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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.

Last but not least, the interactions and deliberations with cluster coordinating agencies, industry associations, technology providers and who were directly or indirectly involved throughout the study were exemplary and the whole exercise was thoroughly a rewarding experience for TERI.

The Energy and Resources Institute (TERI)
New Delhi

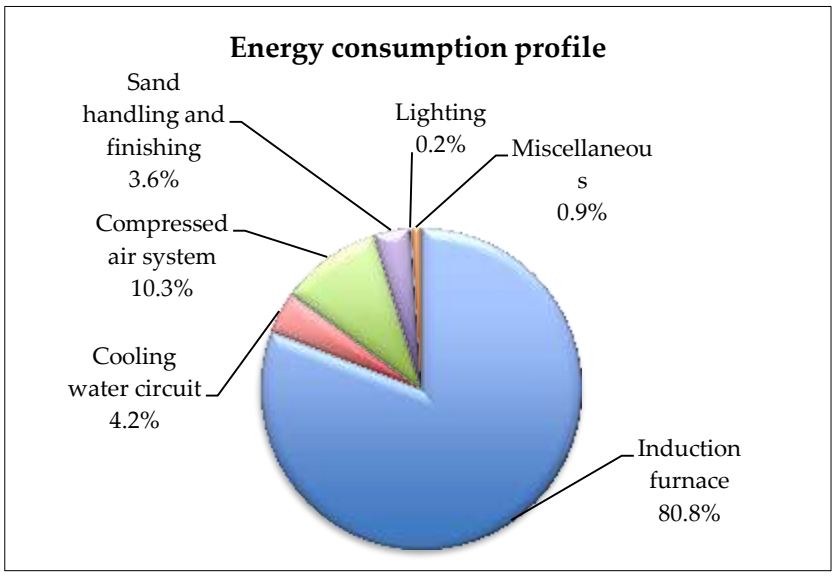
Executive summary

A detailed energy audit at M/s The Allied Foundries 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 The Allied Foundries
No. of years in operation	47
Factory address	N-3 Industrial Estate, Udyambag, Belgaum, Karnataka – 590 008
Type of industry	Spheroidal Graphite (SG) Iron and graded Cast Iron castings
Hours of operation per day	16
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 68.85 toe (~0.8 million kWh) which is equivalent to 56 lakh rupees. The total CO_2 emission during this period is estimated to be 785 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 silicate sand moulding process. The total liquid melting production of the unit during 2014 – 15 was 1,080 tonnes and dispatched production was 670 tonnes. The plant has an installed capacity of 150 tonnes per month. With respect to production in financial year 2014 – 15 the capacity utilization factor for the unit is 60%. The net yield of unit is around 61%.

The energy consumption in the plant is mainly for following: induction furnace, cooling water circuit, compressed air system, sand handling, 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	Investment	Savings	Simple Payback
		Electricity (kWh)	Rs Lakh	Rs Lakh/ year	Year
1	Power factor improvement	458	0.52	0.41	1.3
2	Lid mechanism for induction furnace	12,769	2.00	0.77	2.6
3	Arresting leakages, creating ring main and reducing pressure in compressed air system	25,034	2.00	1.51	1.3
4	Replacement of coil cooling pump with energy efficient pump	3,607	0.15	0.22	0.7
5	Replacement of raw water pump with energy efficient pump	2,948	0.55	0.18	3.1
	Overall	**44,816**	**5.22**	**3.09**	**1.7**

Total five energy conservation measures are identified. Implementing then would attract a one-time investment of Rs 5.2 lakh; it would lead to annual savings of Rs 3.1 lakh. This would result in reduction in energy consumption by 5.6%. The specific energy consumption of entire foundry would improve from 1,196 kWh per tonne to 1,129 kWh per tonne.

1.0 Production and energy consumption

1.1 Introduction

M/s The Allied Foundries foundry unit was set up in 1968. The unit manufactures SG iron and graded CI castings and supplies to various industries. The unit has an installed capacity of 150 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 The Allied Foundries
No. of years in operation	47
Factory address	N-3 Industrial Estate, Udyambag, Belgaum, Karnataka – 590 008
Type of industry	Spheroidal Graphite (SG) Iron and graded Cast Iron castings
Hours of operation per day	16
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 unit uses green sand moulding process. The process flow diagram is shows in figure 1.2.

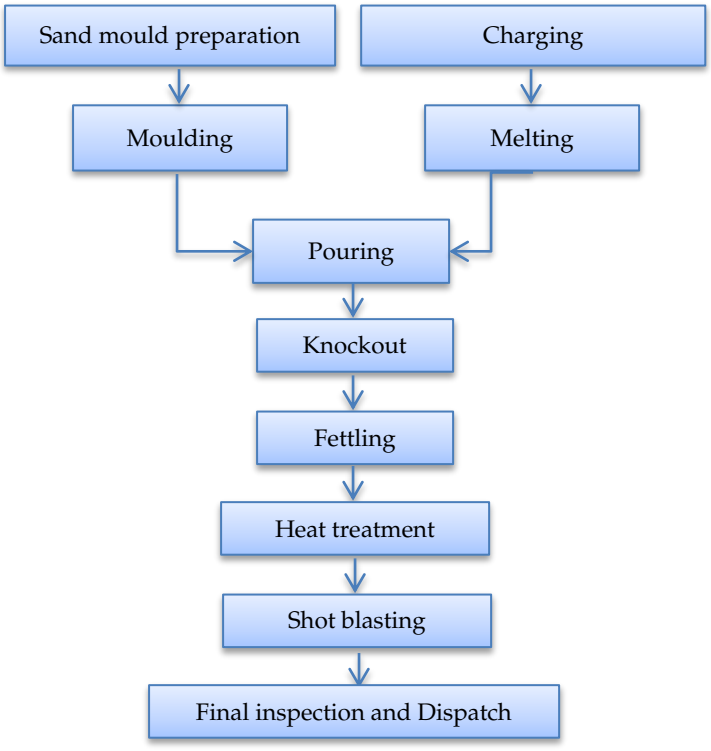


Figure 1.2: Process flow chart

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 1,080 tonnes and dispatched production was 670 tonnes. The overall energy cost incurred for this production was 56.14 lakh rupees. Figure 1.3 refers the monthly production and energy cost profile of the unit.

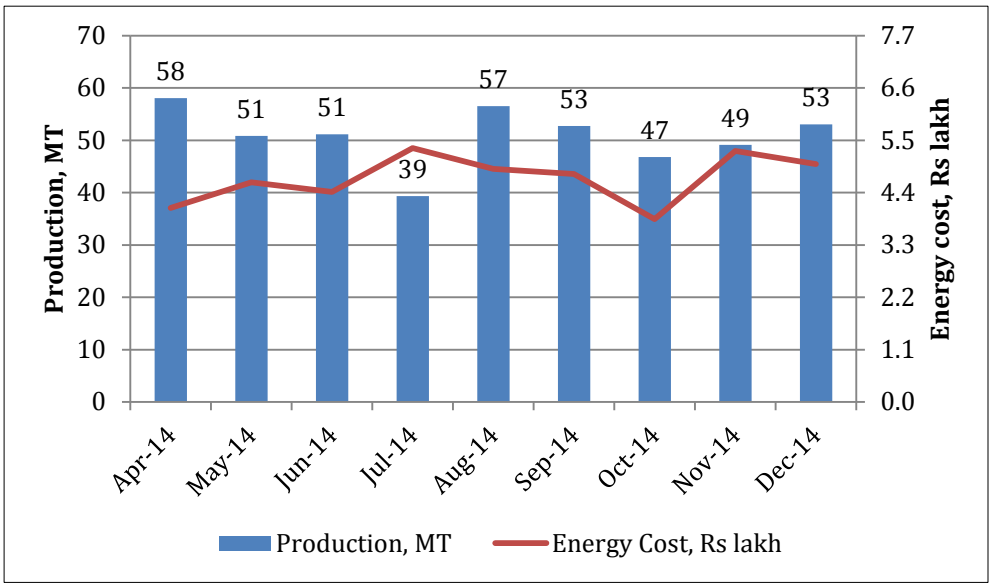


Figure 1.3: Production and energy cost profile

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 68.85 toe (~0.8 million kWh) which is equivalent to 56 lakh rupees. The total CO_2 emission during this period is estimated to be 785 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 150 MT per month. The actual monthly average melting is 90.0 MT. Thus, the capacity utilization (CU) of plant is 60%. The CU varies between 42 – 87%. The CU is low due to lack of orders, thus the plant operates 12 – 16 hours per day only.

1.6.2 Net yield

The raw material consumption of foundry is around 90 tonnes per month and net casting sold is 56 tonnes per month. The net yield of foundry is 61%. The net yield depends on melting loss with spillage, runner and risers, rejection and 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 1,196 kWh per metric tonne of production. The SEC for induction furnace for melting is estimated to be 608 kWh per tonne of melting.

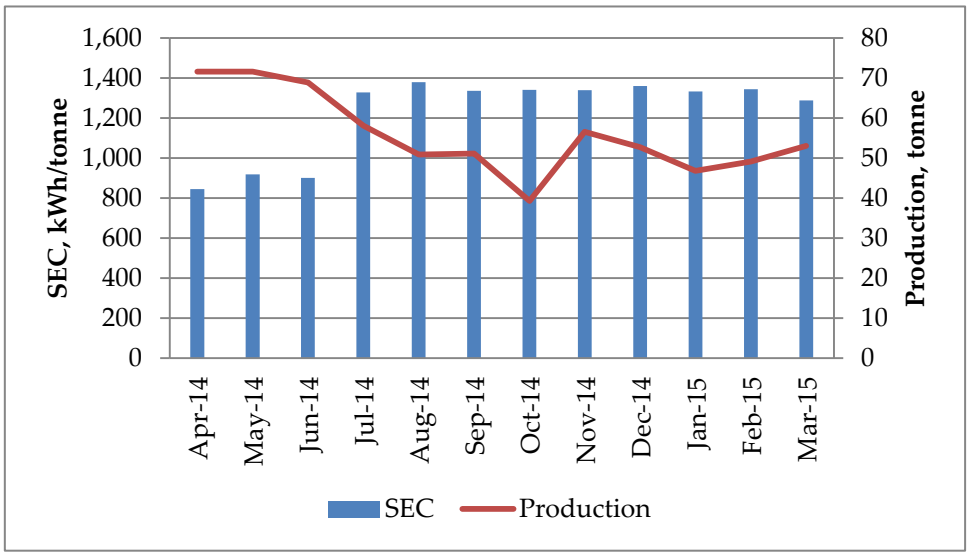


Figure 1.6.3: SEC and production profile

2.0 Electrical systems

2.1 Facility description

2.1.1 General

The main source of electricity for M/s The Allied Foundries 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 433/460 V using two transformers (350 kVA for furnace and 250 kVA for auxiliary) and is fed to the respective power distribution board (PDB) and light distribution board (LDB) at 415/460 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)	350	250
Application	Induction furnace	Auxiliary
Type	ONAN	ONAN
Primary Voltage (V)	11,000	11,000
Primary Current (Amps)	18.36	13.12
Secondary Voltage (Volts)	460	433
Secondary Current (A)	429.3	333.33
Rated No Load Loss (kW)	0.75	0.53
Rated load loss (kW)	4.20	2.85

The rate of power failure in Belgaum, Karnataka is insignificant. To maintain the power factor near to unity, plant has provided the power factor correction system at main incomer at 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 400 kVA contract demand. The minimum billing demand is 300 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)	Power factor	Billed demand (kVA)	Demand charges (Rs)	Energy charges (Rs)	P.F. penalty (Rs)	Monthly electricity bill (Rs)
Apr-14	60465	0.970	379	64430	311,627	-	407,443
May-14	65790	0.968	375	63750	375,003	-	461,910
Jun-14	62045	0.961	385	65450	353,657	620	441,204
Jul-14	77080	0.952	393	66810	439,356	771	533,383
Aug-14	70170	0.947	385	65450	399,969	702	490,161
Sep-14	68305	0.949	390	66300	389,339	-	479,162
Oct-14	52740	0.949	384	65280	300,618	-	384,091
Nov-14	75720	0.942	405	69700	431,604	-	527,200

Month & Year	Electricity consumption (kWh)	Power factor	Billed demand (kVA)	Demand charges (Rs)	Energy charges (Rs)	P.F. penalty (Rs)	Monthly electricity bill (Rs)
Dec-14	71645	0.947	391	66470	408,377	-	500,199
Jan-15	62375	0.947	392	66640	355,538	-	443,510
Feb-15	65995	0.945	392	66640	376,172	-	465,382
Mar-15	68270	0.941	400	68000	389,139	-	480,487
Average	**66717**	**0.952**	**389**	**66243**	**377,533**	**174**	**467844**
Total	**800600**			**794920**	**4530397**	**2,093**	**5,614,132**

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.

