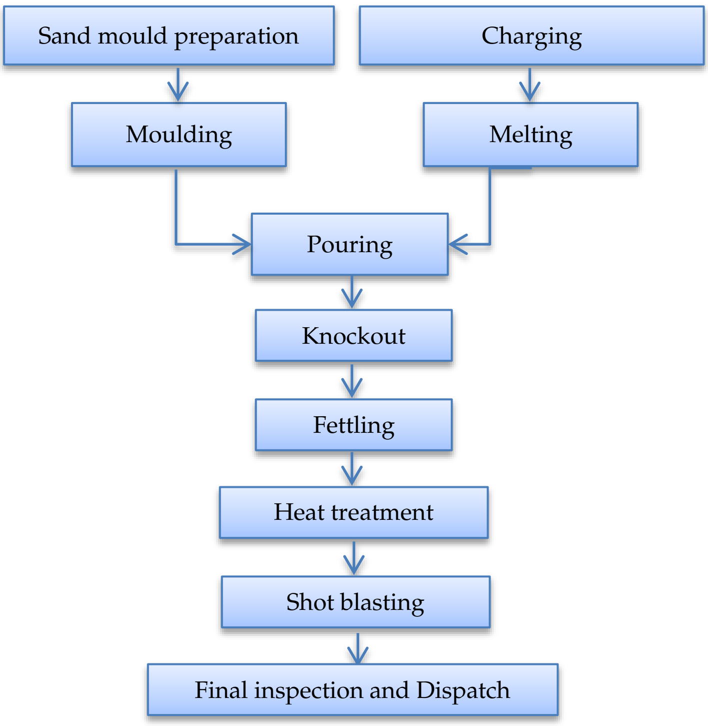


Figure 1.2: Process flow chart

1.3 Production and energy cost

The energy and production data for available period was taken from the unit for the analysis. The total liquid melting production of the unit during 2014–15 was 1,451 tonnes and dispatched production was 921 tonnes. The overall energy cost incurred for this production was 65.23 lakh rupees. Figure 1.3 refers the monthly production and energy cost profile of the unit.

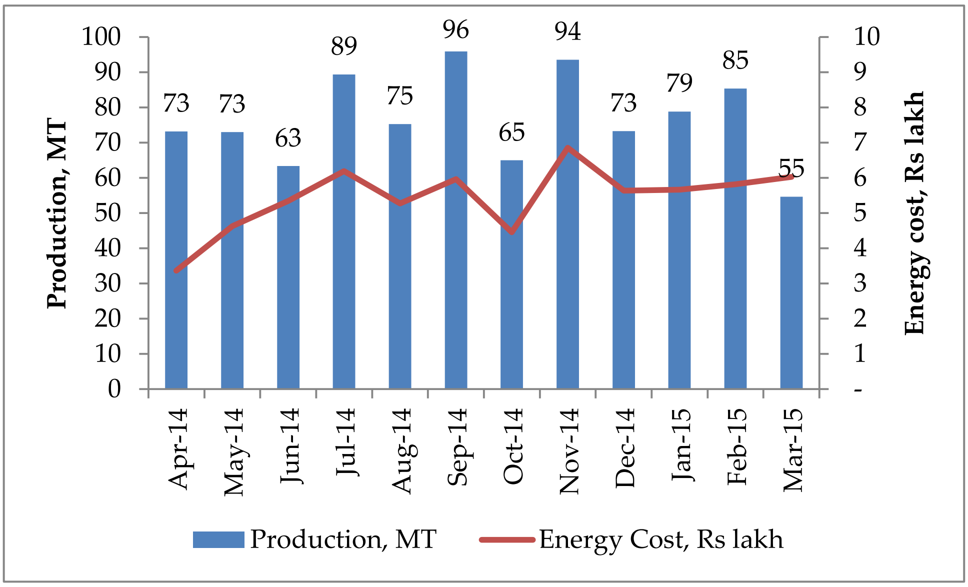


Figure 1.3: Production and energy cost profile

1.4 Energy sources availability and tariff details

Availability of listed energy types as above and their respective tariffs are given in table 1.4.

Table 1.4: Energy sources, availability and tariffs

S No	Energy source	Availability	Tariff details
1	Electricity	Supplied by HESCOM	Tariff category: HT-2(a) Voltage of supply: 11 kV Demand charges: Rs 170/kVA Energy charges: Rs 5.7/kWh (up-to 100,000 units) Rs 6.0/kWh (beyond 100,000 units) Time of day charges: 2200-0600: Rs -1.25/kWh 0600-1800: Rs 0.00/kWh 1800-2200: Rs +1.00/kWh PF penalty charges: For every 0.01 drop below 0.90, penalty Rs 0.03/kWh

1.5 Energy consumption

The total energy consumption of the unit during FY 2014 – 15 was 81.8 toe (951,000 kWh) which is equivalent to 65.2 lakh rupees. The total CO_2 emission during this period is estimated to be 932 tonnes. Electricity was considered for CO_2 emission estimation.

1.6 Performance indicators

1.6.1 Capacity utilization

The unit has an installed capacity of 250 MT per month. The actual monthly average melting is 120.9 MT. Thus, the capacity utilization (CU) of plant is 48%. The CU varies between 42 – 58%. The maximum CU was achieved in month of November in 2014 and minimum was in month of April in 2014. The CU is low due to lack of orders, thus the plant operates 12 hours per day only.

1.6.2 Net yield

The raw material consumption of foundry is around 125 tonnes per month and net casting sold is 76.7 tonnes per month. The net yield of foundry is 61.8%. The distribution of melting loss with spillage, runner and risers, rejection and net yield of foundry is given in figure 1.6.2.

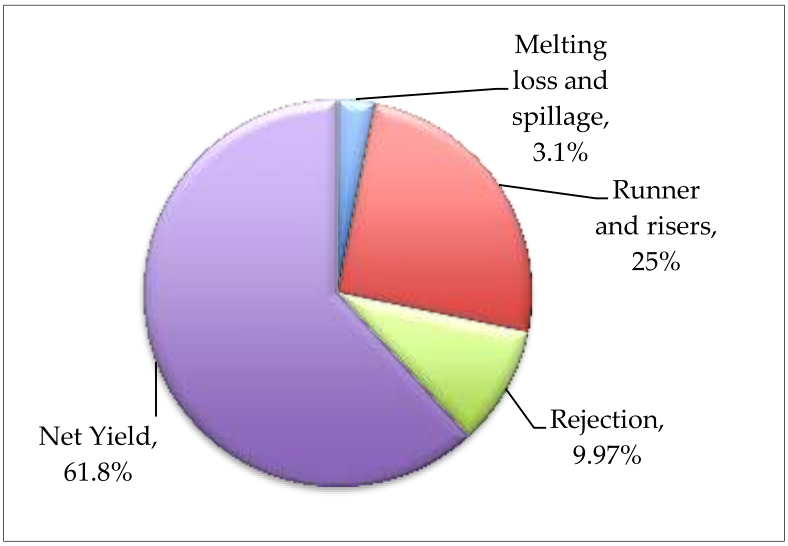


Figure 1.6.2: Net yield of foundry

1.6.3 Specific energy consumption

The average specific energy consumption (SEC) of the plant for the year FY 2014 – 15 was estimated based on the monthly consumption of electricity and monthly production. The overall SEC is estimated to be 1,033 kWh per metric tonne of production. The SEC for induction furnace for melting is estimated to be 642 kWh per tonne of melting.

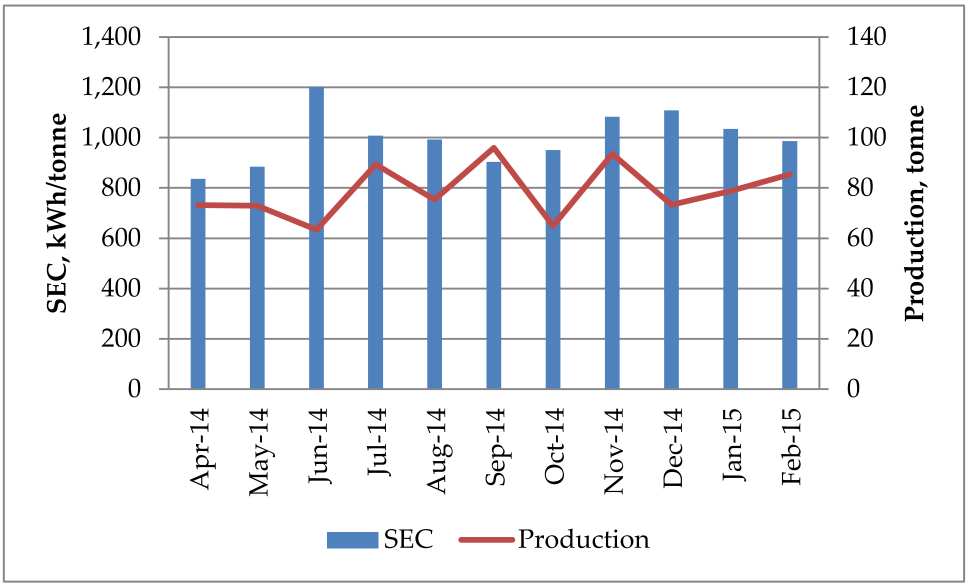


Figure 1.6.3: SEC and production profile

2.0 Electrical systems

2.1 Facility description

2.1.1 General

The main source of electricity for M/s Fluid Metals (India) Pvt Ltd is from Hubli Electricity Supply Company Ltd (HESCOM) at 11 kV grid supply. The 11 kV Main Receiving Station (MRS) is located within the plant premises. The power supplied at 11 kV is step down to 433 V (for auxiliary transformer of 250 kVA) and 575 V (for induction transformer of 500 kVA) and is fed to the respective power distribution board (PDB) and light distribution board (LDB) at 415 V and 575 V through the LT switchgear located at main substation. Table 2.1.1 shows the design specifications and no-load and full-load losses of installed transformer.

Table 2.1.1: Technical specifications of transformer

Parameters	Transformer-1	Transformer-2
Rating (KVA)	500	250
Application	for Induction furnace	for Auxiliary
Type	ONAN	ONAN
Primary Voltage (V)	11,000	11,000
Primary Current (Amps)	26.25	13.12
Secondary Voltage (Volts)	575	433
Secondary Current (A)	666.7	333.33
Rated No Load Loss (kW)	1.1	0.6
Rated load loss (kW)	6.4	3.6

The rate of power failure in Belgaum, Karnataka is insignificant. However to cater the necessary power requirements during power outages, the plant installed diesel generators.

