IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Nitte Conference on Advances in Electrical Engineering NCAEE-2016
NMAM Institute of Technology, Nitte
Vol. 4, Special Issue 2, April 2016

Exploring Energy Auditing in Dairy Industry

Vinutha K[1], Anand Bhat B[2], N. A. Ranjan[3], M. E. Tejamoorthy[4]

Research scholars, E & E Department, MEC, Hassan, India[1,2]

Associate Professors, E & E Department, MEC, Hassan, India[3,4]

Abstract: Energy is the main concern of every one as the conventional sources of energy are depleting and there is a notable growth in the industrial and domestic loads. To bridge this gap there is an immediate need to explore all possible avenues to generate energy and conserve energy. A lot of interest has been generated in the conduct of energy audits as a means to achieve energy conservation. With the advent of energy crisis and exponential hikes in the cost of different forms of energy, energy audit is manifesting its due importance in various sectors. Dairy industry uses electrical energy and thermal energy as main energy source. The total cost of energy plays a vital role in determining the product cost of a commodity. Therefore the identification of potential energy savings and implementation for a given industrial facility is important to ensure its competitive advantage over other similar industries. This paper presents such energy saving methods in a methodological approach, experienced during a preliminary energy audit of a large scale industry. The energy consumption and savings assessed in term of equipments used and its functional purpose. Investing to improve the energy efficiency of a dairy industry provides an immediate and relatively predictable cash flow resulting from lower energy bills.

Keywords: Energy sources, audit, consumption and conservation.

I. INTRODUCTION

India has emerged as the largest milk producing country in the world with present level of annual milk production estimated as 94.5 million tonnes. The dairy sector consumes a significant amount of energy in its heating, cooling and processing activities. Typical dairy plants derive about 70% of their energy requirements in the form of thermal energy and the remaining 30% is consumed in the form electricity. In this direction the energy audit (EA) will help to understand more about the ways energy and fuels used in the industry and helping engineers in identifying the areas where waste can occur and scope for improvement.

Here the dairy industry has been considered, to explore the energy conservation opportunities. Energy audit was carried out in Nandini Hi Tech Product Plant (NHPP) situated at Channarayapatna, Hassan Dist (Karnataka), a strategic location to handle the surplus milk of 4 lakh liters from Hassan, Mandya, Mysore, Shivmoga and Tumkur milk unions.

II. ENERGY AUDIT

A. Distribution system

The plant receives electricity from CESCOM (Chamundeshwari Electricity Supply Corporation Ltd.,) at 11KV with contract demand of 1500kVA and supply power to plant through two distribution transformers. The plant has stand-by DG (Diesel Generator) sets of capacity 1010kVA and 200kVA. Transformer 1 supplies power to refrigeration, LMP (liquid milk processing) plant and capacitor bank. Transformer 2 supplies power to powder plant, boiler, ETP (Effluent treatment plant) sections, lighting purpose and capacitor bank.
Table 1 gives the section wise connected and operating load details of the plant.

Table 1 Load Details (section wise)

SI. NO	Name of Feeder	Connected load in HP	Operated load in HP
1	Powder Plant	1350	1200
2	Dairy Plant	700	500
3	Refrigeration	933	666
4	Boiler	163	62
5	ETP	65	49
6	Lighting	175	105
TOTAL		**3386**	**2582**

B. Demand side management

The audit begins with a detailed analysis of the energy bills of the previous twelve months. This is important because: the bills show the proportionate use of each different energy source/load when compared to the total energy

DOI 10.17148/IJIREEICE/NCAEE.2016.18

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Nitte Conference on Advances in Electrical Engineering NCAEE-2016
NMAM Institute of Technology, Nitte
Vol. 4, Special Issue 2, April 2016

consumption. An examination of where energy is used can point out precisely unknown energy wastes. The total amount spent on energy usage decides the commodity rate.

Over and above, one year energy bills of NHPP dairy were collected from the concerned authorities and analyzed. Table 2 gives the details of energy bill for the years 2014-2015. The analysis of 2014-2015 energy bills reviled the load factor. In addition, milk input, output products and cash flow details were analyzed for the same years. Before March-2015, Powder Plant was completely running by Diesel Generator (DG) set to avoid the change in quality of powder due to any unavoidable interruption in power supply, which automatically leads to CIP (clean in place) mode, for an hour. The remaining section power requirement was taken care by CESCOM supply. Due to this, there was poor utilization of contract demand (1500kVA) and plant average maximum demand was 739.3 kVA (year 2014) and it can be observed in Fig. 1. Due to under utilization of MD (maximum demand) the company was bearing Rs. 191250 per month upto March-2015. 1200kVA UPS (uninterrupted power supply) at a cost of 1.35 crores was installed separately for powder plant operation which provides 30min backup under power interruption from April-2015. The CESCOM now provides electrical energy for all the sections including powder plant for dairy operation. This helped dairy in meeting its maximum demand.