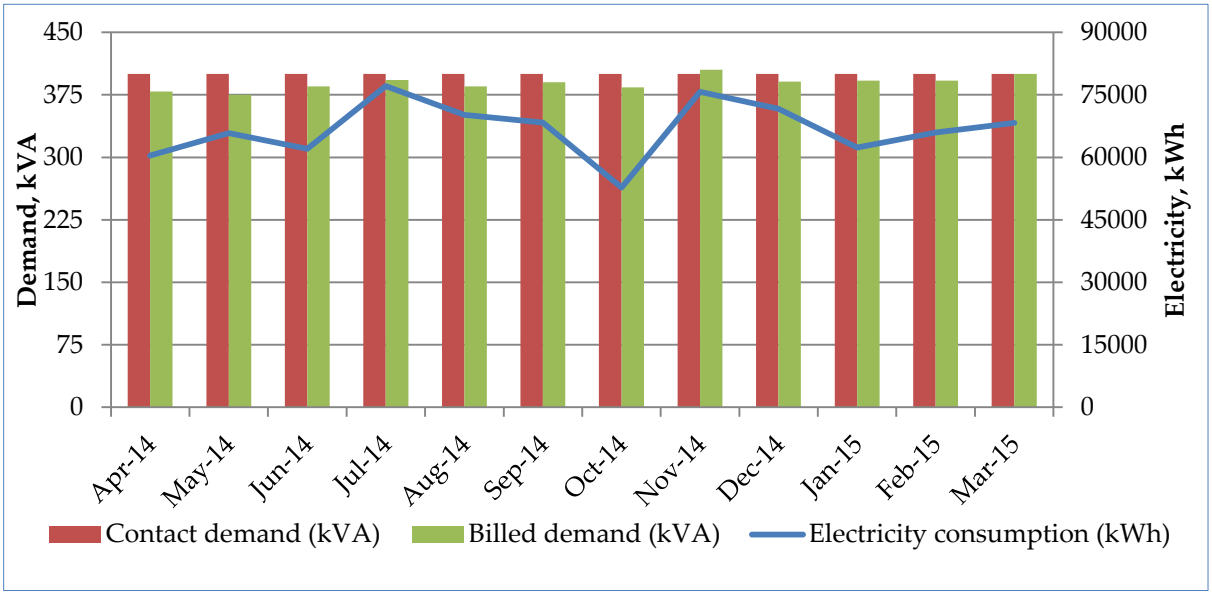


Figure 2.1.2: Demand and energy consumption pattern

As observed from above figure, plant has registered a maximum recorded demand of 405 kVA in the month of November 2014 whereas the minimum recorded demand of 375 kVA in the month of May 2014. The average recorded demand for the period was 389 kVA and it is 97% of the contract demand. Though, in past four months the average demand is 393 kVA which is 98% of contract demand. The average electricity consumption of the plant from HESCOM grid was about 66,717 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 350 kVA transformer are summarises in table 2.2.2.

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

	Transformer 350 kVA		
Parameters	**Minimum**	**Average**	**Maximum**
Voltage, Volt	452	463	484
Current, Amp	61	300	356
Active Power (kW)	25.3	216.0	280.2
Apparent Power (kVA)	48	241	298
Power Factor, pf	0.530	0.898	0.939
% THD (Voltage)	0	6.7	8.1
% THD (Current)	0	25.5	36.0

Observation:

- The load at transformer is variable and it follows the power curve of induction furnace.
- The average demand is found to be about 241 kVA for transformer during the measurement period however; the demand is fluctuating due to instantaneous loads of the utility system. The maximum demand was 298 kVA
- The total harmonic distortion in voltage and current is exceeding the permissible limit 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 350 kVA. Summary of the loading pattern and respective operation efficiency of the transformer is given in table 2.2.3.

Table 2.2.3: Summary of the operational efficiency of transformer

			Calculated parameters	
Transformer	**Load Conditions**	**Rated capacity, kVA**	**% Loading**	**% Efficiency**
350 kVA	Maximum	350	85.27	98.66
	Minimum		13.64	96.83
	Average		68.74	98.75

The average operational loading of transformer is 68.7 % whereas the best efficiency point is 42.3% 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 power control centre (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 transformer is given in figure 2.2.4.

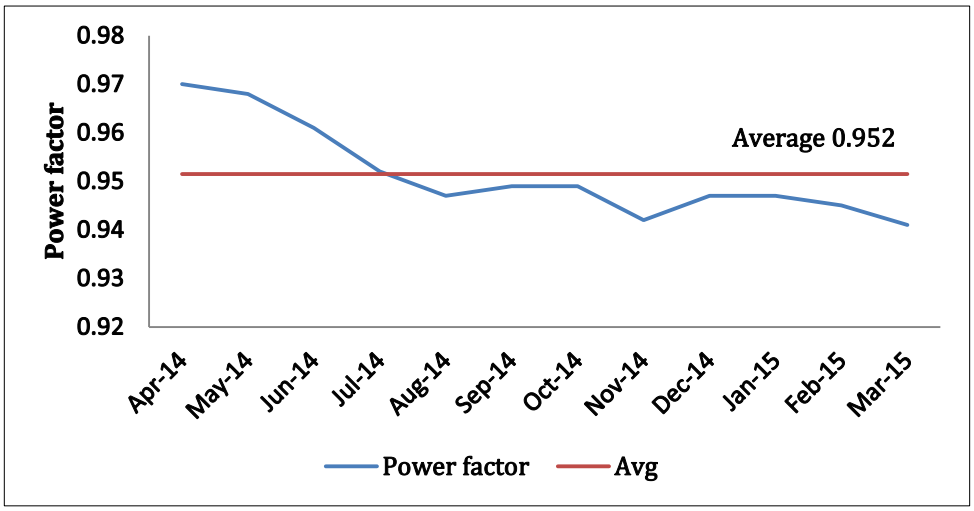


Figure 2.2.4: Power factor variation during the year 2014-15

It has been observed that the average power factor of the plant at main incomer is around 0.939 during measurement and average for past one year is 0.952. 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 66,717 kWh. The plant operates for 12 hours daily. The peak demand of plant is 389 kVA at power factor of 0.952 lag. This corresponds to a load factor of 60%. The load factor is good due to continuous running of induction furnace during operation period. It can still be improved by maintaining furnace at full power, when in operation.

2.3 Energy conservation measures

2.3.1 Improving power factor and demand reduction

The average power factor recorded in foundry was 0.952. The average billed demand is 389 kVA and average maximum load is 370 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 105 kVAr capacity. Poor power factor does not only increase the penalty in billing but also increases demand charges and distribution losses. This will also reduce the demand by 19 kVA. The estimated annual energy savings by improving power factor is 458 kWh equivalents to a monetary saving of Rs 0.41 lakh. The investment requirement is Rs 0.52 lakh with a simple payback period of 1.3 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
Contract demand	kVA	400
Minimum billing demand (@75%)	kVA	300
Average billed demand	kVA	389
Existing power factor	pf	0.952
Proposed power factor	pf	0.999
Existing real load	kW	370
New demand	kVA	371
Reduction in demand	kVA	19
Capacitor bank requirement	kVAr	103
Savings Estimation	**Unit**	**Value**
Annual energy saving	kWh	458
	toe/year	0.04
Energy cost saving	Rs lakh/year	0.03
Demand cost saving	Rs lakh/year	0.38
Monetary saving	Rs lakh/year	0.41
Investment cost for capacitor bank	Rs lakh	0.52
Simple payback period	years	1.3
CO_2 emission avoided	tCO_2/year	0.4

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%	6.7%
% THD Current	8.0%	25.5%
V 5^{th} harmonics	3.0%	3.9%
V 7^{th} harmonics	3.0%	3.1%

3.0 Furnace

3.1 Facility description

The plant is equipped with one induction melting furnace of rating 550 kW and it has three crucibles of capacity 300 and 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	SCR
Make	Inductotherm
Voltage/Frequency, V/Hz	460/500
Rating, kW	250
Crucible capacity, kg	500 and 300
Operating Temperature (°C)	1450
Mode of operation (batch/continuous)	Batch
Batch duration (minute)	83

3.2 Observation and analysis

The study was conducted on 500 kg crucible and three 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

Particular	Unit	Total	Average
Raw material charge	kg	1,560	520
Units consumed	kWh	948	316
Cycle time (melting + pouring)	min	248	83
Specific Energy Consumption	kWh/MT	608	608
Tapping temperature	C	1,445	1,445

- There was no lid cover on furnace crucible, thus leading to radiation and convection losses, around 5% of input energy
- Currently the furnace is operating in one shift (10-11 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 harmonics level is too high due to furnace operation. Current distortion is near 25.5% and voltage distortion is near 6.7%

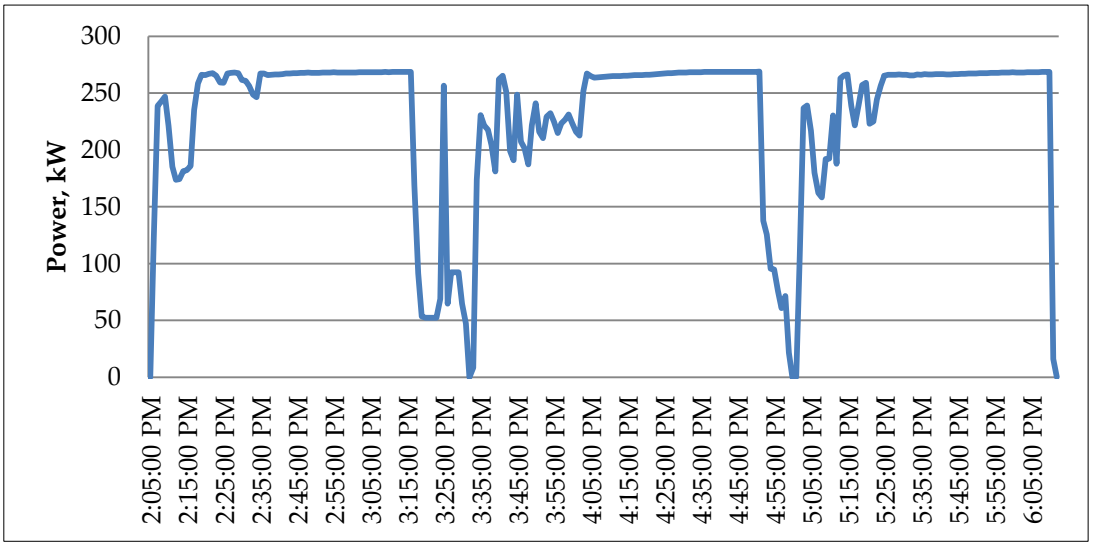


Figure 3.2: Power curve of induction furnace on 21st July 2015

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 608 kWh per metric tonne of melting. 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 25 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 six units per heat can be saved.

Table 3.3.1: Installation of Lid mechanism for induction furnace

Particulars	Unit	Value
Heats per day	heats	7.0
Saving potential per heat	kWh/heat	6.08
Operational days per year	days	300
Annual saving potential	kWh/year	12,769
Energy cost per unit	Rs/kWh	6.05
Monetary saving	Rs lakh/year	0.77
Investment	Rs lakh	2.00
Simple payback period	years	2.6
CO_2 emission avoided	tCO_2/year	12.5

The estimated annual energy savings by using lid mechanism is 12,769 kWh equivalents to a monetary savings of Rs 0.77 lakh. The investment requirement is Rs 2.0 lakh with a simple payback period of 2.6 year. The annual reduction in CO_2 emission is estimated to be 12.5 tCO_2.

