GOVT CO-ED POLYTECHNIC

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LAB MANUAL

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2024692(024)–Energy Conservation & Audit (Lab)

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Experiment No: 1

AIM: Identify the Energy management skills and strategies in the energy management system

Theory: **1. Identify Sources of Energy Consumption**:-

Whether it's natural gas or electricity, understanding what types of energy your company/ organization is using can help you identify the specific areas that are utilizing the most energy. Allowing you to take steps to monitor its usage activity — saving you money while reducing your carbon footprint.

2. Collect Utility Bill Data :-

After identifying which sources of energy your company/ organization is using, you can take steps to monitor the energy usage. Before you begin analyzing which areas need to reduce energy consumption: utility bill data. This is where partnering with a utility data service company, like Urjanet, is helpful because these companies can access and aggregate a large amount of data within your utility bill, for all your accounts. Without collecting your company's invoices, there is no effective way to begin cutting down on costs and energy consumption.

3. Analyze Meter Data

Once data is collected, with the correct program, energy managers can begin to analyze how the energy is being used and identify which buildings are consuming the most energy. In some cases, companies can access interval data, which can identify when energy use is at its peak and when it the lowest. Energy use can be evaluated spanning across months, weeks, days, hours, and even in minutes.

4. Identify Opportunities to Save on Costs

By understanding what time of the days or which days of the week energy consumption is the highest, proactive steps can be taken to reduce costs. Whether it's replacing machinery or understanding which systems may still be running during off hours, there is now a comprehensive understanding on how energy is being consumed?

5. Track Your Progress

After action is taken and changes are made to daily operations, track the difference between energy usage. If the data is the same and no progress is being made, then an alternative action should be taken. Tracking your progress allows you to see if your changes are effectively reducing costs.

Result: Different strategies for energy management are studied.

Experiment No: 2

AIM: Visit the Website of BEE & MEDA/CREDA and collect the information on energy conservation activities.

Apparatus Required: PC with internet connection.

Theory:

BEE:- Bureau of Energy Efficiency was setup by Government of India on 1st March 2002 under the provisions of Energy Conservation Act, 2001. As the whole world is grappling with challenges of climate change and global warming, there is a lot of push to take measures to reduce CO2 emissions across the world. Although renewables sources like solar and wind are identified as sources that can generate energy without CO2 emissions. These sources have not reached a stage where they can completely replace our existing electricity generation methods. Saving energy or using less energy (for doing the same work) has been identified as the easiest way of reducing CO2 emissions. BEE has been started with a mission to create policies and develop strategies with a thrust on sc regulation and market principles to achieve energy efficiency.

BEE coordinates with government, industries, manufacturers and consumers to facilities measures to be taken for conservation of energy.

Major Activities of BEE

BEE does both regulatory and promotional activities. As part of regulatory activities it does following:

- It sets performance standards for appliances and designs labeling scheme for the same. The star rating of various appliances like AC, Refrigerators, Fans, Pumps, Water Heaters, etc is part of this mandate that they have.
- They develop energy efficiency code for buildings and Industries.
- They certify Energy Managers and Energy Auditors who can perform energy audits.
- They develop norms for energy consumption.
- As part of their promotional activities they do:
- Create promotional programs for energy efficiency, star-rating and other awareness programs.
- Arrange and organize trainings for people who can do energy efficiency projects.
- Develop testing and certification procedures and promote testing facilities.
- Promote innovative financing of energy efficiency projects
- Give financial assistance to institutions for promoting efficient use of energy and its conservation
- Prepare educational curriculum on efficient use of energy and its conservation

Experiment No: 3

AIM: Analyze the case study of energy conservation in generation by solar, wind, bio energy, cogeneration and fuel cell technology or any recent technology of generation estimating payback period also.

Apparatus Required: Desktop, internet connection etc.

Theory: Renewable Resources:-

While renewable energy resources have the advantage of unlimited supply over the long haul, they are limited in their availability at any given moment.

For example, the sun rises each day, but its ability to generate power is limited when its cloudy. Another disadvantage is that power plant operators can't crank up renewable energy production when people are consuming more power, such as on a hot day when many people are running air conditioners at the same time.

to solve this problem by using energy storage, like large batteries, to collect electricity from renewable sources when demand is low in order to use it later when demand goes up.