To maintain the power factor near to unity, plant has provided the power factor correction system at main incomer at power control centre (PCC) level.

2.1.2 Electricity consumption data

The power supply to the facility is from HESCOM grid under the tariff category HT-2(a), with 450 kVA contract demand. The minimum billing demand is 338 kVA (75% of the contract demand). The detail of electricity consumption is given in the table 2.1.2.

Table 2.1.2: Monthly electricity consumption details

Month & Year	Electricity consumption (kWh)	Contact demand (kVA)	Power factor	Billed demand (kVA)	Demand charges (Rs)	Energy charges (Rs)	P.F. rebate/ penalty (Rs)	Monthly electricity bill (Rs)
Apr-14	61215	450	0.920	409	69530	327,500	-	336,936
May-14	64555	450	0.900	418	71060	367,964	-	462,840
Jun-14	76100	450	0.895	419	71230	433,770	-	534,147
Jul-14	90010	450	0.900	426	72420	513,057	-	619,453
Aug-14	74730	450	0.906	425	72250	425,961	-	527,778
Sep-14	86650	450	0.908	412	70040	493,905	-	596,218

Month & Year	Electricity consumption (kWh)	Contact demand (kVA)	Power factor	Billed demand (kVA)	Demand charges (Rs)	Energy charges (Rs)	P.F. rebate/ penalty (Rs)	Monthly electricity bill (Rs)
Oct-14	61730	450	0.897	410	69700	351,861	-	445,750
Nov-14	101375	450	0.907	415	70550	578,250	-	685,575
Dec-14	81230	450	0.91	408	69360	463,011	-	563,690
Jan-15	81605	450	0.906	415	70550	465,149	-	566,516
Feb-15	84190	450	0.909	413	70210	479,883	-	581,516
Mar-15	87610	450	0.911	414	70380	499,377	-	602,721
Average	**79250**	**450**	**0.906**	**415**	**70607**	**449974**	**0**	**543595**
2014-15	951000				847280	5399687	-	6523140

Important parameters only are presented in above table, details such as time of day tariff, electricity duty and others are not presented. Figure 2.1.2 presents the contract demand, billed demand and the energy consumed for the year FY 2014 – 15.

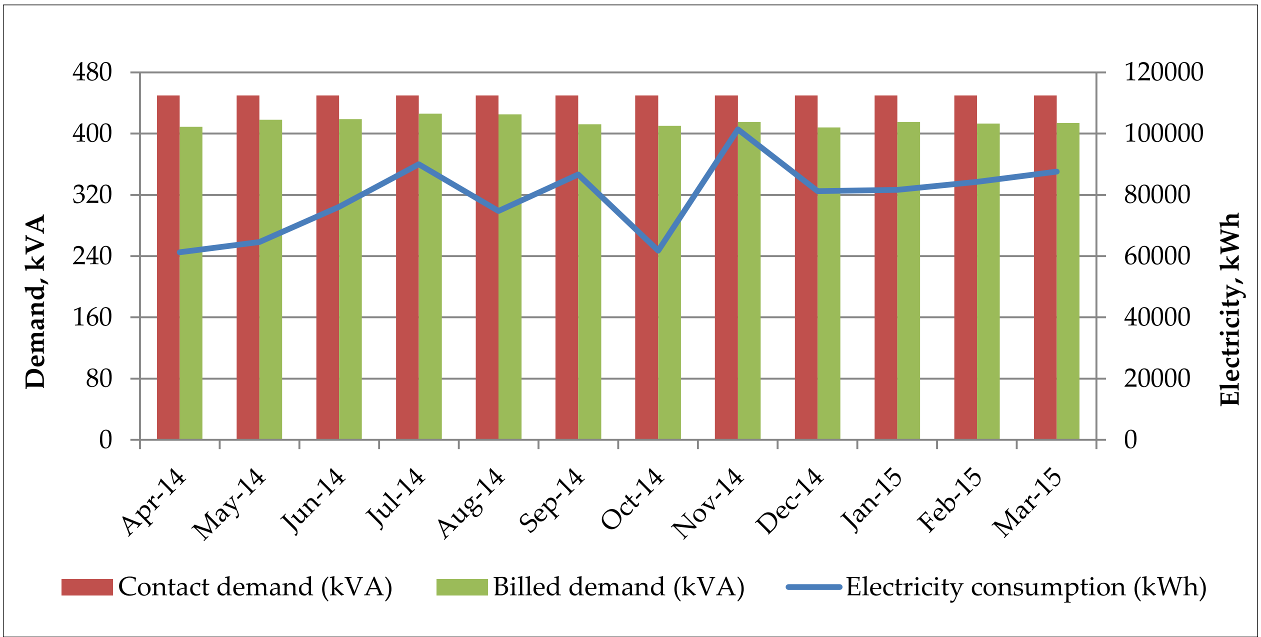


Figure 2.1.2: Demand and energy consumption pattern

As observed from above figure, plant has registered a maximum recorded demand of 426 kVA in the month of July 2014 whereas the minimum recorded demand of 408 kVA in the month of December 2014. The average recorded demand for the period was 415 kVA and it is 92% of the contract demand. The average electricity consumption of the plant from HESCOM grid was about 79,250 kWh per month.

2.2 Observation and analysis

2.2.1 Electrical power measurement

Electrical power data logging was carried out on the main power incomer at LT feeder panel using three-phase power quality analyser extensively. All electrical parameters have been recorded for identification and analysis of demand and power factor management of the plant. The operating power parameters of distribution transformer at LT side were measured evaluate the operational efficiency pattern. Some necessary data has been taken from the plant services department logbook for historical pattern better analysis.

2.2.2 Main system parameters

The electrical and power parameters of 500 kVA transformer are summarises in table 2.2.2.

Table 2.2.2: Summary of electrical and power parameters at main incomer

	Transformer 500kVA		
Parameters	**Minimum**	**Average**	**Maximum**
Voltage, Volt	526	552	581
Current, Amp	38	371	409
Active Power (kW)	4.9	328	352
Apparent Power (kVA)	39.6	355	377
Power Factor, pf	0.104	0.897	0.939
% THD (Voltage)	3.6	12.2	14.6
% THD (Current)	21.6	26.6	28.3

Observation:

- The load at auxiliary transformer is variable while for transformer-1 load is almost constant as it is connected to induction furnace.
- The average demand is found to be about 64 kVA and 304 kVA for transformer-1 and 2 respectively during the measurement period however; the demand is fluctuating due to instantaneous loads of the utility system.
- The total harmonic distortion in voltage and Current at main power incomer level is exceeding the permissible limit for transformer-2 and this may be due to induction melting furnace operation and this could be avoided by installation of harmonic filters.

2.2.3 Transformer

Plant is stepping down the electricity board power using the step down transformer of capacity 500 kVA and 250 kVA. Summary of the loading pattern and respective operation efficiency of the transformer is given in table 2.2.3a.

Table 2.2.3a: Summary of the operational efficiency of transformer-1 and transformer-2

			Calculated parameters	
Transformer	**Load Conditions**	**Rated capacity, kVA**	% Loading	% Efficiency
Transformer-1 500 kVA	Maximum		82.3	98.6
	Minimum	500	6.9	76.1
	Average		60.8	98.8
Transformer-2 250 kVA	Maximum		31.3	98.5
	Minimum	250	5.5	94.4
	Average		25.2	98.4

The average operational loading of transformer-1 and 2 is 60.8 % and 25.5 % respectively whereas the best efficiency point is 41.5% and 40.8 % for transformer-1 and 2 respectively for given losses characteristics.

2.2.4 Power factor management

Plant has provided the power factor correction system at main incomer BUS at LT side as well as at PCC. The power factor pattern at main incomer and its variation with demand was analysed to understand the effect of the capacitor bank during the load changeability conditions. Power factor studied from past 12 months electricity bills and the measured power factor at furnace transformer is given in figure 2.2.4a and 2.2.4b.

