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ELECTRICAL ENERGY CONSERVATION IN A DISTILLERY PLANT- A CASE STUDY

Mr. Chougule G. A*, Mr. Jadhav V. V, Prof. Shaikh S. M

* ME Heat Power Engineering Student. J. J. M. C. O. E. Jaysingpur Maharashtra, India
ME Heat Power Engineering Student. J. J. M. C. O. E. Jaysingpur Maharashtra, India
Assistant Professor, J. J. M. C. O. E. Jaysingpur Maharashtra, India

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ABSTRACT

Energy is a main function for each kind of process. It is the central force behind our productivity, our leisure and our environment. Energy Audit is the integral part of Energy Management. The energy audit can unearth huge profits to the industry. It quantifies the energy uses according to its various functions. It attempts to balance the total energy inputs with the output or the uses. The energy conservation and maximization strategies for a process industry like distillery plant are cost effective, which conserve the environment automatically. The electrical energy audit of a distillery plant has wide scope of energy conservation. The audit has been successfully completed and concluded with the saving of the 18500 kWh per year of energy. The most of the electrical energy is utilized to drive electrical motors used for various processes. Energy will be saving in case of motors with the help of the variable frequency drives, which reduces the speed of the motors as well as energy. The distillery has the beneficial of Rs. 1, 20,910 by implementing given recommendations.

KEYWORDS: Energy audit, Energy conservation, Energy management, Variable Frequency drives.

INTRODUCTION

Energy has an important function. It is the central force behind our productivity, our leisure and our environment. Energy is an indispensable component of industrial product, employment, economic growth, environment and comfort. The energy conservation is cost effective with a short payback period and modest investment. There is a good scope of energy conservation in various sectors, viz., industry, agriculture, transport and domestic. The gap between supply and demand of energy can be bridged with the help of energy conservation. Thus energy conservation is essential in developed as well as developing countries. The distillery plant involves processing raw molasses into products such as rectified spirit, using processes such as fermentation & distillation. All of these operations cause the energy consumption. In this project the energy consumption pattern of these processes will be analyzed and potential for energy saving will be identified. This can be achieved by Energy Conservation and Management Practices. Energy Audit is the integral part of Energy Management. The energy audit can unearth huge profits to the industry. The Energy Audit approach is a key approach for systematic decision making in process management. It quantifies the energy uses according to its various functions. It attempts to balance the total energy inputs with the output or the uses. The energy conservation and maximization strategies for a process industry like distillery plant are cost effective, which conserve the environment automatically.

Problem statement:

Distillery of sugar mill is now widely used in the rectified spirit generation for various commercial & medical applications also. We have to evaluate the total energy consumption of the each sector of the distillery plant of sugar industry. By analyzing that collected data of energy consumption, we have to identify the scope of energy conservation & will give suggestions on that sector to increase the energy efficiency.

METHODOLOGY

Need for Energy Audit:

In this distillery industry, the most operating expenses are often found to be energy (both electrical and thermal), labour and materials. If one were to relate to the manageability of the cost or potential cost savings in each of the components, energy would invariably emerge as a top ranker, and thus energy management function constitutes a strategic area for cost reduction. Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programs which are vital for production and utility activities. Such an audit program will help to keep focus on variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofit for energy conservation equipment etc.

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. Energy Audit provides a “bench-mark" (Reference point) for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.

Types of Energy Audit:

The types of energy audit mostly depends upon the, function and type of industry where it should be carried out. Also the depth of final audit as well as required potential and cost reduction desired is also considered at the time of deciding type of audit. Thus energy audit are classified as,

1. Preliminary Audit
2. Detailed Audit

Detailed Energy Audit Methodology:

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

The work is proposed to carry out in the following steps-

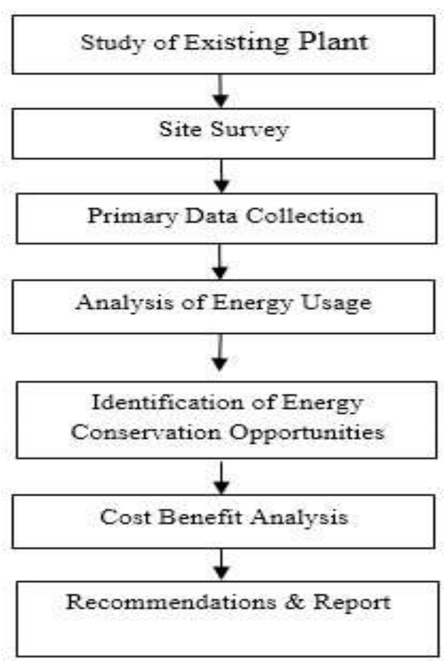

Figure 1- Methodology for Energy Audit

Benefits of energy audit

The identification and implementation of recommendations for energy efficiency improvements arising from an energy audit can deliver different benefits to the industry.