4.0 Compressed air system

4.1 Facility description

The plant has installed one screw type (air cooled) air compressor for meeting the compressed air requirement of instrumentation and service in the plant. The design parameters of the air compressor are presented in Table 4.1.

Table 4.1: Induction melting furnace design parameters

Particulars	Unit	AC01	AC02
Make		Kirloskar	ELGI
Type		Reciprocating	Screw
Model		EH-2.00M	EG22-7.5
Rated Capacity	m^3/min	4.58	3.96
	cfm	162	140
Pressure	bar	9.0	7.0
Power rating	kW	22.0	22.0

4.2 Observation and analysis

Either of air compressors AC01 or AC02 runs continuously in load and unload mode. The compressors will be unloaded while reaching to the set pressure. This is analogous to start/stop control which controls the compressor functions, instead of the motor. When compressors in unload mode, the motor continues to operate however at much reduced load and no compressed air is delivered to the system. The compressed air pressure required at the end use point was observed to be about 6.1 kg/cm^2.

4.2.1 Performance assessment of air compressor

The details of FAD test conducted on the air compressor are given in table 4.2.1. The power curves for loading unloading of air compressor studied are shown in figure 4.2.1.

Table 4.2.1: Performance assessment of air compressor

Particulars	Unit	AC01	AC02
Operating Pressure	bar	7.5	7.5
Initial Pressure	bar	0.5	
Capacity of Receiver	m^3	1.00	
Additional holdup of volume	m^3	0.15	
Pump up time	seconds	127	
Inlet air temperature	C	34.0	
FAD	m^3/min	3.7	
	cfm	130.9	130.3
Isothermal power	kW	12.37	12.16
Motor power	kW	26.9	26.3
Motor efficiency	%	89.0%	89.0%
Shaft power	kW	23.94	23.36

Particulars	Unit	AC01	AC02
Isothermal efficiency	%	51.7%	52.0%
Volumetric efficiency	%	80.9%	93.2%
Specific power consumption	kW/cfm	0.205	0.201

- The FAD of air compressors was estimated to be 131 and 130 cfm respectively and the specific power consumption of air compressor was 0.205 and 0.201 kW per cfm respectively
- The volumetric efficiency of air compressors were estimated to be 80.9% and 93.2% respectively
- The isothermal efficiency of air compressors were estimated to be 51.7% and 52.0% respectively

4.2.2 Leakage test

The leakage test of the compressed air distribution system was conducted on AC01 during the field study. Under this test, all supply valves at utilization end were closed manually and compressor was operated for a period of 30 minutes. The loading and unloading time of the operating compressor during the leakage test is noted. The loading period is the generation of the compressed air, which is due to leakages in the distribution system. The estimated leakage in the compressed air distribution system is shown in table 4.2.2. Figure 4.2.2 shows load-unload cycle during leakage test. In an ideal system once pressure attained, the compressor should never come ON-load again during leakage test.

Table 4.2.2: Leakage assessment

Leakage Test	Unit	Value
Actual FAD	m^3/min	3.71
	cfm	131
ON time	sec	51
OFF time	sec	65
Leakage in plant	%	44%
Leakage in plant	cfm	57.55

Leaks are a significant source of wasted energy in a compressed air system of plant, often wasting a portion of the compressor's output. Compressed air leaks can also contribute to problems with system operations, including:

- Fluctuating system pressure, which can cause air tool and other air-operated equipment to function less efficiently, which possibly affects the production.
- Excess compressor capacity, resulting in higher than necessary costs
- Decreased service life and increased maintenance of supply equipment (including the compressor package) due to unnecessary cycling and increased run time.

By installing suitable application specific nozzles, taking the necessary maintenance practices and periodic inspection of distribution network, it would be possible to reduce the air leakages significantly. Although leaks can occur in any part of the system, the most common problem areas are: couplings, hoses, tubes, fittings, pipe joints, quick disconnects, FRLs (filter, regulator, and lubricator), condensate traps, valves, thread sealants, and point

of use devices. Leakage rates are a function of the supply pressure in an uncontrolled system and increase with higher system pressures.

The total leakage quantity in the system in plant is estimated to 44% of the supplied air (from one compressor) which is equivalent to 58 cfm, which is significant. The permissible line losses in the industrial scenario are less than 5%.

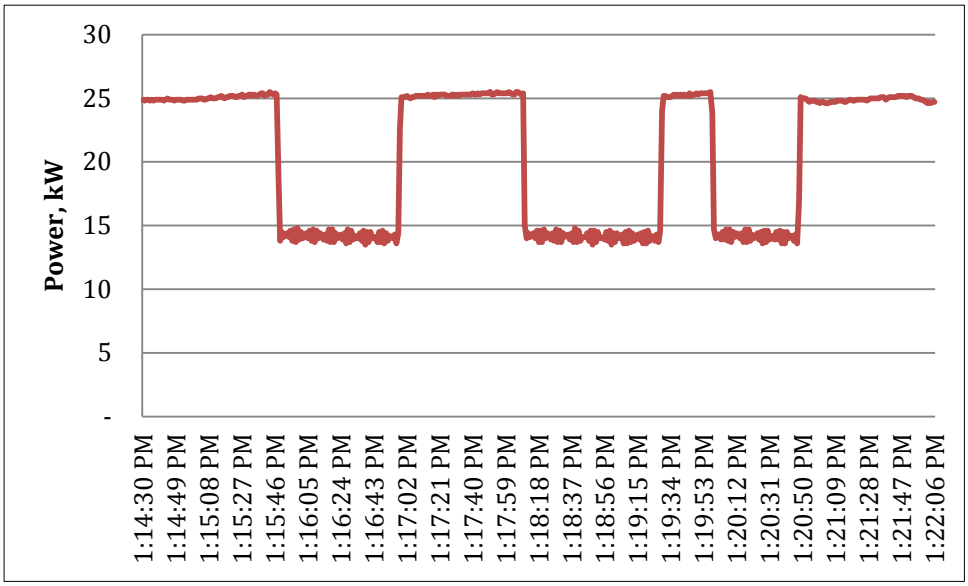


Figure 4.2.2: Power curve during leakage test

4.3 Energy conservation measures

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

4.3.1 Arresting leakages, creating ring main and reducing pressure in compressed air system

From preliminary assessment it was found that leakage in line is very high in both the pipe lines. Leakage test was performed during break time to estimate the amount of leakage. The on time and off time were measured for two air compressors. The leakage in existing compressed air piping system was measured and found to be 44%, which is high.

It is recommended to reduce leakages in the compressed air piping system by periodically checking for air leaks and arresting them, and bring it down to about a nominal level of 5%.

It is recommended to have common ring main system for compressed air network and set screw compressor at 6.5 to 7.0 bar pressure and set reciprocating compressor at 6.0 to 6.5 bar. After reduction of leakage single screw compressor should be able to meet the demand. If in case the demand increases, as pressure falls below 6.5 bar the reciprocating will start delivering compressed air.

Table 4.3.1: Cost benefit analysis

Particulars	Unit	Value
Leakage arresting		
Leakage in plant	%	44%
Energy loss	kW/hour	7.3
Acceptable losses	%	5%
Energy Saving	kW	6.5
Operating hours	hour	3,300.0
Recommended pressure		
Load pressure	bar	6.5
Unload pressure	bar	7.0
Energy Saving	%	4%
Annual energy saving	kWh/ year	25,034
	toe/year	2.15
Monetary saving	Rs lakh/year	1.5
Investment	Rs lakh	2.0
Simple payback period	years	1.3
CO_2 emission avoided	tCO_2/year	24.5

The estimated annual energy savings by arresting air leakage and reducing pressure setting is 25,034 kWh equivalents to a monetary savings of Rs 1.5 lakh. The investment requirement is Rs 2.0 lakh with a simple payback period of 1.3 year. The annual reduction in CO_2 emission is estimated to be 24.5 tCO_2.

5.0 Pumping system and cooling towers

5.1 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 (demineralised water) 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 5.1a.

Table 5.1a: Rated parameters of the pumps taken up for study

Design Parameters	Unit	Coil cooling pump	Raw water pump
Make		Kirloskar	Kirloskar
Type		Mono-Block	Mono-Block
Flow rate	m^3/hour	7.2	13.5
Head	m	45.0	26.0
Motor Power	kW	3.7	2.2
Overall Efficiency	%	34%	40%

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 5.1b.

Table 5.1b: Rated parameters of the cooling tower taken up for study

Parameters	CT
Type	Natural draft
Make/year	NA
Purpose	Coil water cooling in induction melting furnace
Capacity (lpm)	250
Pump power (kW)	2.2
Fan power (kW)	0
Operating hours per day	12
Other Location	Near pump house

5.2 Observation and analysis

5.2.1 Pumps

The operating parameters, such as flow and head, were measured for all operating water pumps. Suction & discharge head of the pumps was measured by using standard pressure gauge from the plant. The flow rate of water delivered by the pumps was measured by using non-intrusive type flow meter. Simultaneously, operating electrical parameters of pump mainly voltage, current, power factor and kW were measured by using portable power analyser. The operating parameters and efficiency estimation is given in table 5.2.1.

Table 5.2.1: Estimation of efficiency of pump associated with induction furnace

Actual Parameters	Unit	Coil cooling pump	Raw water pump
Flow rate	m^3/hour	6.2	9.0
Discharge Pressure	kg/cm^2	4.0	1.5
Differential Head	m	40	15
Power	kW	4.50	2.60
Overall efficiency	**%**	**15.0%**	**14.1%**

5.2.2 Cooling towers in the plant

Operating parameters of cooling towers such as cooling water temperature at inlet and outlet, water flow rates, air flow rates and power consumption of fan motor were monitored by using digital thermometer, non-intrusive type flow meter, anemometer and power analyser respectively. The operating parameters and the performance of the cooling tower are shown in table 5.2.2.

Table 5.2.2: Estimation of operating parameters and performance of cooling towers

Measured Parameters	Unit	Value
Water flow rate	m^3/hour	9.0
Ambient temperature	°C	30.1
RH	%	54.5
T inlet	°C	49.0
T outlet	°C	33.5
Calculations	**Unit**	
DBT	°C	30.1
WBT	°C	22.9
Approach	°C	10.6
Range	°C	15.5
Heat removed to atmosphere	kCal/hour	139,500
	TR	46.13
Effectiveness	%	59%

5.3 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.

5.3.1 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 6.2 m^3/hour which is lower than the design flow of 7.2 m^3/hr. The overall efficiency of the pump is calculated to be 15% 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 Kirloskar KDT 550++ pump.

Table 5.3.1: Replacement of existing coil cooling pump with energy efficient pumps

Recommended Pump Specification	Units	Coil cooling pump
Flow rate	m^3/hour	11.9
Differential Head	m	44.0
Efficiency	%	38.0
Power	kW	3.75
Energy saving	kW	0.75
Operating period	hour	4,800
Annual Energy saving	kWh/year	3,607
	toe/year	0.31
Cost saving		
Energy cost per unit	Rs / kWh	6.05
Annual Monetary Saving	Rs lakh / year	0.22
Investment	Rs lakh	0.15
Simple Payback Period	years	0.7
CO_2 emission avoided	tCO_2/year	3.5

The estimated annual energy savings in coil cooling pump is 3,607 kWh equivalents to a monetary saving of Rs 0.22 lakh. The investment requirement is Rs 0.15 lakh with a simple payback period of 0.7 years. The annual reduction in CO_2 emission is estimated to be 3.5 tCO_2.

5.3.2 Replacement of existing raw water pump with energy efficient pump

The power consumption of raw water pump for panel cooling was measured to be 2.6 kW. The water flow rate was measured to be 9 m^3/hr, which is lower than the design flow of 13.5 m^3/hr. The overall efficiency of the pump is calculated to be 14% which is lower than design efficiency (40%).

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.