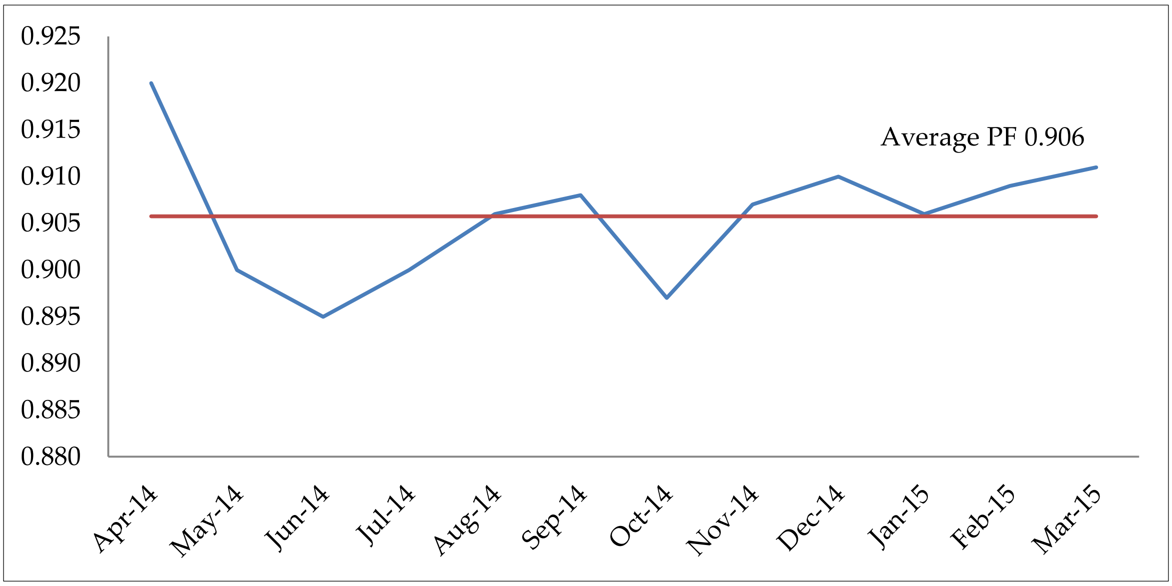


Figure 2.2.4a: Power factor variation during the year 2014-15

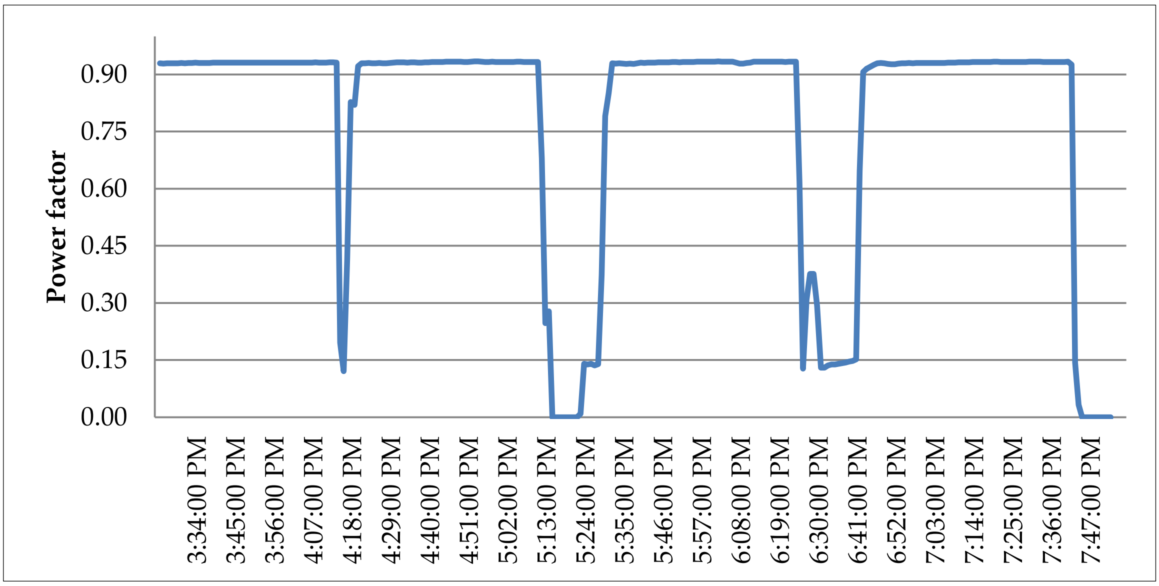


Figure 2.2.4b: Power factor at main incomer of unit for furnace transformer

It has been observed that the average power factor of the plant at main incomer is around 0.897 during measurement and average for past one year is 0.906. It also has been observed that the power factor correction system required capacity augmentation to maintain the power factor unity.

2.2.5 Load factor of plant

The average monthly electricity consumption of plant is 79,250 kWh. The plant operates for 12 hours daily. The peak demand of plant is 415 kVA at power factor of 0.906 lag. This corresponds to a load factor of 70.2%. The high load factor is due to continuous running of induction furnace during operation period.

2.3 Energy conservation measures

2.3.1 Improving power factor and demand reduction

The average power factor recorded in foundry was 0.906. The average billed demand is 415 kVA and average maximum load is 376 kW. The power can be still improved near to unity by connecting capacitor bank. The power factor is quite low at the unit is at verge of paying penalty.

It was recommended to install capacitor bank of 140 kVAr capacity. Poor power factor does not only increase the penalty in billing but also increases demand charges and distribution losses. The estimated annual energy savings by improving power factor is 1,855 kWh equivalents to a monetary saving of Rs 0.87 lakh. The investment requirement is Rs 0.69 lakh with a simple payback period of 0.8 year.

A detailed cost benefit analysis is been given in Table 2.3.1.

Table 2.3.1: Cost benefit analysis

Actual Parameters	Unit	Value
Existing power factor	pf	0.906
Proposed power factor	pf	0.995
Reduction in demand	kVA	37
Capacitor bank requirement	kVAr	138
Savings Estimation	**Unit**	**Value**
Annual energy saving due to	kWh	1,855
distribution loss reduction	toe/year	0.16
Energy cost saving	Rs lakh/year	0.11
Demand cost saving	Rs lakh/year	0.76
Monetary saving	Rs lakh/year	0.87
Investment cost for capacitor bank	Rs lakh	0.69
Simple payback period	years	0.8
CO_2 emission avoided	tCO_2/year	1.8

2.4 General recommendations

It was observed that current and voltage harmonics are crossing limits. In Karnataka as of now there is no penalty on harmonics but other states do have penalty. In future Karnataka may also introduce penalty on harmonics. The plant may consider installing harmonics filters. Table 2.4 gives details of harmonics. Harmonics from logged data is shown in figure 2.4a and 2.4b.

Table 2.4: Details of harmonics

Parameters	Permissible limit	Measure value
% THD Voltage	5.0%	6.2%
% THD Current	8.0%	21.1%
V 5th harmonics	3.0%	4.1%
V 7th harmonics	3.0%	5.3%

Figure 2.4a: Current harmonics

Figure 2.4b: Voltage harmonics

3.0 Furnace

3.1 Facility description

The plant is equipped with one induction melting furnace of rating 350 kW and it has a crucible of capacity 500 kg. The design parameters of the induction melting furnace are presented in Table 3.1.

Table 3.1: Induction melting furnace design parameters

Parameters/equipment ID	Furnace
Equipment	Induction furnace
Type/Year	SCR
Make/Type	Fluxo/SCR
Voltage/Frequency, V/Hz	575/600
Rating, kW	350
Crucible capacity, kg	500
Operating Temperature (°C)	1455 (CI) 1535 (SGI)
Mode of operation (batch/continuous)	Batch
Batch duration (minute)	67

3.2 Observation and analysis

The study was conducted on 500 kg crucible and four sample heats (batches) were studied to arrive at specific energy consumption of induction furnace. The details of observation are given in table 3.2. The power curves for the batches studied are shown in figure 3.2. Detailed furnace logging is given in annexure 3.2.

Table 3.2: Observation and measurement of induction furnace

Type of Casting	Unit	SGI	CI
Raw material charge	kg	512.0	519.0
Units consumed	kWh	318.4	339.0
Cycle time (melting + pouring)	min	73.0	63.0
Specific Energy Consumption	kWh/MT	653	622
Tapping temperature	C	1,535	1,485

- There was no lid cover on furnace crucible, thus leading to radiation and convection losses, around 4% of input energy
- Currently the furnace is operating in one shift (10-12 hours depending on demand) and is left for natural cooling at end of day, leading to bigger crakes in refractory lining and reducing lining life
- It was recommended to use a fan for forced cooling of crucible, this not only increase lining life but also reduce the hours of coil cooling requirement after furnace is switched off
- The rejection level was near to 10%, thus leading to a huge quantity of casting being re-melted

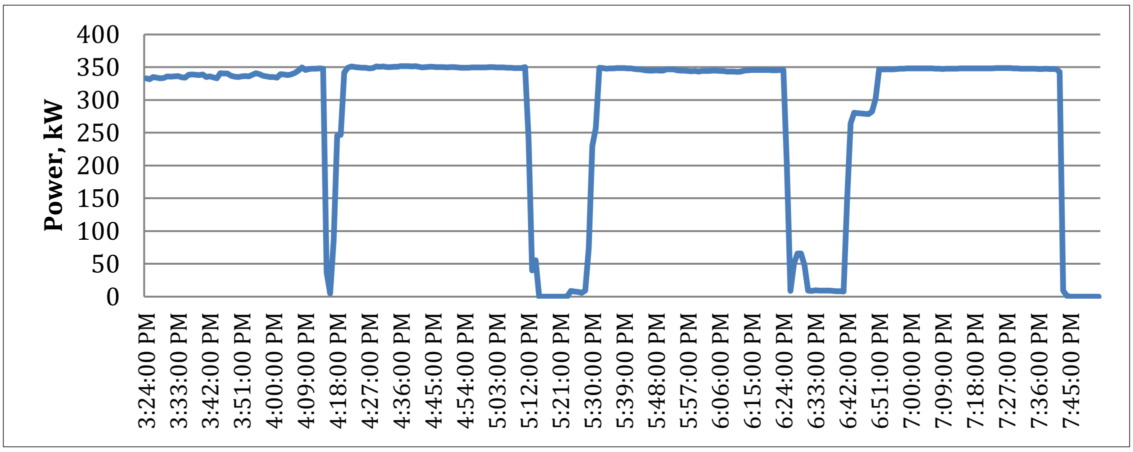


Figure 3.2: Power curve of induction furnace

3.3 Energy conservation measures

Based on the above analysis, identified energy efficiency measures in furnace are discussed in the following paragraphs.

3.3.1 Installation of lid mechanism for induction furnace

The operational parameters of the induction furnace including the electricity consumption and material charged were measured during the detailed energy audit and analysis of the past one year data. The specific energy consumption of the induction furnace was calculated to be 622 kWh and 653 kWh per metric tonne of melting for CI and SGI melting respectively. It was found that the opening of induction furnace is circular with 408 mm diameter. The opening heat losses for one batch (heat) were calculated to be 20-27 kWh per heat. The heat loss is due to radiation and convection loss.

It is recommended to install a hydraulically operated lid mechanism for induction furnace to avoid opening losses. It was estimated that around five units per heat can be saved.

Table 3.3.1: Installation of Lid mechanism for induction furnace

Particulars	Unit	Value
CI heats per day	heats	4
SGI heats per day	heats	5
Saving potential in CI/SGI heat	kWh/heat	5.02/5.36
Operational days per year	days	300
Annual saving potential	kWh/year	13,959
Energy cost per unit	Rs/kWh	6.08
Monetary saving	Rs lakh/year	0.85
Investment	Rs lakh	2.0
Simple payback period	years	2.4
CO_2 emission avoided	tCO_2/year	13.7

The estimated annual energy savings by using lid mechanism is 13,959 kWh equivalents to a monetary savings of Rs 0.85 lakh. The investment requirement is Rs 2.0 lakh with a simple payback period of 2.4 year. The annual reduction in CO_2 emission is estimated to be 13.7 tCO_2.

3.3.2 Remodelling layout of foundry to reduce poring distance

The unit has a cupola and an induction furnace for melting, but currently cupola is not in use. The moulding areas for cupola and induction furnace are different. The moulding section of cupola is quite far from induction furnace. Due lack of space, the pouring of four heats of induction furnace is done in cupola moulding area every-day. The loss due to drop in temperature of molten metal from furnace to cupola section is quite substantial.

It is requested to remodel the layout and shift the finishing section (which is near induction furnace) to far end and use the space for moulding. This will not only reduce the power consumption but also save time hence improving energy efficiency and production efficiency.