- **Solar:-** Radiation from the Sun can be used as a power source as well. Photovoltaic cells can be used to convert this solar energy into electricity. Individually, these cells only generate enough energy to power a calculator, but when combined to create solar panels or even larger arrays, they provide much more electricity
- **Wind** :- Wind energy generates electricity by turning wind turbines. The wind pushes the turbine's blades, and a generator converts this mechanical energy into electricity. This electricity can supply power to homes and other buildings, and it can even be stored in the power grid.
- **Biomass :-** Biomass refers to organic material from plants or animals. This includes wood sewage, and ethanol (which comes from corn or other plants). Biomass can be used as a source of energy because this organic material has absorbed energy from the Sun. This energy is, in turn, released as heat energy when burned.
- **Fuel Cell Technology :-** A fuel cell is a device that generates electricity through an electrochemical reaction, not combustion. In a fuel cell, hydrogen and oxygen are combined to generate electricity, heat, and water. Fuel cells are used today in a range of applications, from providing power to homes and businesses, keeping critical facilities like hospitals, grocery stores, and data centers up and running, and moving a variety of vehicles including cars, buses, trucks, forklifts, trains, and more.
  Fuel cell systems are a clean, efficient, reliable, and quiet source of power. Fuel cells do not need to be periodically recharged like batteries, but instead continue to produce electricity as long as a fuel source is provided.

Result: Energy conservation in generation by solar, wind, bio energy and fuel cell technology are studied.

CREDA – Chhattisgarh State Renewable Energy Development Agency

CREDA – Chhattisgarh State Renewable Energy Development Agency, has been constituted on 25th May 2001 under the Department of Energy, Government of Chhattisgarh for implementation of various schemes pertaining to Renewable Energy sources and Energy Conservation activities. It is registered under Society Act 1973 with the controlling body being Energy Department, Govt. of Chhattisgarh. CREDA is established as the State Nodal Agency by State Govt. for development and promotion of non-conventional & renewable sources of energy. Most of the scheme like National Programmed on Bio-gas Development, Solar Thermal, Solar Photo Voltaic, Remote Village Electrification and Biomass Gasifier, sponsored by Ministry of Non-Conventional & Renewable Energy Sources (MNRE), Government of India are implemented by CREDA.

Major Activities of CREDA

- Promote policies and programmes necessary for popularizing the applications of variou new and renewable energy technologies in the State.
- Development and popularization of non-conventional & renewable sources of energy and energy conservation activities in the State of Chhattisgarh.
- Sponsor, co-ordinate and promote programmes or demonstration projects in the areas of new and renewable sources of energy and energy efficiency.
- Provide technical and financial assistance for extension of renewable energy and energy efficiency projects for Chhattisgarh State.
- Assist the Govt. of India and Govt. of Chhattisgarh in implementation of Renewable Energy programmes and Energy Efficiency and its Conservation.
- Proactively fulfill mandates of the EC Act 2001 in co-ordination with Central & State Governments and other stakeholders.
- To promote use of energy efficient technologies, equipments, processes and devices.
- Information dissemination and public awareness on use of renewable energy sources and energy conservation.
- Pursue power projects based on renewable energy for private sector by creating suitable policy environment.
- Support large scale distribution & marketing of standalone renewable energy devices.

Result: energy conservation activities of BEE & CREDA are studied.

Experiment No: 4

AIM: Estimate electrical energy saving by improving power factor and load facter for a given case study in terms of savings in units and cost

Theory:

Power factor - Power factor is a dimensionless number between 0 and 1 that is defined as the ratio of real power (kW) to apparent power (kVA). Real power is considered to be the work producing component. Apparent power is the product of the total current and voltage used by the load, which includes power used for electromagnetic fields. In other words, real power is the amount of power needed to perform the work in a perfect world while apparent power is the power needed to perform the work in real world conditions. While power factor may vary over time, generally speaking, a high power factor indicates effective utilization of electrical power. A low power factor means you're not fully utilizing the electrical power for which you are paying. A power factor of 1 (unity) is an indication of operating at a perfectly effective use of power while a 0.5 is an indication of a very inefficient use of power. A power factor of any value other than unity is caused by inductive or capacitive reactance and harmonics on the system.

What are causes of low power factor?

Low power factor can be broken into two different categories: lagging and leading. Low lagging power factor conditions can be caused by various combinations of the following inductive devices:

- Induction motors
- Inductive loads of fluorescent ballasts
- Rectifiers providing a DC power supply
- Arc welders
- Solenoids
- Induction heaters
- Lifting magnets
- Transformers.

Improve low power factor?

Low power factor means lower operating efficiency which results in a need for larger conductors (wires) and increased equipment capacity, as well as causing voltage drops as power losses increase. These equate to higher capital investment, higher expenses, and diminished distribution system performance. However, even though energy savings are minimal, correcting power factor can bring significant savings in energy bills if the utility imposes a low power factor penalty in their rate structure, as most utilities do for industrial customers. How much your company can save through installing power factor correction methods depends on your initial power factor, the level you correct it to, motor horsepower rating versus loading, and how the penalty charge is calculated by the utility. All of these variables should be considered when determining the payback potential for different power factor correction methods.