Table 5.3.2: Replacement of existing raw water pump with energy efficient pumps

Recommended Pump Specification	Units	Raw water pump
Flow rate	m^3/hour	13.5
Differential Head	m	26.0
Efficiency	%	53.7%
Power	kW	1.78
Energy saving	kW	0.82
Operating period	hour	3,600
Annual Energy saving	kWh/year	2,948
	toe/year	0.25

Recommended Pump Specification	Units	Raw water pump
Cost saving		
Energy cost per unit	Rs / kWh	6.05
Annual Monetary Saving	Rs lakh / year	0.18
Investment	Rs lakh	0.55
Simple Payback Period	years	3.1
CO_2 emission avoided	tCO_2/year	2.9

The estimated annual energy savings in raw water pump is 2,948 kWh equivalents to a monetary saving of Rs 0.18 lakh. The investment requirement is Rs 0.55 lakh with a simple payback period of 3.1 years. The annual reduction in CO_2 emission is estimated to be 2.9 tCO_2.

6.0 Motors

6.1 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.

6.2 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.

6.2.1 On -load motor test

The operational loading of the electrical motors is calculated using the measured electrical parameters from the unit. The details of motors in sand handling and finishing are given in 6.2.1.

Table 6.2.1: Motor power parameter and loading

Motor Description	Motor Rating						Motor Operating Parameters					%
	Rated power (kW)	Efficiency (%)	V	V_{thd} (%)	A	A_{thd} (%)	kW	kVA	PF	kVAr	Hz	Loading
Sand Mixer Main motor	15.0	89.0%	413	2.1	12.7	18.7	8.2	9.1	0.90	4.0	50.0	49%
Sand Mixer Blender motor	9.3	89.0%	413	3.1	8.1	6.1	3.6	5.8	0.62	4.5	50.0	34%
Shot blast main motor	15.0	89.0%	410	2.3	15.6	9.3	9.8	11.1	0.89	5.2	50.0	58%
Shot blast dust collector	5.5	87.0%	410	2.4	6.5	11.1	2.9	4.6	0.63	3.6	50.0	46%

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.

6.3 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.

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7.0 Lighting system

7.1 Facility description

The total connected lighting load of the plant, as per the inventory collected during the detailed assessment study, was estimated to be 1.7 kW (including ballast losses). The different types of lamps operating in the plant are Fluorescent Tube Light (T-12), Metal Halide (MH). Table 7.1 gives the type of lamps used in different areas of the plant.

Table 7.1: 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	12	52	0.6	6
2	Plant	MH	4	265	1.1	2

7.2 Energy conservation measures

7.2.1 Replacement of existing lighting system with efficient lighting system in phase manner

The foundry is using mixed lighting, including FTL T12 and MH. Fluorescent tube lights of 40W FTLs with conventional copper ballasts consume more energy. About 12 T12 and four T8 were found in different locations of the unit. It is proposed to replace all 40W copper ballast FTLs with 28W FTLs having electronic ballasts. Electronic ballasts help in instantaneous starting of lamps and have improved regulation for varying input voltage. Major benefits of T5 fixtures over conventional T12 FTL are as follows:

- Uniform light output for wide range of supply voltages.
- Instant start and flicker free operation.
- Improves the power factor almost close to unity.
- Less heat generation, hence load on ACs reduces.
- Increased lamp life around 15000 hrs.
- Higher lumen output per watt (around 105 lumens per watt)

Also, it is observed that foundry uses metal halide (4 nos.) lamp for lighting in shop floor. The lumens per watt of MH lamp are low and also the life is short.

It could be recommended to replace the T12 with T5 and MH with induction lamp. But the operating hours of lamps is very low and the payback will be over four years. Hence it is not recommended. Once foundry starts operating in three shifts, then it will become viable.

8.0 Summary of potential savings

8.1 Summary of recommendations

The proposed energy conservation measures (ECMs) for various facilities of The Allied Foundries 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 ECMs under the above categories as given table 8.1:

Table 8.1: Categorization of energy conservation measures

Sr. No.	Type of recommendation	No. of ECM	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)	1	0.22	0.15	0.7
3	Medium term return based (1-2 year)	2	1.92	2.52	1.3
4	Long term return based (> 2 year)	2	0.95	2.55	2.7
	Total	**5**	**3.09**	**5.22**	**1.7**

8.2 Recommended energy conservation measures

The recommended measures considered for energy audit report after discussion with unit representative is given in table 8.2

Table 8.2: Recommended energy conservation measures for implementation

S. No	Energy conservation measures	Annual energy savings	Invest-ment	Savings	Simple Payback
		Electricity (kWh)	Rs Lakh	Rs Lakh/ year	Year
1	Power factor improvement	458	0.52	0.41	1.3
2	Lid mechanism for induction furnace	12,769	2.00	0.77	2.6
3	Arresting leakages, creating ring main and reducing pressure in compressed air system	25,034	2.00	1.51	1.3
4	Replacement of coil cooling pump with energy efficient pump	3,607	0.15	0.22	0.7

S. No	Energy conservation measures	Annual energy savings	Invest-ment	Savings	Simple Payback
		Electricity (kWh)	Rs Lakh	Rs Lakh/ year	Year
5	Replacement of raw water pump with energy efficient pump	2,948	0.55	0.18	3.1
	Overall	**44,816**	**5.22**	**3.09**	**1.7**

Total five energy conservation measures are identified. Implementing then would attract a one-time investment of Rs. 5.2 lakh; it would lead to annual savings of Rs. 3.1 lakh. This would result in reduction in energy consumption by 5.6%. The specific energy consumption of entire foundry would improve from 1,196 kWh per tonne to 1,129 kWh per tonne.

8.3 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 43.9 tonne of CO_2 per year. The life time CO_2 emission reduction in estimated to be 659 tonne. The lifetime energy and CO_2 saving are given in table 8.3

Table 8.3: Lifetime CO_2 savings

S. No	Energy Conservation Measures	Life time energy saving (toe)	Life time CO_2 reduction (tonne)
1	Power factor improvement	0.6	6.7
2	Lid mechanism for induction furnace	16.5	187.7
3	Arresting leakages, creating ring main and reducing pressure in compressed air system	32.3	368.0
4	Replacement of coil cooling pump with energy efficient pump	4.7	53.0
5	Replacement of raw water pump with energy efficient pump	3.8	43.3
	Total	**57.8**	**658.8**

8.4 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.

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

Annexures

Annexure: 3.2 Logging of induction furnace

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	2:05:00 PM	473.8	476.1	476.6	2.2	1.7	2.0	-	-	0	-	-	-	0.0	0.0	-0.0	0.0	-	-	-	50.09
7/21/2015	2:06:00 PM	470.5	472.8	473.5	4.5	4.3	4.6	158	157	159	21.5	21.8	22.5	122.9	2.0	47.1	131.7	0.72	0.72	0.73	50.10
7/21/2015	2:07:00 PM	465.6	467.9	468.6	6.6	6.5	6.7	309	307	309	26.0	26.3	25.5	238.7	6.0	89.6	255.0	0.93	0.93	0.94	50.11
7/21/2015	2:08:00 PM	464.2	466.6	467.4	6.8	6.7	6.9	315	313	315	25.9	26.1	25.4	242.6	10.1	91.2	259.2	0.93	0.93	0.94	50.08
7/21/2015	2:09:00 PM	464.0	466.4	467.0	6.8	6.8	7.1	321	319	321	25.8	26.0	25.3	247.0	14.2	93.3	264.0	0.93	0.93	0.94	50.07
7/21/2015	2:10:00 PM	464.4	466.8	467.4	6.5	6.4	6.7	287	285	288	26.2	26.4	25.6	221.3	17.9	84.0	236.7	0.93	0.93	0.94	50.06
7/21/2015	2:11:00 PM	465.5	467.9	468.4	5.8	5.7	6.1	240	238	241	26.8	27.1	26.2	185.2	21.0	70.6	198.2	0.93	0.93	0.94	50.06
7/21/2015	2:12:00 PM	463.5	466.2	466.8	5.5	5.5	5.8	226	224	227	27.0	27.4	26.4	173.9	23.9	66.3	186.1	0.93	0.93	0.94	50.06
7/21/2015	2:13:00 PM	462.6	465.2	465.9	5.4	5.4	5.6	227	225	228	27.1	27.4	26.4	174.4	26.8	66.4	186.6	0.93	0.93	0.94	50.01
7/21/2015	2:14:00 PM	463.0	465.6	466.3	5.3	5.3	5.6	236	234	237	27.0	27.2	26.3	181.4	29.8	68.9	194.1	0.93	0.93	0.94	49.98
7/21/2015	2:15:00 PM	462.3	464.7	465.6	5.4	5.4	5.6	237	236	238	26.8	27.2	26.2	182.2	32.8	69.3	194.9	0.93	0.93	0.94	49.96
7/21/2015	2:16:00 PM	462.4	464.8	465.6	5.6	5.6	5.8	242	240	243	26.8	27.1	26.2	185.8	35.9	71.3	199.0	0.93	0.93	0.94	49.96
7/21/2015	2:17:00 PM	459.9	462.4	463.0	6.5	6.5	6.8	308	306	309	26.1	26.3	25.5	235.1	39.8	89.6	251.6	0.93	0.93	0.94	49.93
7/21/2015	2:18:00 PM	459.1	461.8	462.4	6.9	7.0	7.2	339	337	339	25.8	25.8	25.1	258.5	44.2	98.0	276.4	0.93	0.93	0.94	49.93
7/21/2015	2:19:00 PM	458.3	460.9	461.7	7.2	7.3	7.5	350	348	350	25.6	25.7	25.0	266.2	48.6	100.7	284.6	0.93	0.93	0.94	49.93
7/21/2015	2:20:00 PM	457.5	460.0	460.7	7.3	7.3	7.5	350	348	350	25.8	25.8	25.1	265.8	53.0	100.3	284.2	0.93	0.93	0.94	49.94
7/21/2015	2:21:00 PM	456.9	459.4	460.1	7.4	7.4	7.7	352	350	352	25.6	25.7	25.0	266.9	57.5	101.3	285.5	0.93	0.93	0.94	49.95
7/21/2015	2:22:00 PM	455.9	458.3	459.1	7.6	7.5	7.7	354	351	354	25.6	25.7	25.1	267.6	61.9	101.9	286.4	0.93	0.93	0.94	49.98
7/21/2015	2:23:00 PM	455.4	457.9	458.8	7.6	7.5	7.8	351	349	351	25.6	25.8	25.1	265.4	66.4	101.1	284.0	0.93	0.93	0.94	50.02
7/21/2015	2:24:00 PM	457.2	459.8	460.5	7.4	7.3	7.6	342	339	342	25.7	25.9	25.2	259.4	70.7	98.9	277.6	0.93	0.93	0.94	50.04
7/21/2015	2:25:00 PM	457.6	460.3	460.8	7.0	7.0	7.3	341	339	341	25.9	26.0	25.2	259.1	75.0	98.3	277.2	0.93	0.93	0.94	50.04
7/21/2015	2:26:00 PM	457.8	460.4	460.9	7.2	7.2	7.5	351	349	352	25.7	25.9	25.2	267.3	79.4	101.5	285.9	0.93	0.93	0.94	50.02
7/21/2015	2:27:00 PM	457.2	459.6	460.5	7.5	7.4	7.8	353	350	353	25.8	26.0	25.2	267.9	83.9	101.9	286.6	0.93	0.93	0.94	50.02
7/21/2015	2:28:00 PM	458.6	461.1	462.0	7.7	7.5	7.8	352	350	352	25.8	26.0	25.2	268.0	88.4	102.2	286.8	0.93	0.93	0.94	49.98
7/21/2015	2:29:00 PM	458.3	460.8	461.6	7.6	7.5	7.9	352	349	352	25.8	25.9	25.1	267.5	92.8	102.2	286.3	0.93	0.93	0.94	49.97
7/21/2015	2:30:00 PM	456.9	459.7	460.2	7.5	7.4	7.7	345	342	345	25.7	25.9	25.1	261.5	97.2	100.1	280.0	0.93	0.93	0.94	49.97