Table 3.3.2: Remodelling layout of foundry to reduce poring distance

Particulars	Unit	Value
SEC for CI melting when poured induction section	kWh/HEAT	317
SEC for CI melting when poured in cupola section	kWh/HEAT	335
Number of heats poured in cupola section daily	heats/day	4
Loss of energy	kWh/year	21,600
Energy saving potential	kWh/year	19,440
	toe/year	1.67
Monetary saving	Rs lakh/year	1.2
Investment in civil works	Rs lakh	1.5
Simple payback period	years	1.3
CO_2 emission avoided	tCO_2/year	19.1

The estimated annual energy savings by remodelling the layout is 19,440 kWh equivalents to a monetary savings of Rs 1.2 lakh. The investment requirement is Rs 1.5 lakh with a simple payback period of 1.3 year. The annual reduction in CO_2 emission is estimated to be 19.1 tCO_2.

3.3.3 Reduction in rejection by improvement of process response study

The produces SGI and graded CI castings. The in-house rejection in plant is 5.91% and the customer end rejection is 4.06%. Overall reject adding to 9.97%. This is very high number. It simple means of 1,451 tonnes of liquid metal 145.8 tonnes are to be re-melted and it would require around 93,620 kWh of electricity to achieve that. With careful process response study for rejection, it can be brought down to 7.5%. The improvement will increase the net yield of foundry from 61.8% to 64.3%.

Response study to reduce rejection is a step-by-step process.

- The unit has to identify all the reasons for rejection
- Quantify number of occurrences of each type of defect
- Arrange all defect in descending order based on number of occurrences
- Address rejection from first in list, this is reduction rejection fast

Consider an example, there are six defect causes identified by a unit, the frequency is counted. Now pareto chart is plotted, as shown in figure 3.3.3. It can be clearly seen that shrink is causing major number of defect, thus it should be addressed first.

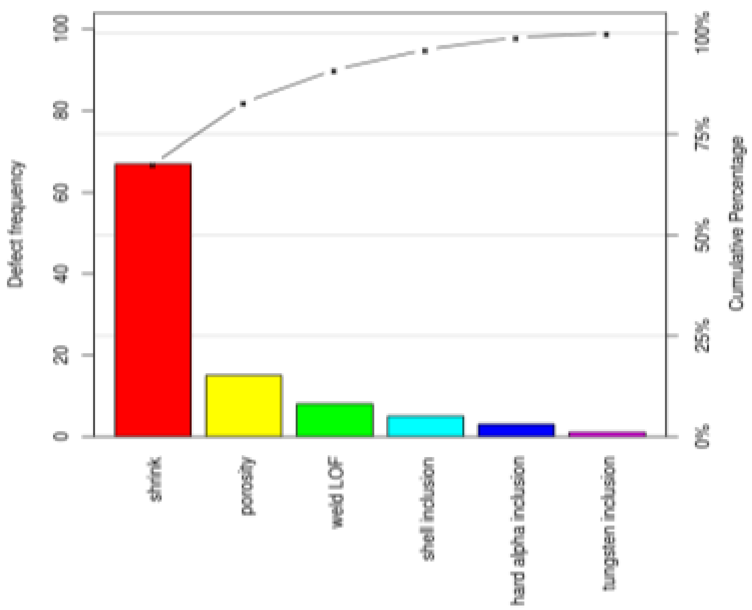


Figure 3.3.3: Pareto chart for rejection study: An example

Table 3.3.3: Reduction in rejection by improvement of process response study

Process response study	Unit	Value
Current Rejection percentage	%	10.0%
Total melting	MT/year	1,451.3
Proposed improved rejection	%	7.5%
New Rejection	MT/year	108.8
Energy saving	kWh/year	23,020
Monetary saving	Rs lakh/year	1.4
Investment	Rs lakh	2.5
Simple Payback Period	year	1.8
CO_2 emission avoided	tCO_2/year	22.6

The estimated annual energy savings by process response study to reduce rejection is 23,020 kWh equivalents to a monetary savings of Rs 1.4 lakh. The investment requirement is Rs 2.5 lakh with a simple payback period of 1.8 year. The annual reduction in CO_2 emission is estimated to be 22.6 tCO_2.

4.0 Pumping system and cooling towers

4.1 Facility description

Pumping systems and cooling towers were installed in the plant, mainly for supplying cooling water to induction furnace. The furnace panel has one DM water pump for its cooling. Soft water is circulated for coil cooling using another pump. The soft water and DM water is cooling using heat exchanger, where raw water flows in secondary circuit. The rated parameters of the pumps have been given in table 4.1a.

Table 4.1a: Rated parameters of the pumps taken up for study

Design parameters	Unit	DM pump furnace Panel	Coil cooling pump	Raw water pump
Make		Ajay	Ajay	Ajay
Type		Mono-Block	Mono-Block	Mono-Block
Flow rate	m^3/ hour	12.0	14.4	24.6
Head	m	20	40	30
Motor Power	kW	2.2	5.5	3.7
Overall Efficiency	%	40%	34%	54%

The plant is equipped with one cooling tower (CT) to cater to the cooling water requirements of the induction furnace. The rated parameters of the cooling towers have been given in table 4.1b.

Table 4.1b: Rated parameters of the cooling tower taken up for study

Parameters	CT
Type	Induced draft
Make/year	NA
Purpose	Coil water cooling in induction melting furnace
Capacity (lpm)	410
Pump power (kW)	3.6
Fan power (kW)	0.75
Operating hours per day	12
Other Location of placement	Roof mounted

4.2 Observation and analysis

4.2.1 Pumps

The operating parameters and efficiency estimation is given in table 4.2.1.

Table 4.2.1: Estimation of efficiency of pump associated with induction furnace

Actual parameters	Unit	DM pump furnace Panel	Coil cooling pump	Raw water pump
Flow rate	m^3/hour	10.0	10.8	19.5
Suction Pressure	kg/cm^2			
Discharge Pressure	kg/cm^2	2.0	4.0	3.0

Actual parameters	Unit	DM pump furnace Panel	Coil cooling pump	Raw water pump
Differential Head	m	20	40	30
Power	kW	1.40	4.50	4.35
Overall efficiency	%	38.8%	26.2%	36.6%

4.2.2 Cooling towers in the plant

The fins of cooling tower were chocked, thus leading to drift loss of water from fan opening on top. The effectiveness of cooling tower has dropped due to this. It is recommended to clean the fins and replace them if not in good condition. The operating parameters and the performance of the cooling tower are shown in table 4.2.2.

Table 4.2.2: Estimation of operating parameters and performance of cooling towers

Measured Parameters	Unit	Value
Water flow rate	m^3/hour	19.5
Ambient temperature	°C	29.6
RH	%	56.9
T inlet	°C	34.5
T outlet	°C	30.9
Calculations	**Unit**	
DBT	°C	29.6
WBT	°C	22.9
Approach	°C	8.0
Range	°C	3.6
Heat removed to atmosphere	kCal/hour	70,200
	TR	23.21
Effectiveness	%	31
Fan power	kW	0.21

4.3 Energy conservation measures

There is a scope of considerable energy savings in the pumps and cooling tower area, as this is clear from the performance assessment that some of the pumps installed are of poor efficiency.

4.3.1 Replacement of existing coil cooling pump with energy efficient pump

The power consumption of furnace coil cooling pump was measured to be 4.5 kW. The water flow rate was measured to be 10.8 m^3/hr which is lower than the design flow of 14.4 m^3/hr. The overall efficiency of the pump is calculated to be 26% which is lower than design efficiency (34%).

The performance of an induction furnace is directly linked with the performance of its cooling water circuit. Therefore, it is recommended to replace the existing furnace coil cooling pump with an energy efficient pump. Details of pump are given in annexure 4.3.

Table 4.3.1: Replacement of existing coil cooling pump with energy efficient pumps

Recommended Pump Specification	Units	Coil cooling pump for Furnace
Flow rate	m^3/hour	14.4
Differential Head	m	40.0
Efficiency	%	51.1%
Power proposed pump	kW	3.07
Power saving	kW	1.43
Operating period	hour	4,800
Annual Energy saving	kWh/year	6,856
Cost saving		
Annual Monetary Saving	Rs lakh / year	0.42
Investment	Rs lakh	0.55
Simple Payback Period	years	1.3
CO_2 emission avoided	tCO_2/year	6.7

The estimated annual energy savings in coil cooling pump is 6,856 kWh equivalents to a monetary saving of Rs 0.42 lakh. The investment requirement is Rs 0.55 lakh with a simple payback period of 1.3 years. The annual reduction in CO_2 emission is estimated to be 6.7 tCO_2.

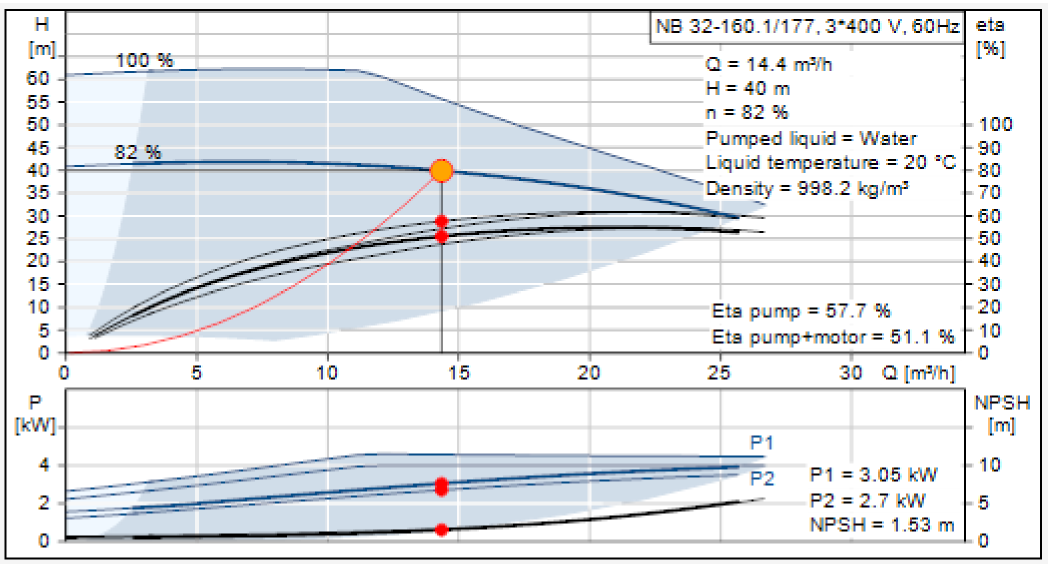


Figure 4.3.1: Proposed coil cooling pump

4.3.2 Replacement of existing raw water pump with energy efficient pump

The power consumption of raw water pump was measured to be 4.35 kW which is higher than its rating (3.7 kW). The water flow rate was measured to be 19.5 m^3/hr which is lower than the design flow of 24.6 m^3/hr. The overall efficiency of the pump is calculated to be 37% which is lower than design efficiency (54%).