1. Setting of energy efficiency targets.
2. Financial benefits in terms of reduced costs or increased profits.
3. Operational benefits including improved productivity, comfort and safety, and security of energy supply.
4. Environmental benefits such as sustainability, conservation of resources and emissions savings including green house effect.

MANUFACUTURING PROCESS

The overall process of rectified spirit generation is divided into basics processes. Molasses is the raw material used for production of alcohol by fermentation. The manufacturing process of alcohol is divided into mainly:

Fermentation:

Fermentation is the enzymatic transformation by microorganisms of organic compounds such as sugars. It is usually accompanied by evolution of gas.It may be defined as the process by which micro-organism obtains energy in which electron donor & the final electron acceptors are the organic molecules. Alcohol fermentation can be affected by using any naturally occurring sugar, starch or cellulose materials coupled with appreciate pre treatment. In fermentation process, the molasses is diluted to specific gravity of about 1.09-1.10. The fermenter is charged with mash containing 5% yeast suspension. The suspension allows fermenting under controlled condition of temperature & pH for 48 Hrs. during fermentation process considerable amount of heat & carbon dioxide are produced.

***Distillation**:*

Distillation is physical process in which the various components of a mixture are separated by value of their difference in their boiling point. In the manufacture of alcohol by fermentation distillation provides a means for separating the ethyl alcohol from the fermented wash. A continuous type of distillation plant consists of distillation columns and condensers. Distillation columns are divided into different columns viz, wash column, degasifying point, aldehyde columns, analyzer column and exhaust column. Extra neutral alcohol is the product from re-distillation of the rectified spirit. Used mainly for portable purpose and medicinal application.

PERFORMANCE ANALYSIS

Energy consumption and Electricity bills:

Electricity is the most widely used form of energy in most of the facilities. The electrical systems are among the least understood of all the plant. In this distillery plant, total requirement of electricity power is 8000 kWh/ day, from which 4000 kWh is supplied by Maharashtra State Electricity Board at Rs. 6.88 /unit. The MSEB power supply is coming to the plant with the help of 11 kV feeders. Present contract demand of the plant is 880 kVA and the minimum billable demand is 748 kVA, which is 85% of the contract demand.

The purchase of the electricity for last year is as shown in given table:

Table 1 -Electricity Distribution

Sr. No		Quantity (in lakh)	Cost (in lakh)
1	Electricity	26.04 kWh	177.92
2	Diesel Generator	0.16	7.8

The analysis of the electricity bill for last year shows in following table,

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Table 2- Electricity Bill for the Year 2015-2016

Month	Units Consumed (kWh)	M.D. Actual (kVA)	M.D. Billing (kVA)	P.F.	Days	L.F (%)	Billing Amount (Rs.)	Avg. Unit Cost (Rs./kWh)
Mar-16	204185	429	748	0.993	31	63	1435795	7.031
Feb-16	165000	386	748	0.997	28	63	1477545	8.950
Jan-16	175040	423	748	0.995	31	55	2086546	11.92
Dec-15	241350	408	748	0.993	31	79	2026646	8.390
Nov-15	230020	417	748	0.985	30	76	1732474	7.530
Oct-15	198950	418	748	0.993	31	64	1976582	9.930
Sept-15	233190	424	748	0.996	30	76	1963813	8.420
Aug-15	230150	426	748	0.991	31	73	1578813	6.850
Jul-15	189470	471	748	0.995	31	54	1578139	8.320
Jun-15	140850	508	748	0.997	30	39	1214395	8.621
May-15	267130	453	748	0.998	31	79	1814377	6.790
Apr-15	234300	459	748	1	30	71	1881760	8.030
Total/ Avg	2509635			0.994			2,07,66,885	