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	2:31:00 PM	456.9	459.6	460.5	7.4	7.3	7.6	344	341	344	25.8	25.9	25.2	260.7	101.5	99.6	279.1	0.93	0.93	0.94	49.96
7/21/2015	2:32:00 PM	455.3	458.2	458.6	7.3	7.2	7.6	339	337	340	25.7	25.9	25.2	256.4	105.8	98.0	274.5	0.93	0.93	0.94	49.95
7/21/2015	2:33:00 PM	454.5	457.2	457.6	7.2	7.2	7.4	330	327	330	25.9	26.0	25.3	248.8	110.0	95.2	266.4	0.93	0.93	0.94	49.93
7/21/2015	2:34:00 PM	455.5	458.1	458.6	7.2	7.1	7.3	326	324	327	25.9	26.0	25.3	246.6	114.1	94.4	264.0	0.93	0.93	0.94	49.94
7/21/2015	2:35:00 PM	454.5	457.1	457.6	7.6	7.5	7.8	354	352	355	25.6	25.7	25.0	267.3	118.5	102.3	286.2	0.93	0.93	0.94	49.95
7/21/2015	2:36:00 PM	455.0	457.4	458.0	7.6	7.5	7.8	354	352	355	25.6	25.7	25.0	267.4	123.0	102.1	286.2	0.93	0.93	0.94	49.95
7/21/2015	2:37:00 PM	456.1	458.7	459.1	7.5	7.4	7.7	351	349	351	25.6	25.8	25.1	265.8	127.4	101.2	284.4	0.93	0.93	0.94	49.97
7/21/2015	2:38:00 PM	456.0	458.6	459.2	7.5	7.4	7.7	351	349	352	25.7	25.9	25.2	266.1	131.8	101.5	284.8	0.93	0.93	0.94	50.00
7/21/2015	2:39:00 PM	455.6	458.4	458.8	7.4	7.3	7.7	352	350	352	25.8	26.0	25.3	266.4	136.3	101.4	285.0	0.93	0.93	0.94	50.04
7/21/2015	2:40:00 PM	455.6	458.3	458.7	7.4	7.3	7.7	352	350	352	25.9	26.0	25.3	266.5	140.7	101.5	285.2	0.93	0.93	0.94	50.05
7/21/2015	2:41:00 PM	454.9	457.5	458.0	7.4	7.4	7.7	353	351	353	25.9	26.0	25.3	266.7	145.2	101.8	285.5	0.93	0.93	0.94	50.07
7/21/2015	2:42:00 PM	454.2	456.8	457.4	7.7	7.6	7.8	354	352	355	25.7	25.8	25.1	267.2	149.6	102.6	286.2	0.93	0.93	0.94	50.07
7/21/2015	2:43:00 PM	454.7	457.3	457.8	7.8	7.7	7.9	354	352	355	25.7	25.9	25.2	267.3	154.1	103.0	286.5	0.93	0.93	0.94	50.10
7/21/2015	2:44:00 PM	455.7	458.2	458.8	7.7	7.7	7.9	353	352	354	25.9	26.0	25.4	267.5	158.5	103.1	286.7	0.93	0.93	0.94	50.11
7/21/2015	2:45:00 PM	454.5	457.0	457.5	7.8	7.8	8.0	355	353	355	25.7	25.7	25.1	267.6	163.0	103.6	287.0	0.93	0.93	0.94	50.10
7/21/2015	2:46:00 PM	456.4	458.9	459.4	7.9	7.8	8.0	353	352	354	25.7	25.7	25.1	267.8	167.5	104.0	287.3	0.93	0.93	0.94	50.08
7/21/2015	2:47:00 PM	456.7	459.1	459.8	7.8	7.8	8.1	353	352	354	25.8	25.9	25.2	268.0	171.9	103.9	287.4	0.93	0.93	0.94	50.03
7/21/2015	2:48:00 PM	456.1	458.6	459.2	7.7	7.7	7.9	354	352	355	25.8	25.8	25.1	268.2	176.4	104.0	287.7	0.93	0.93	0.94	50.01
7/21/2015	2:49:00 PM	456.2	458.6	459.3	7.7	7.7	8.1	354	352	354	25.8	25.8	25.1	268.0	180.9	104.0	287.4	0.93	0.93	0.94	49.98
7/21/2015	2:50:00 PM	457.2	459.7	460.4	7.9	7.9	8.1	353	351	354	25.8	25.9	25.3	268.0	185.3	104.0	287.4	0.93	0.93	0.94	49.96
7/21/2015	2:51:00 PM	456.6	459.2	460.0	7.9	7.8	8.0	353	351	354	25.9	26.0	25.4	267.9	189.8	103.9	287.3	0.93	0.93	0.94	49.92
7/21/2015	2:52:00 PM	457.6	460.1	460.9	7.8	7.8	8.0	353	351	353	25.9	25.9	25.4	268.0	194.3	103.9	287.5	0.93	0.93	0.94	49.93
7/21/2015	2:53:00 PM	457.9	460.5	461.3	7.8	7.8	8.1	352	350	353	25.9	26.0	25.4	268.1	198.7	103.9	287.5	0.93	0.93	0.94	49.93
7/21/2015	2:54:00 PM	457.5	459.9	460.9	7.8	7.7	8.0	353	351	353	25.8	26.0	25.4	268.1	203.2	104.0	287.5	0.93	0.93	0.94	49.96
7/21/2015	2:55:00 PM	456.0	458.5	459.4	7.6	7.6	7.8	354	352	355	25.7	25.8	25.2	268.3	207.7	104.3	287.9	0.93	0.93	0.94	49.99
7/21/2015	2:56:00 PM	455.7	458.1	459.0	7.6	7.6	7.8	354	352	355	25.8	26.0	25.3	268.2	212.1	103.9	287.7	0.93	0.93	0.94	50.01
7/21/2015	2:57:00 PM	456.4	458.8	459.9	7.6	7.5	7.9	354	351	354	25.9	26.0	25.3	268.1	216.6	103.7	287.5	0.93	0.93	0.94	50.04
7/21/2015	2:58:00 PM	454.9	457.5	458.5	7.5	7.5	7.8	355	353	355	25.8	25.9	25.2	268.2	221.1	103.9	287.6	0.93	0.93	0.94	50.05
7/21/2015	2:59:00 PM	455.0	457.4	458.4	7.5	7.4	7.6	355	353	355	25.8	26.0	25.2	268.2	225.5	104.0	287.7	0.93	0.93	0.94	50.08
7/21/2015	3:00:00 PM	456.1	458.5	459.4	7.4	7.4	7.6	354	352	355	25.8	25.9	25.2	268.3	230.0	104.0	287.7	0.93	0.93	0.94	50.12

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	3:01:00 PM	456.9	459.3	460.2	7.2	7.2	7.4	353	351	354	25.7	25.9	25.2	268.2	234.5	103.9	287.6	0.93	0.93	0.94	50.10
7/21/2015	3:02:00 PM	457.1	459.6	460.4	7.2	7.2	7.4	353	351	354	25.7	25.9	25.2	268.3	239.0	104.1	287.8	0.93	0.93	0.94	50.10
7/21/2015	3:03:00 PM	457.2	459.8	460.6	7.3	7.3	7.6	353	351	354	25.7	25.9	25.2	268.4	243.4	104.1	287.9	0.93	0.93	0.94	50.09
7/21/2015	3:04:00 PM	459.2	461.7	462.4	7.4	7.3	7.7	352	350	353	25.8	26.0	25.2	268.4	247.9	104.3	288.0	0.93	0.93	0.94	50.09
7/21/2015	3:05:00 PM	460.8	463.1	464.0	7.4	7.3	7.6	351	349	351	25.8	26.0	25.3	268.4	252.4	104.4	288.0	0.93	0.93	0.94	50.12
7/21/2015	3:06:00 PM	461.9	464.2	465.0	7.3	7.2	7.5	350	348	351	25.8	26.0	25.3	268.5	256.9	104.6	288.1	0.93	0.93	0.94	50.14
7/21/2015	3:07:00 PM	462.1	464.4	465.3	7.3	7.2	7.4	350	348	351	25.7	25.8	25.2	268.5	261.3	104.7	288.2	0.93	0.93	0.94	50.17
7/21/2015	3:08:00 PM	462.8	465.1	465.9	7.3	7.3	7.5	350	347	350	25.8	25.9	25.3	268.5	265.8	104.7	288.2	0.93	0.93	0.94	50.21
7/21/2015	3:09:00 PM	462.6	464.8	465.7	7.3	7.2	7.5	350	348	350	25.7	25.8	25.2	268.6	270.3	104.8	288.3	0.93	0.93	0.94	50.23
7/21/2015	3:10:00 PM	461.3	463.6	464.4	7.4	7.3	7.5	351	349	352	25.5	25.6	25.1	268.5	274.8	104.9	288.3	0.93	0.93	0.93	50.24
7/21/2015	3:11:00 PM	459.6	462.0	462.7	7.3	7.2	7.6	352	350	353	25.5	25.6	25.0	268.6	279.2	104.9	288.3	0.93	0.93	0.93	50.22
7/21/2015	3:12:00 PM	460.3	462.6	463.5	7.4	7.3	7.6	352	349	352	25.5	25.7	25.0	268.7	283.7	104.8	288.4	0.93	0.93	0.93	50.19
7/21/2015	3:13:00 PM	460.1	462.4	463.2	7.3	7.3	7.5	352	350	352	25.6	25.7	25.1	268.7	288.2	104.8	288.4	0.93	0.93	0.93	50.17
7/21/2015	3:14:00 PM	460.2	462.5	463.2	7.5	7.4	7.7	352	350	353	25.5	25.7	25.1	268.7	292.7	105.0	288.5	0.93	0.93	0.93	50.15
7/21/2015	3:15:00 PM	459.7	462.1	462.9	7.5	7.4	7.7	352	350	353	25.6	25.8	25.1	268.7	297.1	104.9	288.5	0.93	0.93	0.93	50.13
7/21/2015	3:16:00 PM	460.0	462.5	463.2	7.3	7.3	7.5	352	350	353	25.5	25.7	25.0	268.8	301.6	105.0	288.5	0.93	0.93	0.94	50.11
7/21/2015	3:17:00 PM	464.5	466.9	467.8	5.3	5.2	5.4	220	218	221	27.8	28.3	27.2	169.0	304.4	66.4	181.5	0.93	0.93	0.93	50.09
7/21/2015	3:18:00 PM	467.5	469.9	470.8	3.8	3.6	3.9	118	117	119	29.8	30.6	28.9	91.5	306.0	36.6	98.5	0.93	0.93	0.93	50.06
7/21/2015	3:19:00 PM	465.3	467.4	468.6	3.0	2.8	3.2	71	69	71	34.1	35.3	32.2	53.5	306.9	23.3	58.4	0.91	0.91	0.92	50.03
7/21/2015	3:20:00 PM	466.4	468.5	469.7	3.2	2.9	3.3	69	67	70	34.1	35.4	32.4	52.3	307.7	22.9	57.1	0.91	0.91	0.92	50.02
7/21/2015	3:21:00 PM	465.5	467.7	468.9	3.2	3.0	3.3	69	67	70	34.1	35.5	32.4	52.3	308.6	22.9	57.1	0.91	0.91	0.92	50.02
7/21/2015	3:22:00 PM	466.1	468.3	469.4	3.5	3.1	3.5	69	67	70	34.2	35.9	32.5	52.3	309.5	22.9	57.1	0.91	0.91	0.92	50.04
7/21/2015	3:23:00 PM	465.8	467.7	469.2	3.3	2.9	3.3	69	67	70	34.2	36.0	32.5	52.2	310.3	23.0	57.1	0.91	0.91	0.92	50.04
7/21/2015	3:24:00 PM	464.3	466.4	467.7	3.6	3.2	3.6	91	89	92	33.4	35.0	31.8	69.0	311.5	29.3	75.0	0.91	0.91	0.92	50.01
7/21/2015	3:25:00 PM	457.8	460.2	461.2	7.4	7.3	7.5	338	335	338	25.8	26.0	25.3	256.5	315.8	100.6	275.5	0.93	0.93	0.93	50.01
7/21/2015	3:26:00 PM	465.3	467.6	468.7	3.3	3.1	3.5	84	83	86	24.1	26.6	35.3	64.6	316.8	26.5	70.0	0.69	0.70	0.73	50.02
7/21/2015	3:27:00 PM	464.4	466.7	467.8	4.0	3.8	4.1	120	119	121	29.6	30.5	28.7	92.3	318.4	36.7	99.3	0.93	0.93	0.93	50.03
7/21/2015	3:28:00 PM	464.8	467.0	468.2	4.0	3.9	4.2	120	119	121	29.6	30.5	28.6	92.4	319.9	36.8	99.5	0.93	0.93	0.93	50.04
7/21/2015	3:29:00 PM	464.3	466.5	467.6	4.0	3.9	4.2	121	119	121	29.5	30.3	28.6	92.4	321.5	36.8	99.5	0.93	0.93	0.93	50.01
7/21/2015	3:30:00 PM	465.9	467.9	469.1	3.3	3.2	3.6	85	83	85	31.7	33.0	30.4	64.6	322.5	27.0	70.0	0.92	0.92	0.93	50.00