The performance of an induction furnace is directly linked with the performance of its cooling water circuit. Therefore, it is recommended to replace the existing raw water pump with an energy efficient pump. Details of pump are given in annexure 4.3

Table 4.3.2: Replacement of existing raw water pump with energy efficient pumps

Recommended Pump Specification	Units	Raw water pump
Flow rate	m^3/hour	24.6
Differential Head	m	30.0
Efficiency	%	59.8
Power proposed pump	kW	3.36
Power saving	kW	0.99
Operating period	hour	3,600
Annual Energy saving	kWh/year	3,553
	toe/year	0.31
Cost saving		
Energy cost per unit	Rs / kWh	6.08
Annual Monetary Saving	Rs lakh / year	0.22
Investment	Rs lakh	0.55
Simple Payback Period	years	2.5
CO_2 emission avoided	tCO_2/year	3.5

The estimated annual energy savings in raw water pump is 3,553 kWh equivalents to a monetary saving of Rs 0.22 lakh. The investment requirement is Rs 0.55 lakh with a simple payback period of 2.5 years. The annual reduction in CO_2 emission is estimated to be 3.5 tCO_2.

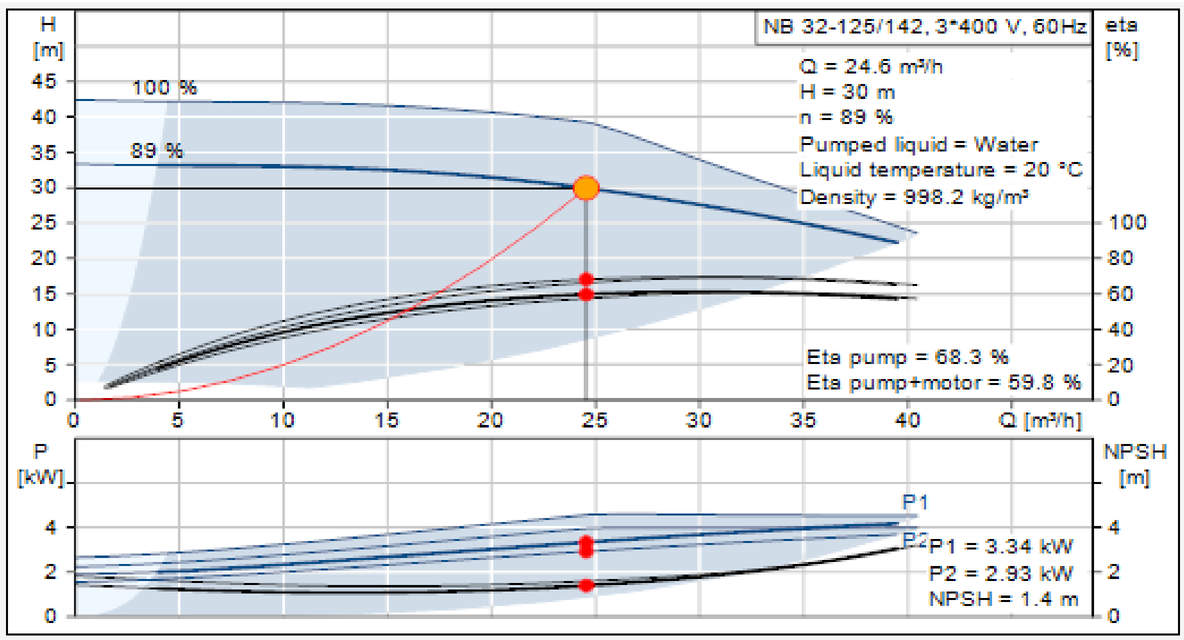


Figure 4.3.2: Proposed raw water pump

5.0 Motors

5.1 Facility description

The energy audit of electrical motors associated with utility and process equipment was carried out to assess the performance and identify potential for energy savings. The study included motors installed in the utility (water pumping, utilities, shot blasting, fettling) process machinery and other associated systems. The study focussed broadly on the following aspects with a view to assess the performance of motors:

- Loading of motors
- Nature of load (fixed or variable)

The details of measurements and observation on each of these three aspects are detailed in the following sections.

5.2 Observations and analysis

Different sections of the plant include pumping and sand handling. The operating parameters of motors were measured using portable instruments to observe load profile and power consumption. The range of motor loadings in different sections was evaluated. To evaluate the operating performance of motors and study the loading pattern, load tests were carried out for about 15 electrical motors in the plant covering utility and process areas.

5.2.1 On -load motor test

The operational loading of the electrical motors is calculated using the measured electrical parameters from the unit. The details are given in table 5.2.1.

Table 5.2.1: Motor power parameter and loading

Motor Description	Motor Rating		Motor Operating Parameters										% Loading
	Rated power (kW)	Efficiency (%)	V	V_{thd} (%)	A	A_{thd} (%)	kW	kVA	PF	kVAr	Hz		
Sand muller Cupola section	5.5	86.0%	409	6.1	6.6	8	4.5	4.7	0.96	1.2	50.2		70%
Sand siever cupola section	0.75	83.0%	409	7.1	0.68	6.2	0.3	0.48	0.58	0.39	50.2		31%
Sand mixer cupola section	7.5	86.0%	408	5.8	9.6	6.4	4.8	6.8	0.71	4.7	50.2		55%
Sand muller induction section	5.5	86.0%	412	4.7	7.7	1.4	4.4	5.5	0.79	3.4	50.2		69%
Sand mixer induction section	7.5	86.0%	409	5.6	8.8	10.6	5	6.2	0.8	3.6	50.2		57%
Lumps reducer motor 1	5.5	87.0%	409	4.9	6.9	7.3	3.4	4.9	0.69	3.5	50.1		54%
Lumps reducer motor 2	5.5	87.0%	408	5.1	6.7	7.8	3.4	4.8	0.72	3.4	50.1		54%
Knock-out	3.7	86.0%	408	5.2	3.9	6.8	1.9	2.8	0.7	2	50.1		44%

Motor Description	Motor Rating						Motor Operating Parameters					%
Shot blast Turbine motor	11.2	87.0%	405	7.2	11.4	9.1	5.8	8	0.72	5.4	50.2	45%
Shot blast Bucket Elevator motor	0.75	83.0%	405	6.1	1.4	7	0.5	0.95	0.47	0.83	50.2	50%
Shot blast Dust collector motor	3.7	85.0%	407	6.3	4.1	13.4	2.1	2.9	0.68	2.1	50.2	48%

The performances of the all-operating motors were assessed to understand the operational loading. The loading of the major motors was found under the normal performance range.

5.3 Energy conservation measures

There is a scope of considerable energy savings in the motors, this section details on it.

5.3.1 Installation of timer for shot blast machine

The plant has installed a table type shot blast machine of 48" to meet shot blasting needs. The machine operates in batch mode and each cycle is of five minutes. The timer in shot blast is not operating and the operator switch off the machine based on judgement and most of time they end up over shooting the time limit.

It is recommended to install a new timer for the shot blast machine. The machine operates for seven hours in a day. It has been estimated that its operation can be brought down by as much as half hour after installing timer.

Table 5.3.1: Installation of timer for shot blast machine

Particular	Unit	Value
Shot blast average power consumption	kW	8.7
Operating hours per day	hour/day	7
Operating hours with timer	hour/day	6.5
Annual energy saving	kWh/year	1,305
Monetary saving	Rs lakh/year	0.08
Investment	Rs lakh	0.05
Simple Payback Period	year	0.6
CO_2 emission avoided	tCO_2/year	1.3

The estimated annual energy savings in timer for shot blast machine is 1,305 kWh equivalents to a monetary saving of Rs 0.08 lakh. The investment requirement is Rs 0.05 lakh with a simple payback period of 0.6 years. The annual reduction in CO_2 emission is estimated to be 1.3 tCO_2.

5.3.2 Replacement of motor of sand muller in cupola section

The plant has installed two sand mullers and two sand mixers to meet its process sand needs. One of each are installed in cupola section and induction furnace section. The motor of sand muller in cupola section is re-winded and its power consumption is higher.

It is recommended to replace the motor of sand muller in cupola section with new energy efficiency motor.

Table 5.3.2: Replacement of motor of sand muller in cupola section

Particular	Unit	Value
Drive rating	kW	5.5
Measured power	kW	4.5
Full load efficiency	%	75
Operating loss old	kW	1.1
Proposed motor	kW	5.5
Operating efficiency	%	89.5
Operating loss new	kW	0.5
Reduction in losses	kW	0.7
Operating hours	hour/year	1,200
Annual energy saving	kWh/year	798
	toe/year	0.07
Monetary saving	Rs lakh/year	0
Investment	Rs lakh	0.2
Simple payback period	year	3.9
CO_2 emission avoided	tCO_2/year	0.8

The estimated annual energy savings in sand muller motor is 798 kWh equivalents to a monetary saving of Rs 0.07 lakh. The investment requirement is Rs 0.19 lakh with a simple payback period of 3.9 years. The annual reduction in CO_2 emission is estimated to be 0.8 tCO_2.

5.4 General observations and recommendations

- The under loaded condition of motors in the plant are mainly because of its operating pattern.
- Inspecting motors regularly for wear in bearings and housings (to reduce frictional losses) and for dirt/dust in motor ventilating ducts (to ensure proper heat dissipation).
- Checking load conditions to ensure that the motor is not over or under loaded. A change in motor load from the last test indicates a change in the driven load, the cause of which should be understood.
- Lubricating appropriately. Manufacturers generally give recommendations for how and when to lubricate their motors. Inadequate lubrication can cause problems, as noted above. Over lubrication can also create problems, e.g. excess oil or grease from the motor bearings can enter the motor and saturate the motor insulation, causing premature failure or creating a fire risk.
- Checking periodically for proper alignment of the motor and the driven equipment. Improper alignment can cause shafts and bearings to wear quickly, resulting in damage to both the motor and the driven equipment.
- Ensuring that supply wiring and terminal box are properly sized and installed. Inspect regularly the connections at the motor and starter to be sure that they are clean and tight.
- Ambient conditions can also have a detrimental effect on motor performance. For example, excessively high temperatures, high dust loading, corrosive atmosphere, and humidity can impair insulation properties; mechanical stresses due to load cycling can

lead to misalignment. However, with adequate care, motor performance can be maintained.