Table 2 Energy bills for years 2014 and 2015 for NHPP

Month	**MD reading (kVA)**	**Demand charges @170 rs @340 rs**	**Energy charges @5.35 @5.65rs**	**kWh meter reading**	**kVAh reading**	**PF**	**Tax @6%**	**Rebate**	**Total charges (Rs)**
Jan-14	389.55	191250	1296507	234780	239445	0.95	77790.42	44767.5	1520880
Feb-14	401	191250	1051410	325662	342803	0.95	63084.60	-	1254096
Mar-14	491.85	191250	1492618	269490	274065	0.98	89557.11	61590	1711836
Apr-14	784.05	191250	1439904	260160	264735	0.98	86394.24	55323.75	1662224
May-14	960	191250	1590720	271012	274590	0.98	95443.20	42877	1834536
Jun-14	757.95	191250	1280220	218370	219915	0.99	76813.20	76813.2	1332098
Jul-14	790.8	191250	1520166	258361	263055	0.98	91519.99	38790	1769575
Aug-14	821.25	191250	1496760	254460	257595	0.98	90110.95	42082.5	1736865
Sep-14	825	191250	1424940	242490	255775	0.99	85787.39	40301.25	1666726
Oct-14	828.15	191250	1764600	299100	308775	0.97	105876.00	50475	2010652
Nov-14	825	191250	1567500	266250	274395	0.97	94050.00	37803.75	1815197
Dec-14	997	191250	1772610	300435	310785	0.97	106356.60	55061.25	2006388
Jan-15	529.8	191250	1693590	287265	294285	0.99	101615.40	46856.25	1939600
Feb-15	961.65	191250	1276710	217785	222780	0.96	76602.60	24963.75	1519598
Mar-15	800	191250	2522850	425475	435000	0.97	151371.00	91875	2769810
Apr-15	1295.7	220320	4000125	655305	659745	0.99	24007.55	15470	4061946
May-15	965.25	191250	2979564	489360	493935	0.97	178773.84	10255	3221440
Jun-15	0	191250	3575314	586230	590100	0.97	214518.88	8411	3832584
Jul-15	1212	206040	3597085	589770	591225	0.99	215825.12	9581	3870946
Aug-15	1380	234600	4057597	664650	669390	0.97	243455.84	9677	4356911

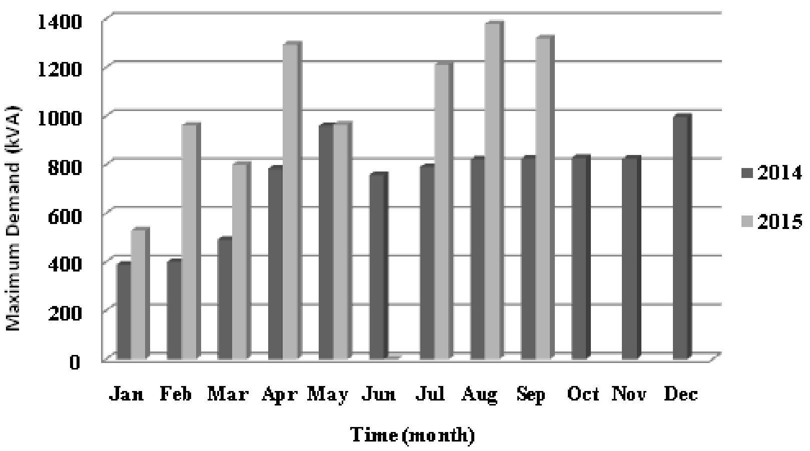

Fig. 1 Variation in MD as a function of time in month.

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Nitte Conference on Advances in Electrical Engineering NCAEE-2016
NMAM Institute of Technology, Nitte
Vol. 4, Special Issue 2, April 2016

C. Performance evaluation of DG sets

1010 kVA DG set is kept as a standalone supply for powder plant under CESCOM powder interruption. Separate 200 kVA DG is taking care of other sections during power failure.

Before UPS installation the powder plant was operated by DG set of 1010 kVA continuously throughout the day.

Specific Energy Calculation

$$\text{Specific energy} = \frac{\text{Number of units generated}}{\text{Total amount of fuel consumed in liters}}$$

$$\text{Specific energy} = \frac{273432}{85985} = 3.18 \text{ units / liters.}$$

Average units generated per liters of fuel for a span of 7 days is 3.02 units / liters.