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	3:31:00 PM	465.1	467.2	468.2	2.8	2.7	2.9	62	61	63	20.0	20.4	22.1	47.3	323.3	19.4	51.2	0.52	0.52	0.53	49.98
7/21/2015	3:32:00 PM	467.0	469.2	469.9	1.7	1.4	1.6	-	-	-	-	-	-	-	323.3	-	-	-	-	-	49.95
7/21/2015	3:33:00 PM	466.5	468.5	469.5	2.1	1.8	2.1	11	11	12	1.9	1.9	6.9	8.4	323.5	3.7	9.3	0.07	0.07	0.09	49.99
7/21/2015	3:34:00 PM	462.1	464.1	465.0	5.8	5.7	5.9	227	225	228	27.0	27.4	26.6	174.0	326.4	66.2	186.2	0.93	0.93	0.94	50.02
7/21/2015	3:35:00 PM	461.1	463.1	464.1	6.9	6.9	7.2	302	300	302	25.9	26.2	25.5	230.7	330.2	87.2	246.7	0.93	0.93	0.94	50.02
7/21/2015	3:36:00 PM	461.8	463.8	465.0	6.8	6.8	7.0	290	287	290	26.1	26.4	25.7	221.6	333.9	83.8	236.9	0.93	0.93	0.94	50.01
7/21/2015	3:37:00 PM	461.8	463.7	464.8	6.7	6.7	6.9	285	282	285	26.2	26.5	25.7	217.6	337.5	82.5	232.8	0.93	0.93	0.94	50.04
7/21/2015	3:38:00 PM	462.1	464.1	465.2	6.4	6.4	6.6	266	264	267	26.4	26.8	26.0	204.0	340.9	77.7	218.3	0.93	0.93	0.94	50.06
7/21/2015	3:39:00 PM	462.3	464.1	465.2	5.9	5.9	6.1	236	234	237	26.8	27.3	26.4	181.0	344.0	69.1	193.8	0.93	0.93	0.94	50.05
7/21/2015	3:40:00 PM	457.4	459.4	460.4	7.4	7.4	7.6	346	343	346	25.6	25.9	25.1	262.1	348.3	98.6	280.0	0.93	0.93	0.94	50.05
7/21/2015	3:41:00 PM	456.0	458.0	458.9	7.5	7.4	7.6	351	349	351	25.4	25.7	25.0	265.4	352.7	99.9	283.6	0.93	0.93	0.94	50.02
7/21/2015	3:42:00 PM	456.3	458.4	459.1	7.1	7.1	7.4	332	330	332	25.7	26.0	25.2	251.2	356.9	94.8	268.5	0.93	0.93	0.94	49.98
7/21/2015	3:43:00 PM	457.0	459.2	460.0	6.0	5.9	6.2	262	261	263	26.5	26.8	26.0	199.1	360.2	75.4	212.9	0.93	0.93	0.94	49.96
7/21/2015	3:44:00 PM	458.1	460.2	461.0	5.7	5.6	5.9	251	249	252	26.5	26.8	26.0	190.8	363.4	72.5	204.1	0.93	0.93	0.94	49.96
7/21/2015	3:45:00 PM	456.6	458.9	459.4	6.8	6.8	7.0	329	326	329	25.5	25.8	25.1	248.7	367.6	94.4	266.0	0.93	0.93	0.94	49.93
7/21/2015	3:46:00 PM	458.3	460.4	461.1	6.0	6.0	6.2	273	271	273	26.2	26.4	25.7	207.3	371.0	78.9	221.8	0.93	0.93	0.94	49.93
7/21/2015	3:47:00 PM	457.7	459.7	460.5	6.0	6.0	6.2	266	264	266	26.3	26.5	25.8	201.5	374.4	76.8	215.7	0.93	0.93	0.94	49.94
7/21/2015	3:48:00 PM	458.6	460.5	461.5	5.8	5.8	6.1	246	245	247	26.6	27.0	26.1	187.4	377.5	71.6	200.6	0.93	0.93	0.94	49.95
7/21/2015	3:49:00 PM	457.2	459.2	460.1	6.4	6.4	6.7	292	290	293	26.1	26.3	25.6	221.5	381.2	84.3	237.0	0.93	0.93	0.94	49.95
7/21/2015	3:50:00 PM	457.4	459.5	460.5	6.9	6.8	7.2	318	315	318	25.9	26.1	25.3	241.0	385.2	91.5	257.8	0.93	0.93	0.94	49.95
7/21/2015	3:51:00 PM	458.2	460.1	461.1	6.4	6.3	6.6	284	282	285	26.3	26.4	25.7	216.0	388.8	82.1	231.1	0.93	0.93	0.94	49.96
7/21/2015	3:52:00 PM	457.9	460.0	461.0	6.3	6.2	6.4	277	275	277	26.2	26.5	25.8	210.4	392.3	79.9	225.1	0.93	0.93	0.94	49.99
7/21/2015	3:53:00 PM	457.3	459.3	460.3	6.7	6.6	6.9	302	300	302	26.0	26.2	25.5	229.2	396.1	87.0	245.1	0.93	0.93	0.94	50.01
7/21/2015	3:54:00 PM	456.9	458.9	459.9	6.8	6.8	7.1	307	304	307	26.0	26.2	25.5	232.2	400.0	88.4	248.5	0.93	0.93	0.94	50.04
7/21/2015	3:55:00 PM	457.4	459.1	460.3	6.7	6.6	6.9	297	294	297	26.1	26.4	25.6	225.0	403.8	85.9	240.8	0.93	0.93	0.94	50.03
7/21/2015	3:56:00 PM	457.7	459.7	461.0	6.3	6.3	6.7	283	280	283	26.3	26.5	25.8	214.8	407.3	82.0	229.9	0.93	0.93	0.94	50.00
7/21/2015	3:57:00 PM	458.1	460.2	461.2	6.5	6.4	6.7	294	292	294	26.2	26.4	25.6	223.3	411.1	85.4	239.1	0.93	0.93	0.94	49.96
7/21/2015	3:58:00 PM	458.2	460.2	461.4	6.6	6.5	6.8	299	296	298	26.1	26.4	25.6	226.8	414.8	86.7	242.8	0.93	0.93	0.94	49.94
7/21/2015	3:59:00 PM	458.0	459.9	461.2	6.7	6.6	6.9	305	302	304	26.2	26.4	25.6	231.2	418.7	88.4	247.6	0.93	0.93	0.94	49.95
7/21/2015	4:00:00 PM	458.4	460.4	461.5	6.5	6.5	6.8	294	292	294	26.3	26.5	25.6	223.5	422.4	85.5	239.3	0.93	0.93	0.94	49.96

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	4:01:00 PM	458.0	460.1	461.2	6.4	6.3	6.7	284	282	284	26.5	26.7	25.8	215.9	426.0	82.6	231.2	0.93	0.93	0.94	49.97
7/21/2015	4:02:00 PM	458.6	460.7	461.9	6.3	6.2	6.5	280	277	280	26.3	26.6	25.7	212.7	429.6	81.6	227.9	0.93	0.93	0.94	49.99
7/21/2015	4:03:00 PM	456.9	459.2	460.2	6.9	6.9	7.2	332	330	333	25.7	25.9	25.2	251.8	433.8	96.7	269.7	0.93	0.93	0.94	50.01
7/21/2015	4:04:00 PM	456.5	458.6	459.7	7.3	7.3	7.5	353	351	353	25.5	25.6	25.0	267.3	438.2	102.5	286.3	0.93	0.93	0.94	49.98
7/21/2015	4:05:00 PM	455.9	458.2	459.2	7.2	7.2	7.4	350	348	350	25.6	25.8	25.0	264.9	442.6	101.0	283.5	0.93	0.93	0.94	49.98
7/21/2015	4:06:00 PM	455.4	457.4	458.5	7.3	7.3	7.5	349	347	349	25.8	25.9	25.1	263.6	447.0	100.1	282.0	0.93	0.93	0.94	50.00
7/21/2015	4:07:00 PM	455.2	457.4	458.4	7.3	7.2	7.5	350	348	350	25.6	25.8	25.0	264.0	451.4	100.2	282.4	0.93	0.93	0.94	50.05
7/21/2015	4:08:00 PM	456.6	458.7	459.7	7.3	7.2	7.5	349	347	349	25.7	25.8	25.1	264.2	455.8	100.5	282.7	0.93	0.93	0.94	50.08
7/21/2015	4:09:00 PM	455.9	457.8	458.9	7.2	7.3	7.5	350	348	350	25.7	25.8	25.0	264.5	460.2	100.7	283.0	0.93	0.93	0.94	50.08
7/21/2015	4:10:00 PM	455.1	457.1	458.1	7.2	7.2	7.5	351	349	351	25.6	25.7	25.0	264.9	464.7	101.0	283.5	0.93	0.93	0.94	50.07
7/21/2015	4:11:00 PM	454.2	456.3	457.2	7.3	7.3	7.5	352	350	352	25.7	25.7	25.0	265.0	469.1	101.1	283.6	0.93	0.93	0.94	50.04
7/21/2015	4:12:00 PM	453.1	455.2	456.1	7.3	7.3	7.6	353	351	353	25.7	25.7	25.0	265.1	473.5	101.2	283.7	0.93	0.93	0.94	50.02
7/21/2015	4:13:00 PM	452.6	454.7	455.7	7.3	7.3	7.5	353	351	353	25.8	25.7	25.1	264.9	477.9	101.2	283.6	0.93	0.93	0.94	49.98
7/21/2015	4:14:00 PM	454.0	456.0	456.9	7.3	7.3	7.6	352	350	352	25.8	25.8	25.1	265.2	482.3	101.3	283.9	0.93	0.93	0.94	49.96
7/21/2015	4:15:00 PM	454.3	456.3	457.3	7.3	7.4	7.7	352	350	352	25.8	25.8	25.1	265.2	486.7	101.5	284.0	0.93	0.93	0.94	49.93
7/21/2015	4:16:00 PM	454.6	456.6	457.7	7.3	7.3	7.6	352	350	352	25.8	25.8	25.1	265.6	491.2	101.9	284.5	0.93	0.93	0.94	49.93
7/21/2015	4:17:00 PM	455.3	457.5	458.5	7.2	7.3	7.6	352	350	352	25.8	25.8	25.1	265.7	495.6	102.1	284.7	0.93	0.93	0.94	49.93
7/21/2015	4:18:00 PM	456.1	458.3	459.2	7.3	7.3	7.5	351	349	352	25.8	25.8	25.0	265.9	500.0	102.3	285.0	0.93	0.93	0.94	49.91
7/21/2015	4:19:00 PM	457.1	459.1	460.1	7.2	7.1	7.4	350	348	350	25.8	25.8	25.1	265.7	504.5	102.2	284.7	0.93	0.93	0.94	49.92
7/21/2015	4:20:00 PM	460.3	462.2	463.3	7.1	7.2	7.4	349	346	349	25.9	26.0	25.2	266.3	508.9	102.3	285.2	0.93	0.93	0.94	49.98
7/21/2015	4:21:00 PM	459.4	461.3	462.5	7.1	7.1	7.4	349	347	349	25.9	25.9	25.2	266.2	513.3	102.4	285.3	0.93	0.93	0.94	50.01
7/21/2015	4:22:00 PM	459.1	460.9	462.2	7.2	7.2	7.4	350	348	350	25.9	25.9	25.1	266.4	517.8	102.7	285.5	0.93	0.93	0.94	50.04
7/21/2015	4:23:00 PM	459.4	461.5	462.6	7.1	7.1	7.4	349	347	350	25.9	26.0	25.2	266.6	522.2	102.7	285.7	0.93	0.93	0.94	50.04
7/21/2015	4:24:00 PM	458.9	461.0	462.0	7.1	7.2	7.4	350	348	351	25.9	25.9	25.1	266.9	526.7	103.2	286.2	0.93	0.93	0.94	50.03
7/21/2015	4:25:00 PM	458.4	460.3	461.8	7.3	7.4	7.6	351	349	351	25.9	25.8	25.1	267.2	531.1	103.8	286.7	0.93	0.93	0.94	50.02
7/21/2015	4:26:00 PM	459.4	461.3	462.8	7.2	7.2	7.5	351	348	351	26.0	26.1	25.3	267.5	535.6	103.7	286.9	0.93	0.93	0.94	50.01
7/21/2015	4:27:00 PM	459.4	461.4	462.7	7.3	7.2	7.6	351	349	351	26.1	26.2	25.3	267.7	540.0	103.7	287.1	0.93	0.93	0.94	50.00
7/21/2015	4:28:00 PM	457.6	459.8	461.0	7.1	7.2	7.5	353	350	353	26.0	26.0	25.3	267.9	544.5	104.2	287.5	0.93	0.93	0.94	49.99
7/21/2015	4:29:00 PM	458.8	460.8	462.0	7.2	7.2	7.6	352	350	352	26.2	26.1	25.4	268.0	549.0	104.3	287.6	0.93	0.93	0.94	49.97
7/21/2015	4:30:00 PM	458.5	460.5	461.6	7.4	7.5	7.7	352	350	352	26.3	26.2	25.5	268.0	553.4	104.3	287.6	0.93	0.93	0.94	49.94