- Rewinding can affect a number of factors that contribute to deteriorated motor efficiency.

6.0 Lighting system

6.1 Facility description

The total connected lighting load of the plant, as per the inventory collected during the detailed assessment study, was estimated to be 2.7 kW (including ballast losses). The different types of lamps operating in the plant are Fluorescent Tube Light (T-12), Mercury Vapour. Table 6.1 gives the type of lamps used in different areas of the plant.

Table 6.1: Details of the lighting system

S. No	Location in the plant	Type of lamps & ballast	No. of lamps	Rated wattage, watt (including ballast)	Connected load, kW	Average operating hours
1	Office and Plant	FTL T12	6	52	0.3	10
2	Plant	HPMV	9	265	2.4	5

6.2 Energy conservation measures

6.2.1 Replacement of existing lighting system with energy efficient lighting system in phase manner

The foundry is using mixed lighting, including FTL T12 and HPMV. Fluorescent tube lights of 52W FTLs with conventional copper ballasts consume more energy. About six such lamp fittings were found in different locations of the unit. It is proposed to replace all 52W copper ballast FTLs with T5 tube light.

Also, it is observed that foundry uses mercury vapour lamp for lighting in shop floor. Nine numbers of such fixtures of 250 W are currently being used. The lumens per watt of HPMV lamp are low and also the life is short. It is recommended to replace existing HPMV lamps by induction lamps. Total nine lamps are to be replaced with 120 W induction lamps.

Table 6.2.1: Replacement of existing lighting system with energy efficient lighting system

Parameters	Unit	Existing	Proposed
Type of lamp		T-12/HPMV	T-5/Induction lamp
Wattage of lamp	Watts	52/265	30/120
Working days per year	Days/year	300	300
Existing power consumption	kWh/year	4,514	2,160
Savings in electricity consumption	kWh/year		2,354
Monetary benefits	Rs lakh/year		0.14
Total investment cost	Rs lakh		0.76
Simple payback period	Years		5.3
CO_2 emission avoided	tCO_2/year		2.3

The envisaged annual energy saving potential in lighting is 2,354 kWh per year equivalent to a monetary saving of Rs 0.14 lakh per year. The investment requirement is Rs 0.76 lakh with a simple payback period of 5.3 years. The annual reduction in CO_2 emission is estimated to be 2.3 tCO_2.

7.0 Summary of potential savings

7.1 Summary of recommendations

The proposed energy conservation measures (ECMs) for various facilities of Fluid Metals (India) is categorized as no investment, short term investment and medium term investment based recommendations as per the following criteria:

- The energy savings measures, which are having immediate returns, are considered to be no investment recommendations.
- The energy saving measures, which are having a simple payback period of less than a year, are considered to be short term measures.
- The energy saving measures, which are having a simple payback period of 1 to 2 year, are considered to be medium term measures.
- The energy saving measures, which are having a simple payback period greater than 2 years, are considered to be long term measures.

The number of energy conservation measures under the above categories as given table 7.1:

Table 7.1: Categorization of energy conservation measures

Sr. No	Type of recommendation	No of ECMs	Energy cost saving potential (Rs lakh)	Investment required (Rs lakh)	Simple payback (years)
1	No investment based	0	-	-	-
2	Short term return based (< 1 year)	2	0.95	0.74	0.8
3	Medium term return based (1-2 year)	3	3.00	4.55	1.5
4	Long term return based (> 2 year)	4	1.26	3.50	2.8
	Total	**9**	**5.21**	**8.79**	**1.7**

7.2 Recommended energy conservation measures

The recommended measures considered for energy audit report after discussion with unit representative is given in table 7.2

Table 7.2: Recommended energy conservation measures for implementation

S. No	Energy conservation measures	Annual energy savings	Investment	Savings	Simple payback
		Electricity (kWh)	(Rs Lakh)	Rs lakh/ year	year
1	Power factor improvement	1,855	0.69	0.87	0.8
2	Lid mechanism for induction furnace	13,959	2.00	0.85	2.4
3	Remodeling layout of foundry to reduce poring distance	19,440	1.50	1.18	1.3
4	Reduction in rejection by improvement of process response study	23,020	2.50	1.40	1.8
5	Replacement of coil cooling pump of induction furnace	6,856	0.55	0.42	1.3

S. No	Energy conservation measures	Annual energy savings	Investment	Savings	Simple payback
6	Replacement of raw water pump of induction furnace	3,553	0.55	0.22	2.5
7	Installation of timer for shot blast machine	1,305	0.05	0.08	0.6
8	Replacement of motor of sand muller in cupola section	798	0.19	0.05	3.9
9	Replacement of existing lighting system with energy efficient lighting system	2,354	0.76	0.14	5.3
	Overall	**73,141**	**8.8**	**5.21**	**1.7**

Total nine energy conservation measures are identified. Implementing then would attract a one-time investment of Rs 8.8 lakh; it would lead to annual savings of Rs 5.21 lakh. This would result in reduction in energy consumption by 7.7%. The specific energy consumption of entire foundry would improve from 1,033 kWh per tonne to 953 kWh per tonne.

7.3 Lifetime energy and CO_2 savings

Implementation of the energy conservation measures in the unit may result in reduction in CO_2 emissions due to reduction in overall energy consumption. The estimated reduction in GHG emission by implementation of the recommended energy conservation measures is 71.7 tonne of CO_2 per year. The life time CO_2 emission reduction in estimated to be 1,075 tonne. The lifetime energy and CO_2 saving are given in table 7.3

Table 7.3: Lifetime CO_2 savings

S. No	Energy Conservation Measures	Life time energy saving (toe)	Life time CO_2 reduction (tonne)
1	Power factor improvement	2.39	27.27
2	Lid mechanism for induction furnace	18.01	205.20
3	Remodeling layout of foundry to reduce poring distance	25.08	285.77
4	Reduction in rejection by improvement of process response study	29.70	338.40
5	Replacement of coil cooling pump of induction furnace	8.84	100.79
6	Replacement of raw water pump of induction furnace	4.58	52.23
7	Installation of timer for shot blast machine	1.68	19.18
8	Replacement of motor of sand muller in cupola section	1.03	11.73
9	Replacement of existing lighting system with energy efficient lighting system	3.04	34.60
	Overall	**94.4**	**1,075**

7.4 Renewable energy recommendation

The use of renewable energy technologies is not techno-economically feasible for melting, which is the most energy-intensive area in foundry application. Moreover, some of these technologies are not fully commercially mature and hence was not recommended for implementation.

Annexures

Annexure: 3.2 Logging of induction furnace

Date	Time	Voltage (Line)			Current (Line)			kW	kVA	PF Line1		
		L1	L2	L3	L1	L2	L3	Sum	Sum	L1	L2	L3
5/13/2015	4:16:00 PM	568.3	571.3	567.5	38.1	40.1	42.1	4.79	39.56	0.106	0.152	0.104
5/13/2015	4:17:00 PM	561.3	564.5	559.8	158.4	155.9	163.8	85.26	154.46	0.397	0.430	0.418
5/13/2015	4:18:00 PM	555.7	561.0	553.9	311.5	296.6	314.8	245.90	296.76	0.813	0.823	0.847
5/13/2015	4:19:00 PM	555.4	560.5	553.4	315.7	301.2	318.7	246.54	300.62	0.805	0.815	0.839
5/13/2015	4:20:00 PM	557.7	561.6	554.5	375.3	375.2	397.7	341.76	369.95	0.909	0.926	0.929
5/13/2015	4:21:00 PM	554.8	558.7	551.4	381.3	382.6	406.4	349.01	375.07	0.917	0.936	0.936
5/13/2015	4:22:00 PM	558.5	562.5	554.5	380.6	382.4	406.2	350.87	377.09	0.917	0.936	0.936
5/13/2015	4:23:00 PM	556.0	559.9	551.9	382.2	381.5	408.2	349.96	376.22	0.916	0.936	0.938
5/13/2015	4:24:00 PM	555.7	559.5	551.8	382.4	380.6	408.9	349.73	376.04	0.915	0.936	0.938
5/13/2015	4:25:00 PM	555.0	558.9	551.0	382.3	380.4	408.9	349.21	375.49	0.915	0.936	0.938
5/13/2015	4:26:00 PM	554.8	558.7	551.0	382.4	380.7	408.1	349.08	375.23	0.916	0.936	0.938
5/13/2015	4:27:00 PM	553.8	557.8	550.3	382.2	380.3	407.5	348.19	374.31	0.916	0.935	0.937
5/13/2015	4:28:00 PM	554.7	558.8	551.2	382.2	380.6	407.4	348.87	374.97	0.916	0.935	0.938
5/13/2015	4:29:00 PM	557.6	561.6	554.2	382.7	380.9	407.2	351.07	377.13	0.917	0.935	0.938
5/13/2015	4:30:00 PM	561.5	565.6	558.3	378.9	378.6	402.5	350.74	376.34	0.919	0.936	0.938
5/13/2015	4:31:00 PM	561.4	565.4	558.2	379.4	379.3	402.5	351.13	376.64	0.920	0.937	0.939
5/13/2015	4:32:00 PM	566.1	570.1	562.9	375.1	374.9	397.6	350.08	375.36	0.920	0.937	0.939
5/13/2015	4:33:00 PM	565.5	569.3	562.3	376.1	375.3	398.3	350.20	375.56	0.920	0.936	0.939
5/13/2015	4:34:00 PM	564.1	568.0	561.1	377.3	376.8	399.5	350.54	375.99	0.920	0.936	0.938
5/13/2015	4:35:00 PM	564.3	568.2	561.5	377.1	377.9	398.0	350.48	375.94	0.922	0.936	0.938
5/13/2015	4:36:00 PM	559.7	563.5	556.8	381.2	381.9	403.3	351.61	377.26	0.921	0.936	0.938
5/13/2015	4:37:00 PM	560.4	564.2	557.4	381.0	380.8	403.0	351.55	377.14	0.920	0.936	0.938
5/13/2015	4:38:00 PM	559.5	563.4	556.7	381.3	382.6	403.2	351.68	377.33	0.921	0.936	0.937
5/13/2015	4:39:00 PM	558.2	562.2	555.4	381.7	382.5	404.3	351.31	376.90	0.921	0.937	0.938
5/13/2015	4:40:00 PM	558.5	562.3	555.6	382.1	382.5	404.2	351.63	377.19	0.921	0.936	0.938
5/13/2015	4:41:00 PM	564.2	568.1	561.2	376.9	377.6	398.1	350.57	375.73	0.922	0.937	0.938
5/13/2015	4:42:00 PM	567.6	571.5	564.9	373.7	375.5	393.0	349.72	374.64	0.924	0.937	0.938
5/13/2015	4:43:00 PM	565.4	569.5	562.7	375.4	376.7	395.8	350.16	375.12	0.923	0.937	0.939
5/13/2015	4:44:00 PM	563.2	567.4	560.4	377.2	378.5	398.0	350.54	375.50	0.923	0.937	0.938
5/13/2015	4:45:00 PM	563.5	567.6	560.5	376.7	378.2	397.4	350.35	375.23	0.923	0.938	0.939
5/13/2015	4:46:00 PM	563.8	568.1	560.9	375.9	377.9	395.8	349.95	374.62	0.924	0.938	0.939
5/13/2015	4:47:00 PM	563.6	567.4	560.5	376.9	378.3	396.4	350.18	374.96	0.924	0.938	0.939
5/13/2015	4:48:00 PM	564.6	568.4	561.4	376.1	377.8	395.4	350.12	374.86	0.924	0.938	0.939
5/13/2015	4:49:00 PM	565.1	569.0	562.0	375.4	377.3	394.4	349.81	374.54	0.924	0.938	0.939
5/13/2015	4:50:00 PM	564.7	568.5	561.6	375.8	377.6	395.1	349.91	374.70	0.924	0.937	0.938
5/13/2015	4:51:00 PM	565.3	569.5	562.2	375.3	377.6	394.5	349.91	374.80	0.924	0.937	0.938
5/13/2015	4:52:00 PM	566.8	570.7	563.5	374.4	376.3	393.0	349.74	374.48	0.924	0.938	0.939
5/13/2015	4:53:00 PM	568.9	572.7	565.8	372.6	374.3	390.5	349.26	373.85	0.925	0.938	0.939
5/13/2015	4:54:00 PM	568.9	572.8	565.9	372.6	374.4	390.4	349.26	373.87	0.925	0.938	0.939
5/13/2015	4:55:00 PM	569.3	573.3	566.4	372.2	374.2	390.1	349.22	373.88	0.925	0.938	0.938
5/13/2015	4:56:00 PM	567.8	572.1	564.9	373.1	375.5	391.9	349.51	374.30	0.924	0.937	0.938
5/13/2015	4:57:00 PM	565.8	570.4	563.0	374.3	377.0	394.3	349.83	374.73	0.924	0.937	0.938
5/13/2015	4:58:00 PM	566.2	570.8	563.5	373.9	376.5	394.0	349.76	374.63	0.924	0.938	0.938
5/13/2015	4:59:00 PM	568.2	572.6	565.5	372.5	374.9	391.8	349.39	374.21	0.924	0.937	0.938
5/13/2015	5:00:00 PM	566.8	571.4	564.2	373.7	376.1	393.3	349.72	374.62	0.924	0.937	0.938