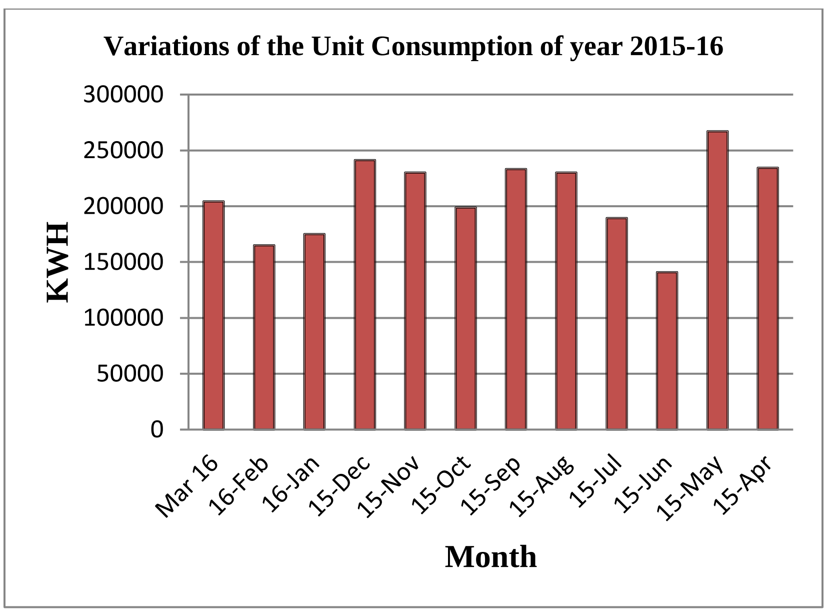

Figure 1- Variation of the unit consumption of year 2015-16

Load Factor:

The load factor (L.F) variation of the plant is shown in Figure-and is also tabulated in Table-. It is observed that the lowest value of 39% load factor was in the month of June-2015 due to lowest units' consumption. The maximum value of 79 % was in the month of May-2015 due to highest units' consumption.

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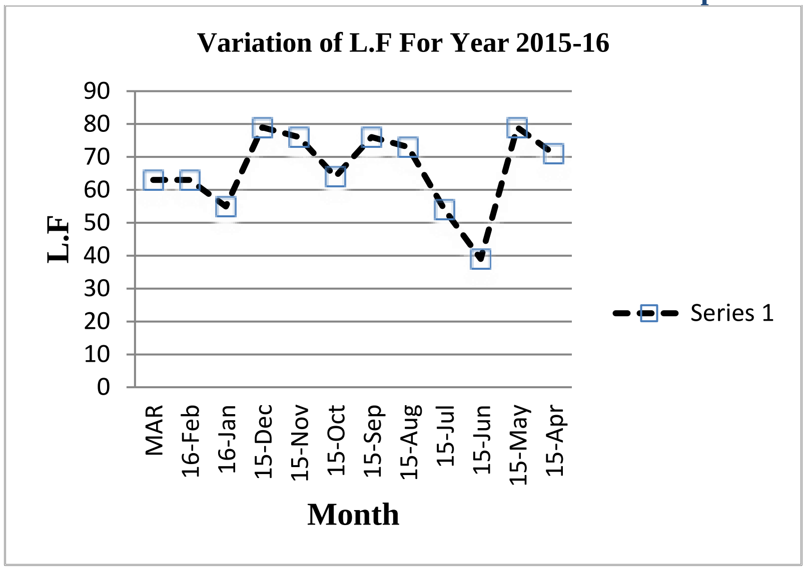

Figure 2- Variation of L.F for year 2015-16

Power Factor:

The variation of power factor for last one-year is shown in the Figure and is tabulated in Table. It is observed that the power factor value for last year varies between 0.991 and 1. The value of power factor obtained for last year is found to be satisfactory.

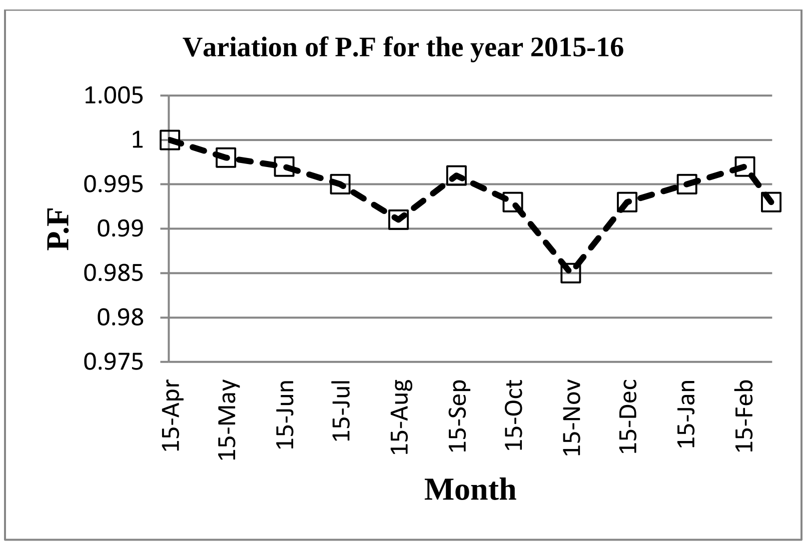

Figure 3- variation of P.F for the year 2015-16

Pumps & Motors Analysis:

Electric motor systems account for about 60 percent of global industrial electricity consumption and close to 70 percent of industrial electricity demand. Electric motors drive both, core industrial processes, like presses or rolls, and auxiliary systems like compressed air generation, ventilation or water pumping. They are utilized throughout all industrial branches, though their main Applications vary. Size classes vary between motors with less than one kW and large industrial motors with several kW rated power.

In this distillery plant, the various motors of different power are used for various applications. The total numbers of motors are 98. The total consumption of power is calculated with considering average 10 hours working of each motor with respected applications.

Table 3 – Total Consumption by Electrical Motors

Sr. No	Power Motor (hp)	Power Motor (kW)	No Of Motors	Considering 10 Hrs Of Working For Motors	Total Power Consumption (kW)
1	75.0	55.16	2.0	551.6	1103
2	40.0	29.41	3.0	294.1	882.0
3	30.0	22.00	4.0	221.0	884.0
4	20.0	14.7.	10	147.0	1470
5	15.0	11.00	12	110.0	1320
6	12.5	9.19	4.0	91.90	365.6
7	10.0	7.35	1.0	73.50	73.50
8	7.5.0	5.50	39	55.00	2145
9	5.0	3.667	10	36.67	366.7
10	3.0	2.20	11	22.00	242..0
11	2.0	1.47	2.0	14.70	29.40
				Total	**8881.2**

The total consumption by electrical motors is 8881.2 kW as shown in table

Pump:-

The most critical aspect of energy efficiency in a pumping system is matching of pumps to loads. Hence even if an efficient pump is selected, but if it is a mismatch to the system then the pump will operate at very poor efficiencies. In addition efficiency drop can also be expected over time due to deposits in the impellers. Performance assessment of pumps would reveal the existing operating efficiencies in order to take corrective action. The purpose of the Performance Test is determination of the pump efficiency during the operating condition. Performance analysis of the pump is as follows,

Table 5- Performance analysis of pump

Sr.No	Parameter	Value
1	Flow delivered by pump	225 m^3/Hr
2	Suction head	1 m
3	Delivery head	35 m
4	Total head (h2-h1)	34 m
5	Power required	29.4 kW
6	Motor efficiency	90 %
7	Density of water	1000 Kg/m^3
8	Hydraulic power	20.84 kW
9	Overall system efficiency	70.96 %

RESULTS & DISCUSSION

Findings

The list of findings from the performance analysis of the distillery plant is as follows,

1. ***Electrical***
    a. Old technology lighting system has more electrical energy consumption.
    b. Dust is noticed on the tube lights.
    c. Pumps and motors have unnecessary large power consumption at high speed.

2. ***Pumps & motors***
   a. Many motors are under maintenance is identified.
   b. More power consumption by motors and pumps are noticed.
   c. Proper maintenance scheduled is not worked for pumps and motors.
   d. Advanced technology must need for the pump and motors.

For improving performance of the equipments and get energy saving opportunities various short term and long term recommendations are suggested. Those are as follows,

Recommendations:

Short term

- ***Electrical***
  a. Avoid repeated rewinding of motors. Observations show that rewound motors practically have an efficiency loss of up to 5%. This is mainly due to increase in no load losses. Hence use such rewound motors on low duty cycle applications only.
  b. Turning off unnecessary lights and retrofitting lighting systems with appreciate energy efficient fixtures.
  c. Optimize the tariff structure with utility supplier.
  d. Schedule your operations to maintain a high load factor.

- ***Pumps:***
  a. Matching of the motor with the appropriate-sized pump.
  b. It is advisable to use a number of pumps in series and parallel to cope with variations in operating conditions by switching on or off pumps rather than running one large pump with partial load.
  c. Modern synthetic flat belts in place of conventional V-belts can save 5% to 10% of energy.
  d. Drive transmission between pumps and motors is very important. Loose belts can cause energy loss up to 15-20%. So check the proper installation of the pump system, including shaft alignment, coupling of motor and pump.
  e. Properly organized maintenance is very important. Efficiency of worn out pumps can drop by 10-15% unless maintained properly.