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	4:31:00 PM	458.3	460.3	461.6	7.5	7.6	7.9	352	351	353	26.4	26.2	25.6	268.2	557.9	104.6	287.9	0.93	0.93	0.94	49.94
7/21/2015	4:32:00 PM	459.2	461.3	462.4	7.5	7.5	7.8	352	350	352	26.3	26.2	25.5	268.3	562.4	104.7	288.0	0.93	0.93	0.94	49.94
7/21/2015	4:33:00 PM	457.8	459.9	460.8	7.4	7.5	7.8	353	351	353	26.3	26.2	25.5	268.3	566.9	104.8	288.1	0.93	0.93	0.93	49.91
7/21/2015	4:34:00 PM	458.2	460.4	461.4	7.4	7.5	7.8	353	351	353	26.3	26.1	25.5	268.4	571.3	104.9	288.2	0.93	0.93	0.93	49.91
7/21/2015	4:35:00 PM	457.4	459.5	460.6	7.4	7.5	7.8	354	352	354	26.2	26.1	25.4	268.5	575.8	105.3	288.5	0.93	0.93	0.93	49.90
7/21/2015	4:36:00 PM	457.6	459.6	460.8	7.5	7.6	7.8	354	352	354	26.1	26.1	25.3	268.6	580.3	105.7	288.6	0.93	0.93	0.93	49.90
7/21/2015	4:37:00 PM	456.1	458.2	459.4	7.6	7.7	7.9	355	353	355	25.9	25.8	25.1	268.7	584.8	105.9	288.8	0.93	0.93	0.93	49.93
7/21/2015	4:38:00 PM	456.7	458.8	460.1	7.7	7.7	8.0	354	352	355	26.0	25.9	25.2	268.6	589.2	105.7	288.7	0.93	0.93	0.93	49.95
7/21/2015	4:39:00 PM	456.1	458.3	459.5	7.6	7.7	7.9	355	353	355	26.0	25.9	25.2	268.6	593.7	105.7	288.7	0.93	0.93	0.93	50.01
7/21/2015	4:40:00 PM	457.1	459.3	460.4	7.6	7.7	7.9	354	352	355	26.0	26.0	25.3	268.7	598.2	105.8	288.8	0.93	0.93	0.93	50.03
7/21/2015	4:41:00 PM	457.3	459.6	460.6	7.4	7.5	7.8	354	352	354	26.2	26.1	25.4	268.7	602.7	105.5	288.6	0.93	0.93	0.93	50.04
7/21/2015	4:42:00 PM	456.6	458.8	460.0	7.5	7.5	7.8	354	352	355	26.0	25.9	25.2	268.7	607.1	105.6	288.7	0.93	0.93	0.93	50.03
7/21/2015	4:43:00 PM	456.5	458.5	460.0	7.5	7.5	7.7	354	352	355	26.0	25.9	25.3	268.6	611.6	105.5	288.6	0.93	0.93	0.93	50.03
7/21/2015	4:44:00 PM	455.6	457.8	459.0	7.3	7.4	7.7	355	353	356	26.0	25.9	25.3	268.7	616.1	105.4	288.6	0.93	0.93	0.93	50.01
7/21/2015	4:45:00 PM	454.6	456.8	458.2	7.4	7.4	7.7	356	354	356	26.0	25.9	25.2	268.7	620.6	105.5	288.7	0.93	0.93	0.93	49.99
7/21/2015	4:46:00 PM	454.7	457.0	458.2	7.4	7.4	7.7	356	354	356	26.0	25.9	25.3	268.7	625.1	105.4	288.7	0.93	0.93	0.93	49.99
7/21/2015	4:47:00 PM	455.6	457.7	459.1	7.3	7.3	7.5	355	353	356	26.1	26.0	25.3	268.7	629.5	105.3	288.6	0.93	0.93	0.93	49.97
7/21/2015	4:48:00 PM	456.5	458.7	459.9	7.3	7.3	7.6	354	352	355	26.1	26.1	25.4	268.7	634.0	105.2	288.6	0.93	0.93	0.93	49.99
7/21/2015	4:49:00 PM	455.7	457.8	459.1	7.3	7.2	7.6	355	353	356	26.1	26.0	25.4	268.7	638.5	105.3	288.7	0.93	0.93	0.93	49.97
7/21/2015	4:50:00 PM	455.1	457.0	458.4	7.2	7.3	7.6	356	354	356	26.0	26.0	25.3	268.8	643.0	105.5	288.8	0.93	0.93	0.93	49.95
7/21/2015	4:51:00 PM	455.2	457.4	458.7	7.2	7.2	7.4	356	353	356	26.0	26.0	25.3	268.8	647.5	105.4	288.8	0.93	0.93	0.93	49.94
7/21/2015	4:52:00 PM	461.3	463.5	465.0	4.7	4.7	5.0	180	178	181	28.8	28.9	27.6	137.7	649.8	54.2	148.0	0.93	0.93	0.94	49.93
7/21/2015	4:53:00 PM	461.4	463.6	464.9	4.5	4.4	4.7	164	163	165	29.1	29.3	27.9	125.6	651.8	49.5	135.0	0.93	0.93	0.93	49.93
7/21/2015	4:54:00 PM	462.7	464.8	466.2	4.0	3.8	4.2	125	123	125	30.6	31.1	29.2	95.3	653.4	38.4	102.7	0.92	0.93	0.93	49.91
7/21/2015	4:55:00 PM	463.4	465.4	466.8	3.7	3.6	4.0	124	123	125	30.6	31.0	29.1	94.8	655.0	38.3	102.2	0.92	0.93	0.93	49.91
7/21/2015	4:56:00 PM	465.1	467.2	468.6	3.5	3.2	3.7	99	98	100	32.5	33.5	30.8	75.6	656.3	31.6	82.0	0.92	0.92	0.93	49.89
7/21/2015	4:57:00 PM	467.9	470.0	471.3	3.5	3.2	3.6	80	78	80	34.8	35.8	32.6	60.6	657.3	26.6	66.2	0.91	0.91	0.92	49.88
7/21/2015	4:58:00 PM	467.7	469.6	471.0	3.4	3.1	3.6	94	92	94	33.8	34.7	31.7	71.5	658.5	30.5	77.8	0.91	0.92	0.92	49.85
7/21/2015	4:59:00 PM	467.3	469.2	470.4	3.4	2.9	3.2	28	28	29	5.2	5.5	11.1	21.5	658.8	8.8	23.4	0.10	0.10	0.12	49.83
7/21/2015	5:00:00 PM	466.7	468.6	469.8	3.3	2.6	2.9	-	-	-	-	-	-	-	658.8	-	-	-	-	-	49.84

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	5:01:00 PM	468.4	470.2	471.5	3.4	2.7	3.0	-	-	1	-	-	-	0.0	658.8	-0.2	0.2	-	-	-	49.86
7/21/2015	5:02:00 PM	464.7	466.7	467.9	4.9	4.5	4.9	140	139	141	15.9	16.1	19.1	107.0	660.6	40.8	114.8	0.54	0.54	0.55	49.88
7/21/2015	5:03:00 PM	459.8	461.9	463.1	6.9	6.7	7.0	311	308	310	26.5	26.7	25.9	236.9	664.6	88.8	253.0	0.93	0.93	0.94	49.93
7/21/2015	5:04:00 PM	461.5	463.7	464.8	6.9	6.7	7.1	312	309	312	26.4	26.7	25.8	239.0	668.6	89.7	255.3	0.93	0.93	0.94	49.99
7/21/2015	5:05:00 PM	462.1	464.2	465.6	6.2	6.1	6.4	283	280	283	26.7	27.0	26.0	217.0	672.2	81.8	231.9	0.93	0.93	0.94	50.03
7/21/2015	5:06:00 PM	463.2	465.4	466.6	5.6	5.4	5.8	234	232	234	27.4	27.8	26.7	180.0	675.2	68.1	192.4	0.93	0.93	0.94	50.01
7/21/2015	5:07:00 PM	463.9	466.0	466.9	5.5	5.3	5.7	211	209	211	27.7	28.3	27.1	162.3	677.9	61.8	173.6	0.93	0.93	0.94	50.01
7/21/2015	5:08:00 PM	463.4	465.4	466.4	5.7	5.4	5.9	206	204	206	27.8	28.5	27.3	158.2	680.5	60.3	169.3	0.93	0.93	0.94	50.01
7/21/2015	5:09:00 PM	461.2	463.3	464.2	6.2	6.0	6.3	251	249	251	27.0	27.5	26.6	192.0	683.7	73.5	205.6	0.93	0.93	0.94	50.03
7/21/2015	5:10:00 PM	461.1	463.4	464.0	6.4	6.2	6.6	251	249	252	27.1	27.4	26.5	192.2	686.9	73.9	205.9	0.93	0.93	0.94	50.06
7/21/2015	5:11:00 PM	459.8	462.0	462.9	7.0	6.8	7.1	302	300	302	26.6	26.8	26.0	230.4	690.8	88.1	246.7	0.93	0.93	0.94	50.06
7/21/2015	5:12:00 PM	462.2	464.4	465.1	6.1	6.0	6.3	245	243	245	27.2	27.4	26.6	187.7	693.9	72.1	201.1	0.93	0.93	0.94	50.08
7/21/2015	5:13:00 PM	459.6	462.0	462.7	7.4	7.3	7.5	345	342	345	25.8	26.1	25.5	263.0	698.3	100.5	281.6	0.93	0.93	0.94	50.09
7/21/2015	5:14:00 PM	459.3	461.5	462.3	7.4	7.3	7.6	348	346	349	25.8	26.1	25.5	265.6	702.7	100.9	284.1	0.93	0.93	0.94	50.10
7/21/2015	5:15:00 PM	458.9	460.9	462.1	7.5	7.4	7.6	350	347	350	25.8	26.1	25.5	266.3	707.1	101.0	284.8	0.93	0.93	0.94	50.08
7/21/2015	5:16:00 PM	460.7	462.7	463.7	6.9	6.8	7.1	312	310	312	26.2	26.5	25.8	238.7	711.1	91.1	255.5	0.93	0.93	0.94	50.08
7/21/2015	5:17:00 PM	462.4	464.4	465.4	6.6	6.5	6.8	289	286	289	26.5	26.8	26.1	221.6	714.8	84.7	237.2	0.93	0.93	0.94	50.06
7/21/2015	5:18:00 PM	460.6	462.5	463.6	6.8	6.7	7.0	314	311	314	26.2	26.5	25.8	239.8	718.8	91.6	256.7	0.93	0.93	0.94	50.04
7/21/2015	5:19:00 PM	459.8	461.9	463.0	7.2	7.1	7.3	337	335	337	25.9	26.1	25.6	257.2	723.1	98.4	275.4	0.93	0.93	0.94	50.05
7/21/2015	5:20:00 PM	460.1	462.3	463.3	7.3	7.2	7.4	340	337	340	25.9	26.2	25.6	259.2	727.4	99.1	277.5	0.93	0.93	0.94	50.03
7/21/2015	5:21:00 PM	462.3	464.5	465.5	6.6	6.4	6.7	291	288	291	26.4	26.7	26.0	223.1	731.1	85.5	239.0	0.93	0.93	0.94	50.05
7/21/2015	5:22:00 PM	462.8	465.1	466.1	6.6	6.4	6.7	293	291	293	26.4	26.7	26.0	225.1	734.9	86.3	241.1	0.93	0.93	0.94	50.04
7/21/2015	5:23:00 PM	463.3	465.4	466.6	6.9	6.8	7.1	318	315	318	26.2	26.6	25.7	244.5	738.9	93.5	261.8	0.93	0.93	0.94	50.04
7/21/2015	5:24:00 PM	462.2	464.6	465.6	7.2	7.0	7.4	334	332	334	26.1	26.4	25.6	256.5	743.2	98.0	274.6	0.93	0.93	0.94	50.01
7/21/2015	5:25:00 PM	461.4	463.7	464.7	7.3	7.2	7.4	346	344	347	25.8	26.2	25.5	265.2	747.6	100.8	283.8	0.93	0.93	0.94	50.02
7/21/2015	5:26:00 PM	460.8	463.0	464.2	7.3	7.1	7.4	348	346	348	25.9	26.2	25.4	266.1	752.1	101.3	284.8	0.93	0.93	0.94	49.98
7/21/2015	5:27:00 PM	461.8	464.0	465.1	7.4	7.2	7.4	347	345	347	25.9	26.3	25.5	266.1	756.5	101.3	284.8	0.93	0.93	0.94	49.97
7/21/2015	5:28:00 PM	461.0	463.1	464.4	7.3	7.1	7.4	348	346	348	25.8	26.2	25.4	266.2	761.0	101.6	284.9	0.93	0.93	0.94	49.99
7/21/2015	5:29:00 PM	462.4	464.6	465.8	7.2	7.1	7.4	347	345	347	26.0	26.3	25.5	266.5	765.4	101.6	285.3	0.93	0.93	0.94	50.01
7/21/2015	5:30:00 PM	464.0	466.3	467.4	7.3	7.1	7.5	346	343	346	25.9	26.3	25.6	266.3	769.8	101.8	285.1	0.93	0.93	0.94	49.99