Each liter of diesel costs Rs.59.315 (as per 2014 rate),

$$\text{Therefore cost of production of 1 unit} = \frac{59.315}{3.18} = 18.65 \text{ Rs.}$$

From Table 3 it can be observed that diesel consumption is reduced considerably from Mar-2015. After installation of UPS, the company savings from the diesel fuel cost is brought down by Rs. 30 lakhs per month. The payback period for installation cost of UPS was within 8 months.

Table 3 Operating details of DG sets form Jan-2014

Month	Quantity Consumed (Lts)	Rate/Lt (Rs)	Total Amount (Rs)	Units Generated (kWh)	Specific Energy (kWh/Litre)
Jan-14	81720	58.51	4781437	281934	3.45
Feb-14	60920	59.12	3601590.4	201036	3.30
Mar-14	73975	59.47	4419266.5	242638	3.28
Apr-14	64929	59.47	3878858.46	220759	3.4
May-14	83285	60	5078390.75	270676	3.25
Jun-14	87184	60.52	5276375.67	289450	3.32
Jul-14	85060	61.6	5239696	272192	3.2
Aug-14	79451	62.21	4942646.71	266955	3.36
Sep-14	78409	62.82	4925653.38	257966	3.29
Oct-14	81235	59.58	5159950.25	255890	3.15
Nov-14	85985	56.58	4865031.3	273432	3.18
Dec-14	94855	51.9	4922974.5	294050	3.1
Jan-15	89622	47.04	4440880.84	293960	3.28
Feb-15	69425	44.7	3087209.55	231185	3.33
Mar-15	46858	47.35	2219068.28	157443	3.36
Apr-15	8150	47.34	385821	27547	3.38
May-15	4630	47.24	218721.2	15186	3.28
Jun-15	4680	47.22	220989.6	15912	3.4
Jul-15	1655	47.22	78149.1	5379	3.25
Aug-15	8635	41.02	354207.7	28496	3.3
Sep-15	6899	40.55	279754.45	23456	3.4

III. ENERGY CONSERVATION OPPORTUNITY

Since plant is already installed with energy efficient motors and VFD's (variable frequency drives) no energy conservation is possible in this area. Energy audit process sighted possibility of energy conservation in lighting and boiler loads.

DOI 10.17148/IJIREEICE/NCAEE.2016.18

IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Nitte Conference on Advances in Electrical Engineering NCAEE-2016
NMAM Institute of Technology, Nitte
Vol. 4, Special Issue 2, April 2016

A. Energy conservation in Lighting

Objective of lighting system management is to improve the quality of lighting while minimizing energy consumption. Lighting in this dairy industry can be grouped as

a) Low power lighting loads and

b) High power lighting loads.

During energy audit it was decided to replace some of these lighting gadgets with energy efficient lamps (EEL). For example, CFL are replaced with LED. With these change, it is expected that the same lighting intensity can be obtained with reduced wattage.

Company has long straight roads leading to different sections and staff quarters. It also has focus lighting is Metal-halide lamps of capacity 150W each. It is suggested to replace it by LED lamps, thus reducing both energy and maintenance cost with long life.

Annual saving by implementing these suggestions is shown in Table 4. Taking Rs. 5.85 per unit as tariff, annual savings works out to be Rs 3,23,503.83.

Table 4 Anticipated annual energy saving with Energy Efficient Lamps (EEL)

SI. No	Details	Savings (units)
1	Replacement of (11W×2) CFL to 14W LED	700.8
2	Replacement of (36W×2) CFL to 30W LED	2759
3	Replacement of (70W) MH to 30W LED	51840
Total		55299.8

B. Energy conservation in Boiler

There are two boilers in dairy each of same capacity and its details are given in Table 5.The boiler is a huge energy guzzler and thermal energy saving can be achieved by many methods.

Table 5 Rating of Existing Boilers

Characteristics	**Boiler 1**	**Boiler 2**
Working pressure (kg/cm2)	14.5	14.5
Working temp (°C)	100	100
Evaporation capacity (kg/hr)	4500	4500
Company	Forbes Marshell	Forbes Marshell
Fuel used	Furnace oil	Furnace oil
Type	3 pass smoke tube	3 pass smoke tube

1) Energy efficient fuel

Furnace oil is used as fuel for the boilers; its calorific value is 9650 kCal/kg and is available at 18 Rs/kg. In place of FO, agro fuel like ‘Briquette’ which is made by agricultural wastes can be used. Briquette calorific value is 3800 – 4000 kCal/kg and it costs 5.1 Rs/kg, which is economical, easily available and environmental friendly.