- ***Motor***
  a. Properly size to the load for optimum efficiency. (High efficiency motors offer of 4 - 5% higher efficiency than standard motors)
  b. Avoid frequent rewinding of motors. The Greater the number of rewind will cause lesser the efficiency.
  c. Carry out preventive maintenance and condition monitoring schedule regularly.
  d. Provide proper ventilation for the motors. For every 10 ^{o}C increase in motor operating temperature over recommended peak, the motor life is estimated to be halved.
  e. Check for under-voltage and over-voltage conditions. So balance the three-phase power supply. An imbalanced voltage can reduce 3 - 5% in motor input power.

- ***Lighting***
  a. Replace the old ceiling fans with new advanced technology energy efficient fans.
  b. Select ballasts and lamps carefully with high power factor and long-term efficiency in mind.
  c. Use of electronic ballast in place of conventional choke saves energy upto 20%.
  d. Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
  e. Clean the lamps and fixtures regularly. Illumination levels fall by 20-30% due to collection of dust.
  f. Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
  g. Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.

Long term:

1. The electrical motors have large electoral energy consumption than any other equipment in distillery industry. High power motors are used for the cooling tower for water pumping process. Consumption of the motors are high, so avoid these, the VFD for the same is best energy saving option recommended.

For energy saving opportunities in motors, use if variable frequency drives is suggested. The cost benefit analysis of the VFD as follows,

Advantages of VFD:

1. ***Energy savings:***
   The primary function of VFD is to provide energy saving. The VFD can save the energy up to 50%.
2. ***Low motor starting current:***
   At the time of starting the motor start with low frequency so it takes low current at starting therefore VFD can be used as starter.
3. ***Reduction of thermal and mechanical stresses on motors and belts during starts:***
   By using VFD the thermal and mechanical stress on motors and belts during starting get reduced hence chances of wear & tear of various part get decreased.
4. ***Simple installation:***
   As VFD is single unit and it does not required any concrete construction so its installation is simple.
5. ***Lower KVA:***
   As VFD has nearly unity power factor it has lower KVA rating.

The cost benefits analysis for the VFD system will used for the motors in the distillery plant with their payback calculation and annual saving.

Table 6 - CBA of VFD for Motors

Sr. no	**Parameter**	
1	Energy saving by use of VFD	Approx.- 3 kWh
2	Annual saving of energy	25200 kW/yr
3	Electricity cost / kWh	Rs. 6.82/ kWh
4	Annual saving Rs.	Rs. 1,71,864
5	Rated Ampere	60
6	Cost of VFD system for 60 amps.	2.16 lakh
7	Simple payback period	1.3 Year

Energy efficient motors will also consume less power for same requirement of work. So use of that motors will be essential for cost beneficial. The figure shows that performance of the standard motors as well as the energy efficient motors on full load applications.

Advantages of Energy Efficient Motors

1. Reduced operating costs
2. Less heat losses
3. Extended winding lifespan
4. Extended lubricating grease service life
5. Lower noise levels than other motors
6. Reduced energy costs. The higher purchase price investment pays off.

Lighting

a. Install efficient alternatives to incandescent lighting, mercury vapor lighting, etc. Efficacy (lumens/watt) of various technologies range from best to worst approximately as follows: low pressure sodium, high pressure sodium, metal halide, fluorescent, mercury vapor, incandescent.
b. Replace the regular tubes with the CFL tube lights or LED tubes.
c. Replace the regular indicating lamps with LED low wattage lamps.

➢ **Cost benefit analysis**

1. Table describes the calculations for replacement for existing Fluorescent tubes with conventional electromagnetic chokes with Proposed LED Tube. There is a saving of 18 watt per tube. Hence the total 63 KWh energy has been saved per Annum.