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	5:31:00 PM	463.9	466.3	467.4	7.3	7.2	7.4	346	343	346	25.9	26.2	25.5	266.1	774.3	102.0	285.0	0.93	0.93	0.94	49.96
7/21/2015	5:32:00 PM	464.1	466.4	467.5	7.4	7.3	7.5	345	343	345	26.0	26.3	25.5	265.7	778.7	101.7	284.5	0.93	0.93	0.94	49.98
7/21/2015	5:33:00 PM	463.5	465.9	466.8	7.4	7.2	7.6	345	343	346	26.0	26.3	25.5	265.7	783.1	101.8	284.5	0.93	0.93	0.94	49.98
7/21/2015	5:34:00 PM	464.3	466.6	467.5	7.4	7.3	7.5	346	343	346	25.9	26.1	25.5	266.3	787.6	102.7	285.5	0.93	0.93	0.94	50.01
7/21/2015	5:35:00 PM	464.7	466.9	467.9	7.4	7.4	7.6	345	343	346	25.9	26.1	25.5	266.2	792.0	102.7	285.4	0.93	0.93	0.94	50.05
7/21/2015	5:36:00 PM	465.5	467.8	468.9	7.5	7.5	7.7	345	343	346	25.9	26.1	25.5	266.7	796.4	103.2	286.0	0.93	0.93	0.94	50.05
7/21/2015	5:37:00 PM	466.4	468.5	469.6	7.5	7.4	7.6	344	342	345	25.8	26.1	25.4	266.4	800.9	103.1	285.7	0.93	0.93	0.94	50.05
7/21/2015	5:38:00 PM	466.1	468.4	469.3	7.4	7.3	7.6	344	342	345	25.9	26.2	25.5	266.3	805.3	102.8	285.5	0.93	0.93	0.94	50.05
7/21/2015	5:39:00 PM	466.7	468.8	469.6	7.3	7.2	7.5	344	342	345	25.9	26.1	25.5	266.7	809.8	103.0	285.9	0.93	0.93	0.94	50.04
7/21/2015	5:40:00 PM	465.9	467.9	468.7	7.2	7.1	7.4	345	343	346	25.9	26.1	25.5	266.8	814.2	102.9	286.0	0.93	0.93	0.94	50.01
7/21/2015	5:41:00 PM	465.3	467.4	468.2	7.3	7.2	7.5	345	343	346	25.9	26.2	25.5	266.6	818.7	102.8	285.8	0.93	0.93	0.94	49.96
7/21/2015	5:42:00 PM	466.4	468.5	469.3	7.2	7.1	7.4	344	342	345	25.9	26.2	25.5	266.5	823.1	102.7	285.6	0.93	0.93	0.94	49.94
7/21/2015	5:43:00 PM	466.6	468.6	469.5	7.4	7.3	7.5	344	342	345	25.9	26.1	25.5	266.4	827.5	103.2	285.7	0.93	0.93	0.94	49.93
7/21/2015	5:44:00 PM	468.5	470.7	471.5	7.3	7.2	7.5	343	341	344	25.9	26.1	25.5	266.9	832.0	103.6	286.3	0.93	0.93	0.94	49.91
7/21/2015	5:45:00 PM	468.1	470.1	470.8	7.4	7.3	7.5	344	341	344	26.0	26.2	25.5	266.8	836.4	103.4	286.1	0.93	0.93	0.94	49.90
7/21/2015	5:46:00 PM	468.2	470.3	471.1	7.3	7.2	7.5	343	341	344	26.0	26.3	25.5	266.9	840.9	103.4	286.2	0.93	0.93	0.94	49.88
7/21/2015	5:47:00 PM	467.9	470.2	471.0	7.3	7.1	7.5	344	342	344	26.1	26.4	25.5	267.0	845.3	103.3	286.3	0.93	0.93	0.94	49.88
7/21/2015	5:48:00 PM	467.2	469.3	470.2	7.5	7.3	7.6	344	342	345	26.1	26.4	25.5	267.2	849.8	103.6	286.6	0.93	0.93	0.94	49.88
7/21/2015	5:49:00 PM	467.9	470.2	470.9	7.3	7.3	7.6	344	342	344	26.2	26.4	25.5	267.2	854.2	103.7	286.6	0.93	0.93	0.94	49.91
7/21/2015	5:50:00 PM	467.0	469.1	469.8	7.5	7.3	7.7	345	343	346	26.1	26.3	25.6	267.4	858.7	104.0	286.9	0.93	0.93	0.94	49.91
7/21/2015	5:51:00 PM	464.9	467.1	467.8	7.5	7.4	7.6	347	345	347	25.9	26.2	25.5	267.5	863.2	104.3	287.1	0.93	0.93	0.94	49.90
7/21/2015	5:52:00 PM	463.1	465.3	466.1	7.5	7.4	7.6	348	346	349	25.9	26.1	25.5	267.6	867.6	104.3	287.2	0.93	0.93	0.94	49.92
7/21/2015	5:53:00 PM	466.1	468.3	469.1	7.5	7.3	7.6	346	344	346	26.0	26.3	25.6	267.7	872.1	104.1	287.2	0.93	0.93	0.94	49.95
7/21/2015	5:54:00 PM	468.4	470.6	471.3	7.5	7.3	7.6	344	342	345	26.0	26.3	25.6	267.8	876.5	104.3	287.4	0.93	0.93	0.94	49.96
7/21/2015	5:55:00 PM	468.8	471.0	471.6	7.3	7.2	7.5	344	342	345	26.0	26.3	25.6	267.8	881.0	104.2	287.4	0.93	0.93	0.94	49.97
7/21/2015	5:56:00 PM	468.2	470.5	471.1	7.3	7.2	7.6	344	342	345	26.3	26.4	25.6	267.9	885.5	104.0	287.4	0.93	0.93	0.94	49.96
7/21/2015	5:57:00 PM	468.0	470.3	471.0	7.2	7.1	7.4	345	343	345	26.1	26.3	25.6	268.0	889.9	104.3	287.6	0.93	0.93	0.94	49.98
7/21/2015	5:58:00 PM	468.6	470.6	471.5	7.3	7.2	7.5	345	343	345	26.0	26.2	25.6	268.1	894.4	104.8	287.9	0.93	0.93	0.93	49.96
7/21/2015	5:59:00 PM	469.5	471.4	472.3	7.3	7.2	7.4	344	342	345	26.0	26.3	25.7	268.3	898.9	104.7	288.0	0.93	0.93	0.93	49.97
7/21/2015	6:00:00 PM	470.7	472.8	473.7	7.3	7.1	7.4	343	341	344	26.1	26.5	25.7	268.3	903.3	104.4	287.9	0.93	0.93	0.93	49.99

Date	Time	Voltage (Line)			%VTHD			Current (Line)			% ATHD			kW	kWh	kVAr	kVA	PF Line1			Hz
		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	Sum		Sum	Sum	L1	L2	L3	
7/21/2015	6:01:00 PM	470.8	472.9	474.0	7.1	6.9	7.3	343	341	343	26.2	26.6	25.7	268.3	907.8	104.1	287.7	0.93	0.93	0.94	49.98
7/21/2015	6:02:00 PM	470.7	472.7	473.9	6.9	6.7	7.2	343	341	343	26.3	26.5	25.6	268.2	912.3	104.0	287.7	0.93	0.93	0.94	50.02
7/21/2015	6:03:00 PM	471.4	473.4	474.5	7.1	7.0	7.3	343	340	343	26.0	26.4	25.6	268.3	916.8	104.6	287.9	0.93	0.93	0.93	50.05
7/21/2015	6:04:00 PM	471.6	473.6	474.9	7.2	7.0	7.3	343	340	343	26.0	26.3	25.6	268.3	921.2	104.7	288.1	0.93	0.93	0.93	50.08
7/21/2015	6:05:00 PM	472.6	474.7	475.6	7.2	7.1	7.4	342	340	343	26.0	26.3	25.6	268.4	925.7	104.8	288.2	0.93	0.93	0.93	50.10
7/21/2015	6:06:00 PM	473.9	476.0	476.9	7.2	7.1	7.4	341	339	342	26.1	26.4	25.6	268.5	930.2	104.8	288.3	0.93	0.93	0.93	50.11
7/21/2015	6:07:00 PM	475.0	476.9	477.9	7.2	7.0	7.3	341	338	341	26.1	26.5	25.6	268.5	934.7	104.7	288.2	0.93	0.93	0.93	50.12
7/21/2015	6:08:00 PM	475.6	477.8	478.6	7.2	7.0	7.4	340	338	341	26.1	26.6	25.6	268.6	939.1	104.8	288.3	0.93	0.93	0.93	50.11
7/21/2015	6:09:00 PM	475.3	477.7	478.2	7.1	6.9	7.3	340	338	341	26.1	26.6	25.6	268.6	943.6	104.7	288.3	0.93	0.93	0.94	50.09
7/21/2015	6:10:00 PM	472.3	474.9	475.3	7.3	7.1	7.5	342	340	343	26.1	26.4	25.6	268.7	948.1	104.9	288.5	0.93	0.93	0.93	50.05
7/21/2015	6:11:00 PM	480.9	483.4	484.0	3.2	2.9	3.1	21	21	22	4.9	5.0	8.4	16.0	948.4	7.4	17.9	0.07	0.07	0.08	50.05
7/21/2015	6:12:00 PM	481.1	483.6	484.1	3.5	3.0	3.1	-	-	0	-	-	-	0.0	948.4	-0.0	0.0	-	-	-	50.04