2) Economizers

Steam generation in a boiler requires feed water that is often a mixture of returned condensate and treated make up water. Flue gases from large boilers are typically 230 – 340°C (450 - 650°F). Stack Economizers recover some of this heat for pre-heating water. Boiler stack economizers are simply heat exchangers with hot flue gas on one side and water on the other. An economizer that recovers 5% of boiler input should easily have a 2 year payback in a year-round application. Since present boilers fuel gas temperature is 240°C, economizer can be installed.

Calculation of waste heat recovery from economizer

Flue gas temperature at outlet of boiler burner =240ºC

Feed water temperature = 30ºC

Water consumption per hour = 4200 kg/hr

Specific heat of water = 4.19 kJ/kg C

Heat required for rising temperature of water is given by
Q = S × m × ΔT
Where, S = specific heat of water
m = mass of water (flow rate)
ΔT = temperature difference

Lowest considered flue gas temperature coming out of boiler = 180ºC
Maximum temperature of flue gas available = 240 – 180 = 60°C
Heat transfer efficiency between airs (flue gas) to water is 70%
Rise in feed water temperature = 60 × 0.7 = 42ºC
Feed water temperature at outlet of economizer = 30 + 42
= 72 ºC

Assumptions
1. Steady operating conditions exist
2. Effectiveness of the heat exchanger remains constant

Maximum heat recovery in heat exchanger
Q_{max} = S × m × ΔT
= 4.18 kJ/kg ºC × 1.167 kg/s × (72 – 30) ºC
= 204.88 kJ/s

A heat exchanger of reasonable size and cost can capture 75% of this heat transfer potential
Q = 0.75 × Q_{max}
= 0.75 × 204.88
= 153.66 kJ/s

The heat exchanger operates 24h a day & 356 days a year.
Operating hours = 24 h/day × 365 days/year
= 8760 h/year
Energy saved = heat transfer rate × operating time
= 153.66 kJ/s × 8760 h/year × 3600 s/h
= 4.846×10^9 kJ/year

Furnace efficiency is 80%
Heat energy produced by 1 kg FO = 40375.6 kJ/kg
Energy savings converted to Rs/year is
Fuel saved = Energy saved / Furnace efficiency
= 4.846×10^9 / 0.8
= 6.06×10^9 kJ/year / 40375.6 kJ/kg
= 150028.73 kg/year

The price of FO is 18 Rs/kg, the amount of money saved will be
Money saved = Fuel saved × Price of fuel
= 150028.73 kg/year × 18 Rs/kg
= 27, 00,517.14 Rs/year

Therefore, the installation of the proposed heat exchanger will save the company Rs 27, 00,517.14 a year, and the installation cost of the heat exchanger will probably be recovered from the fuel savings in a short time.

3) Solar water heater

Solar water heater can be installed for preheating the feed water using solar energy thereby reducing the use of fossil fuels. The above potential of energy conservation requires minor changes in pipeline arrangement of feed water, solar panel installation and hot water storage tank integrated with existing system. The life of solar water heating plant is around 15-20 years.

The risk involved in installing the above proposal is high cost. Bur MNRE (Ministry of New and Renewable Energy) provides opportunities and incentives for Technology and Quality upgradation support to micro, small and medium enterprise.

DOI 10.17148/IJIREEICE/NCAEE.2016.18

IV. CONCLUSION

Calculation has been done on the basis of measured/ collected data. Reduction in electricity bill is possible, thus making the industry eco friendly. Set of suggestion is highlighted in conserving energy by minimum resource mobilization at the boiler which works for 24×7 continuously with pay-back period. Economic feasibility of adopting solar gadgets is also recommended to the concerned for further study. Majority of the suggestions is readily accepted for further study and implementation of the same.

ACKNOWLEDGMENT

Authors wish to thank authorities of Nandini Hi Tech Product Plant (an unit of KMF), Channarayapatna, Hassan for providing the necessary facilities to carry out the work in the esteemed organization and also initiating us to publish the outcome.

REFERENCES

[1]. Nissanga Nishad Rasanajan Mendis, Nisal Perera: " Energy Audit: A Case Study", 1-4244-0555 6/06/$20.00 ©2006 IEEE.
[2]. John Upton, Michael Murphy: "Dairy Farm Energy Consumption", Teagasc National Dairy Conference 2010.
[3]. Detailed Project Report on Renewable Energy Harnessing (10000 LPD Solar Water Heater) Technology, Gujarat Dairy Cluster, Gujarat (India).
[4]. Swapnil Ratnakar Mane: "Energy Management In A Dairy Industry", Energy Science & Engineering, IIT Bombay, Mumbai.
[5]. Yunus A. Cengel and Afshin J. Ghajar, Heat and Mass Transfer, Mc Graw Hill Education,2013.