Table 5.8 – CBA of LED Tubes

Detail	**Type**	**Rating / Saving**
Existing Fitting	Wattage of Fluorescent tubes with conventional electromagnetic chokes (Total No. 60)	36 watt
Proposed Fitting	Wattage of LED Tube	14 watt
Saving per bulb	Wattage	22watt
Saving per annum	kWh (350 days & 10 working hours)	77 kWh
Total Saving	For 60 tubes	4620 kWh
Amount savable @6.82/KWh	For 60 tubes	Rs.31508/-
Price Difference	For 60 tubes @450/-	Rs. 27000/-
Payback period	Months	11Months (approx)

2. Table describes the calculations for Replacement for existing Mercury Vapor Lamp with Metal Halide Lamp. Hence the total 365 KWh energy has been saved per annum.
Table 5.9 - CBA of Metal Halide Lamp

Detail	**Type**	**Rating / Saving**
Existing Fitting	Wattage of Mercury Vapor Lamp (13 No's)	500 watt
Proposed Fitting	Wattage of Metal Halide Lamp	250watt
Saving per bulb	Wattage	250 watt
Saving per annum	kWh (350 days & 10 working hours)	875 kWh
Total Saving	For 13 Lamps	11375 kWh
Amount savable @6.82/KWh	For 1 Lamps	Rs.5967/-
Price Difference	For 13 Lamps @400/-	Rs. 5200/-
Payback period	Month	1Months (approx)

3. Use of renewable energy source such as solar for lighting. The solar street lighting system is best option for the halogen lamps used in the industry with higher life. The proposed design and benefit analysis of this is as below,

Design:
The solar street lighting is better option for the outside and inside street lighting. Now the halogen lamps of 500 watts are used for this purpose. The solar street lighting system of 240 bright LED array is used. Solar street lights harness energy from the sun to provide an alternative source of energy to conventional street lighting. The system consists of a SPV Module, Luminaire, Battery and with Battery box. The SPV Modules convert solar energy to electrical energy during the day,which in turn is used to charge the battery. At dusk the LED light is switched "ON" automatically and switched "OFF" at dawn. All components are weather proof and aesthetically designed.
The design and components of the system is,

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a. SPV Module
b. Battery Box
c. Lamp with charge controller
d. Lamp Post

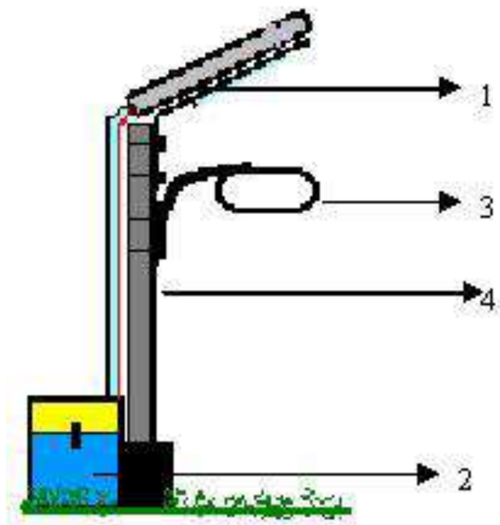

Figure 1 - Solar street light system

Benefits:

The advantages of the solar system over the conventional light system used in distillery plant is as discussed below,

1. Zero running cost.
2. Guaranteed working in rainy weather.
3. Perfect alternative for power cuts.
4. No line voltage, trenching, or metering
5. No power outages
6. Battery backup for cloudy or rainy days
7. Easy to install with quick connect plugs less than 1 hour
8. No scheduled maintenance for up to 5 years
9.

Cost benefit analysis of solar street lighting

The overall investment with the amount of saving through this system is calculated with the payback of the system in table.

Table 7 – CBA of solar street lighting

Sr. no	**Details**	**Savings**
1	Energy consumption of 500 watt halogen lamp per hour	0.5 kW
2	Daily consumption of (10 hours)	5 kW
3	Annual consumption of halogen lamp	1800 kW
4	Amount savable @6.82/KWh	Rs. 12,276
5	Cost of solar street lighting (approx.) Rs	Rs. 25,000
6	Payback period	2 years

CONCLUSION

In electrical energy, the analysis of the electrical bill shows that the power factor is well maintained by the distillery unit, it varies from 0.92 to 0.96. The most of the electrical energy is utilized to drive electrical motors used for various processes. Energy will be saving in case of motors with the help of the variable frequency drives, which reduces the speed of the motors as well as energy.

In lighting system, the old technology system is required more power as per the analysis. The old system is replaced by the latest energy efficient technology system such as Fluorescent tubes are replaced with LED, Halogen lamp will replaced by Metal Halide Lamp. Also the old ceiling fans will replace with low wattage high speed ceiling fans. The total energy of 18500 kWh will saved by implementation of such technology with the total beneficial of the Rs. 1, 20,910.

Also the use of renewable energy sources are cost beneficial of Rs. 12,276 with the minimum investment of Rs. 25000 and lower payback period 2 years .

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