Date	Time	Voltage (Line)			Current (Line)			kW	kVA	PF Line1		
5/13/2015	5:01:00 PM	564.8	569.3	562.0	375.7	378.0	395.7	350.25	375.25	0.923	0.937	0.938
5/13/2015	5:02:00 PM	566.9	571.5	564.3	373.6	376.2	393.5	349.88	374.78	0.924	0.937	0.938
5/13/2015	5:03:00 PM	567.7	572.2	565.0	373.4	375.7	392.8	349.83	374.74	0.924	0.937	0.938
5/13/2015	5:04:00 PM	568.2	572.9	565.6	372.9	375.3	392.6	349.80	374.80	0.923	0.937	0.938
5/13/2015	5:05:00 PM	569.9	574.5	567.2	371.4	374.0	391.0	349.51	374.40	0.924	0.938	0.938
5/13/2015	5:06:00 PM	571.5	576.1	568.8	370.1	372.8	389.2	349.20	374.03	0.924	0.938	0.938
5/13/2015	5:07:00 PM	572.0	576.5	569.2	369.8	372.3	389.1	349.14	374.01	0.924	0.937	0.938
5/13/2015	5:08:00 PM	573.6	577.9	570.7	368.7	371.0	387.4	348.85	373.67	0.924	0.937	0.938
5/13/2015	5:09:00 PM	574.2	578.6	571.4	368.0	370.6	386.6	348.68	373.45	0.924	0.937	0.938
5/13/2015	5:10:00 PM	573.1	577.7	570.4	368.8	371.2	387.8	348.86	373.67	0.924	0.937	0.938
5/13/2015	5:11:00 PM	568.2	572.5	565.4	373.6	375.2	393.5	349.95	375.15	0.923	0.937	0.938
5/13/2015	5:12:00 PM	572.2	576.1	569.8	277.0	278.8	291.8	239.63	278.58	0.667	0.691	0.681
5/13/2015	5:13:00 PM	578.7	581.3	577.0	115.0	115.9	120.8	40.00	116.91	0.228	0.268	0.245
5/13/2015	5:14:00 PM	339.6	341.3	338.2	120.4	119.7	128.9	55.54	119.74	0.265	0.285	0.283
5/13/2015	5:15:00 PM	-	-	-	-	-	9.8	-	-	-	-	-
5/13/2015	5:16:00 PM	-	-	-	-	-	9.9	-	-	-	-	-
5/13/2015	5:17:00 PM	-	-	-	-	-	9.7	-	-	-	-	-
5/13/2015	5:18:00 PM	-	-	-	-	-	9.8	-	-	-	-	-
5/13/2015	5:19:00 PM	-	-	-	-	-	9.8	-	-	-	-	-
5/13/2015	5:20:00 PM	-	-	-	-	-	9.8	-	-	-	-	-
5/13/2015	5:21:00 PM	77.3	134.1	76.9	-	-	9.9	(0.00)	0.67	-	-	-
5/13/2015	5:22:00 PM	357.8	620.1	355.8	-	-	9.8	0.00)	3.10	-	-	-
5/13/2015	5:23:00 PM	393.5	611.8	391.8	4.3	4.5	13.8	0.61	7.63	0.008	0.011	0.008
5/13/2015	5:24:00 PM	602.9	606.4	601.3	57.5	59.5	61.7	8.78	62.34	0.127	0.162	0.131
5/13/2015	5:25:00 PM	597.5	600.8	595.9	52.4	54.4	56.7	7.86	56.53	0.124	0.163	0.128
5/13/2015	5:26:00 PM	594.6	597.7	592.9	49.0	51.0	53.2	7.40	52.69	0.126	0.166	0.128
5/13/2015	5:27:00 PM	588.6	591.8	587.1	41.6	43.4	45.7	6.09	44.56	0.120	0.165	0.123
5/13/2015	5:28:00 PM	585.7	588.9	584.4	56.7	58.4	61.3	9.10	59.70	0.120	0.166	0.131
5/13/2015	5:29:00 PM	576.6	580.1	575.1	160.9	158.8	167.4	74.74	161.84	0.350	0.390	0.380
5/13/2015	5:30:00 PM	568.3	573.2	566.4	297.2	283.3	301.2	229.57	289.88	0.773	0.787	0.811
5/13/2015	5:31:00 PM	569.4	574.9	567.8	308.8	293.9	312.7	257.35	301.66	0.838	0.846	0.870
5/13/2015	5:32:00 PM	570.4	574.6	566.8	371.5	370.0	397.5	348.90	375.31	0.914	0.935	0.938
5/13/2015	5:33:00 PM	571.2	575.6	567.2	370.3	367.9	399.2	348.77	375.25	0.911	0.936	0.939
5/13/2015	5:34:00 PM	575.2	579.6	571.1	366.2	363.8	395.3	347.58	373.83	0.911	0.936	0.940
5/13/2015	5:35:00 PM	573.0	577.8	568.9	369.3	364.6	397.4	348.12	374.53	0.911	0.935	0.940
5/13/2015	5:36:00 PM	570.8	575.5	566.7	370.3	367.9	399.2	348.38	375.07	0.911	0.935	0.938
5/13/2015	5:37:00 PM	569.9	574.5	565.9	371.3	369.0	399.0	348.50	375.10	0.912	0.935	0.938
5/13/2015	5:38:00 PM	568.3	572.9	564.4	373.0	369.9	400.7	348.79	375.46	0.911	0.935	0.938
5/13/2015	5:39:00 PM	569.7	574.3	566.1	371.4	370.1	396.7	348.43	374.69	0.915	0.936	0.938
5/13/2015	5:40:00 PM	569.2	573.9	566.5	371.1	372.9	392.5	348.23	374.00	0.920	0.936	0.936
5/13/2015	5:41:00 PM	569.2	573.9	566.5	370.7	373.0	392.9	348.22	374.08	0.919	0.935	0.936
5/13/2015	5:42:00 PM	572.6	577.4	569.9	367.5	369.8	389.2	347.33	372.97	0.920	0.936	0.936
5/13/2015	5:43:00 PM	575.7	580.4	572.8	364.9	366.6	386.4	346.56	372.08	0.920	0.936	0.937
5/13/2015	5:44:00 PM	576.5	581.3	573.4	364.0	366.3	385.5	346.40	371.85	0.920	0.936	0.937
5/13/2015	5:45:00 PM	581.6	586.4	578.4	359.7	361.9	379.6	345.17	370.18	0.922	0.936	0.938
5/13/2015	5:46:00 PM	584.1	588.8	581.1	357.7	359.8	376.6	344.60	369.46	0.922	0.936	0.938
5/13/2015	5:47:00 PM	584.0	588.6	580.7	357.7	359.3	377.9	344.64	369.52	0.921	0.936	0.938
5/13/2015	5:48:00 PM	580.9	585.4	577.8	359.6	362.7	379.5	345.04	369.92	0.922	0.937	0.937

Date	Time	Voltage (Line)			Current (Line)			kW	kVA	PF Line1		
5/13/2015	5:49:00 PM	581.6	586.4	578.6	359.2	362.8	377.4	344.86	369.64	0.924	0.937	0.937
5/13/2015	5:50:00 PM	581.8	586.4	579.0	359.1	363.7	375.7	344.79	369.50	0.925	0.937	0.936
5/13/2015	5:51:00 PM	573.9	578.5	570.7	365.9	368.2	386.3	346.56	371.64	0.922	0.936	0.938
5/13/2015	5:52:00 PM	573.0	577.8	570.0	366.4	368.7	387.1	346.69	371.71	0.922	0.937	0.938
5/13/2015	5:53:00 PM	574.6	579.4	572.0	365.0	368.3	384.7	346.47	371.48	0.923	0.937	0.937
5/13/2015	5:54:00 PM	580.3	585.1	578.4	360.2	366.6	374.7	345.14	369.78	0.927	0.936	0.935
5/13/2015	5:55:00 PM	582.1	586.9	579.5	358.8	362.2	376.2	344.81	369.34	0.925	0.937	0.937
5/13/2015	5:56:00 PM	581.2	586.1	578.5	359.5	362.5	377.5	344.98	369.51	0.925	0.937	0.938
5/13/2015	5:57:00 PM	582.3	587.4	580.7	358.8	365.8	369.8	344.41	368.79	0.930	0.936	0.934
5/13/2015	5:58:00 PM	583.8	588.6	582.2	357.8	364.8	367.8	344.01	368.30	0.931	0.936	0.934
5/13/2015	5:59:00 PM	586.2	590.6	584.6	355.9	365.8	364.7	344.10	368.37	0.932	0.937	0.932
5/13/2015	6:00:00 PM	585.4	589.8	583.4	356.2	363.6	365.3	343.18	367.33	0.931	0.936	0.934
5/13/2015	6:01:00 PM	584.4	588.9	582.2	357.9	363.4	368.7	344.04	368.35	0.930	0.936	0.935
5/13/2015	6:02:00 PM	583.3	588.1	581.0	358.3	363.0	371.1	344.24	368.52	0.929	0.937	0.936
5/13/2015	6:03:00 PM	583.2	588.0	581.2	358.6	363.3	370.4	344.13	368.47	0.929	0.936	0.935
5/13/2015	6:04:00 PM	582.1	586.7	579.9	359.5	363.7	372.7	344.55	368.91	0.928	0.937	0.936
5/13/2015	6:05:00 PM	581.7	586.4	579.7	360.0	364.5	372.5	344.74	369.10	0.929	0.936	0.936
5/13/2015	6:06:00 PM	584.7	589.2	583.4	357.4	365.7	366.3	344.15	368.51	0.932	0.936	0.933
5/13/2015	6:07:00 PM	586.5	591.6	585.4	360.3	363.0	365.5	344.33	369.60	0.930	0.931	0.932
5/13/2015	6:08:00 PM	587.1	592.5	586.1	362.7	359.4	365.5	343.43	369.64	0.927	0.927	0.932
5/13/2015	6:09:00 PM	587.3	592.6	586.4	362.0	359.5	364.9	343.32	369.39	0.927	0.927	0.932
5/13/2015	6:10:00 PM	587.5	592.7	586.7	361.1	359.5	363.8	343.12	368.82	0.929	0.929	0.932
5/13/2015	6:11:00 PM	586.8	592.0	586.5	359.5	360.5	363.2	342.91	368.08	0.930	0.931	0.933
5/13/2015	6:12:00 PM	582.6	587.5	581.4	357.2	361.7	370.9	343.29	367.46	0.928	0.937	0.936
5/13/2015	6:13:00 PM	582.0	586.8	580.5	359.0	362.0	374.2	344.56	368.78	0.927	0.937	0.937
5/13/2015	6:14:00 PM	580.2	584.9	578.6	361.2	362.5	377.0	345.05	369.45	0.926	0.937	0.938
5/13/2015	6:15:00 PM	578.0	582.7	576.3	363.0	363.9	379.5	345.49	369.95	0.925	0.937	0.939
5/13/2015	6:16:00 PM	576.8	581.5	575.0	363.9	364.8	380.9	345.74	370.25	0.925	0.937	0.939
5/13/2015	6:17:00 PM	576.6	581.4	574.8	364.0	365.0	380.8	345.75	370.22	0.925	0.937	0.939
5/13/2015	6:18:00 PM	577.1	581.6	575.3	364.1	364.4	380.7	345.71	370.21	0.925	0.937	0.939
5/13/2015	6:19:00 PM	576.8	581.4	575.1	364.1	364.5	381.1	345.74	370.23	0.925	0.937	0.939
5/13/2015	6:20:00 PM	576.5	581.0	574.8	364.3	364.7	381.3	345.77	370.23	0.925	0.937	0.939
5/13/2015	6:21:00 PM	580.1	585.4	578.1	360.1	363.5	377.8	345.25	369.71	0.925	0.937	0.937
5/13/2015	6:22:00 PM	579.6	584.9	577.5	360.4	364.3	378.7	345.46	370.00	0.925	0.938	0.937
5/13/2015	6:23:00 PM	577.1	581.1	576.4	365.8	362.8	380.7	345.83	370.41	0.925	0.936	0.939
5/13/2015	6:24:00 PM	576.1	579.0	575.9	368.8	362.2	380.7	345.91	370.39	0.926	0.935	0.940
5/13/2015	6:25:00 PM	581.3	583.4	581.1	250.4	244.9	258.5	197.20	251.93	0.606	0.619	0.622
5/13/2015	6:26:00 PM	591.8	593.2	592.8	66.8	68.8	67.5	8.85	69.56	0.141	0.124	0.116
5/13/2015	6:27:00 PM	585.9	586.9	585.7	142.1	141.9	149.0	50.21	146.29	0.292	0.321	0.311
5/13/2015	6:28:00 PM	583.4	584.1	582.8	170.2	169.3	179.4	65.88	174.86	0.349	0.395	0.384
5/13/2015	6:29:00 PM	584.3	585.3	583.6	169.9	169.2	179.5	65.91	175.04	0.348	0.396	0.384
5/13/2015	6:30:00 PM	587.8	589.3	588.2	134.1	133.2	140.2	47.91	138.03	0.278	0.303	0.296
5/13/2015	6:31:00 PM	593.2	595.2	594.7	66.1	69.2	68.5	9.09	69.97	0.140	0.138	0.111
5/13/2015	6:32:00 PM	593.2	595.0	594.8	65.2	67.5	66.5	8.92	68.41	0.142	0.131	0.117
5/13/2015	6:33:00 PM	597.9	598.8	599.0	66.4	68.7	66.9	9.54	69.87	0.153	0.132	0.123
5/13/2015	6:34:00 PM	597.5	598.3	598.5	64.3	66.6	64.9	9.36	67.67	0.155	0.135	0.124
5/13/2015	6:35:00 PM	596.4	597.3	597.6	63.0	65.1	63.6	9.19	66.14	0.155	0.135	0.125
5/13/2015	6:36:00 PM	596.6	597.4	597.7	61.2	63.6	62.0	9.06	64.48	0.158	0.138	0.125

Date	Time	Voltage (Line)			Current (Line)			kW	kVA	PF Line1		
5/13/2015	6:37:00 PM	596.9	597.8	598.0	60.6	63.0	61.6	9.06	63.98	0.158	0.140	0.126
5/13/2015	6:38:00 PM	596.3	597.4	597.5	58.0	60.4	59.1	8.80	61.24	0.160	0.143	0.127
5/13/2015	6:39:00 PM	596.0	596.9	597.1	54.6	56.8	55.8	8.43	57.66	0.161	0.146	0.130
5/13/2015	6:40:00 PM	597.2	598.3	598.6	53.5	55.6	54.6	8.34	56.56	0.163	0.147	0.132

Annexure: 4.3 Details of pumps proposed

Description	Coil cooling pump	Raw water pump
Product name:	NB 32-160.1/177 A-F-A-BAQE	NB 32-125/142 A-F-A-BAQE
Technical:		
Speed for pump data:	2880 rpm	2880 rpm
Actual calculated flow:	14.4 m /h	24.6 m /h
Resulting head of the pump:	40 m	30 m
Actual impeller diameter:	177 mm	142 mm
Impeller nom:	160.1 mm	125 mm
Impeller max:	177 mm	142 mm
Shaft seal:	BAQE	BAQE
Secondary shaft seal:	NONE	NONE
Shaft diameter:	24 mm	24 mm
Curve tolerance:	ISO9906:2012 3B	ISO9906:2012 3B
Pump version:	A	A
Materials:		
Pump housing:	Cast iron	Cast iron
	EN-GJL-250	EN-GJL-250
	ASTM A48-40 B	ASTM A48-40 B
Impeller:	Cast iron	Cast iron
	EN-GJL-200	EN-GJL-200
	ASTM A48-30 B	ASTM A48-30 B
Material code:	A	A
Installation:		
Maximum ambient temperature:	55 C	55 C
Maximum operating pressure:	16 bar	16 bar
Flange standard:	EN 1092-2	EN 1092-2
Connect code:	F	F
Pump inlet:	DN 50	DN 50
Pump outlet:	DN 32	DN 32

Description	Coil cooling pump	Raw water pump
Pressure stage:	PN 16	PN 16
Wear ring(s):	neckring(s)	neckring(s)
Liquid:		
Liquid temperature range:	0 - 120 C	0 - 120 C
Liquid temp:	20 C	20 C
Density:	998.2 kg/m	998.2 kg/m
Kinematic viscosity:	1 mm2/s	1 mm2/s
Electrical data:		
Motor type:	SIEMENS	SIEMENS
IE Efficiency class:	NEMA Premium / IE3 50Hz	NEMA Premium / IE3 50Hz
Number of poles:	2	2
Rated power - P2:	4 kW [4.6 kW]	4 kW [4.6 kW]
Mains frequency:	50 Hz	50 Hz
Rated voltage:	3 x 380-420D/660-725Y V [3 x 440-480D/0-0Y V]	3 x 380-420D/660-725Y V [3 x 440-480D/0-0Y V]
Rated current:	7,60-6,90/4,40-4,00 A [7,60-6,90/-A]	7,60-6,90/4,40-4,00 A [7,60-6,90/- A]
Starting current:	710-710 % [820-820 %]	710-710 % [820-820 %]
Cos phi - power factor:	0,91	0,91
Rated speed:	2880 rpm	2880 rpm [3555 rpm]
Efficiency:	IE3 88,5%	IE3 88,5%
Motor efficiency at full load:	88,5-88,5 %	88,5-88,5 %
Motor efficiency at 3/4 load:	89,4-89,4 % [89,2-89,2 %]	89,4-89,4 % [89,2-89,2 %]
Motor efficiency at 1/2 load:	89,4-89,4 % [88,8-88,8 %]	89,4-89,4 % [88,8-88,8 %]
Enclosure class (IEC 34-5)::	55 (Protect. water jets/dust)	55 (Protect. water jets/dust)
Insulation class (IEC 85):	F	F
Motor protec:	PTC	PTC
Motor No:	83U15213	83U15213
Lubricant type:	Grease	Grease

[i] The photograph in cover page was taken during energy audit