Correcting your power factor

The first step in the process of correcting your power factor is identifying what is causing the low power factor. This information will be extremely important in determining the right approach for bringing your power factor closer to unity. There are many different strategies that can be used individually or in combination to correct low power factor. A few of these strategies are:

- Install capacitors in the distribution system
- Minimize operation of idling or lightly loaded motors
- Install variable frequency drive (VFD) systems to lightly loaded induction motors
- Install new motors that will be operated near their rated capacity
- Replace lightly loaded motors with motors sized to be operated near their rated capacity
- Avoid operation of equipment above its rated voltage.

load factor :- In electrical engineering the **load factor** is defined as the average load divided by the peak load in a specified time period. It is a measure of the utilization rate, or efficiency of electrical energy usage; a high load factor indicates that load is using the electric system more efficiently, whereas consumers or generators that underutilize the electric distribution will have a low load factor.

Experiment No: 5

AIM: - Case study on the energy conservation measures taken in street lightning.

Theory: -

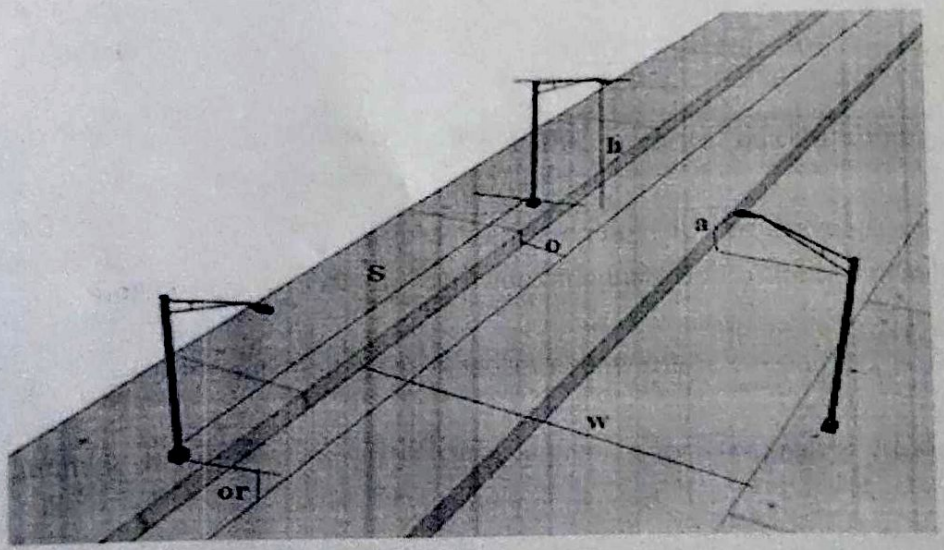
Technical Assessment of Street Lighting Technologies for Energy Efficiency:-

Lighting components can be grouped based on their functions. They are generally described as the structural systems, electrical systems, and optical systems. The items covered include: **Structural** (1) Poles (2) Pole Bases (foundations) , **Optical** (1) Luminaries , **Electrical** (1)Lamps (2)Ballasts (3)Service Cabinets (fuse box)

Type of Lamp	Luminous Efficacy (lm/W)	Colour Rendering Properties	Lamp life in hrs	Remarks
High-pressure Mercury Vapour (MV)	35-65 lm/W	Fair	10,000-15,000	High energy use, poor lamp life
Metal Halide (MH)	70-130 lm/W	Excellent	8,000-12,000	High luminous efficacy, poor lamp life
High Pressure Sodium Vapour (HPSV)	50-150 lm/W	Fair	15,000-24,000	Energy-efficient, poor color rendering
Low Pressure Sodium Vapour	100-190 lm/W	Very Poor	18,000-24,000	Energy-efficient, very poor color rendering
Low Pressure Mercury Fluorescent Tubular Lamp (T12 &T8)	30-90 lm/W	Good	5,000-10,000	Poor lamp life, medium energy use, only available in low wattages
Energy-efficient Fluorescent Tubular Lamp (T5)	100-120 lm/W	Very Good	15,000-20,000	Energy-efficient, long lamp life, only available in low wattages
Light Emitting Diode (LED)	70-160 lm/W	Good	40,000-90,000	High energy savings, low maintenance, long life, no mercury. High investment cost, nascent technology

Effective Energy-efficient Street Lighting Systems :-

Features	Benefits
Proper pole height and spacing	Provides uniform light distribution, which improves appearance for safety and security Meets recommended light levels Minimizes the number of poles, reducing energy and maintenance costs
Proper luminaries aesthetics	Blends in with the surroundings
High lamp efficacy and luminaries efficiency	Minimizes energy cost
Life of the luminaries and other components	Reduces lamp replacement costs
Cost effectiveness	Lowers operating cost
High lumen maintenance	Reduces lamp replacement costs
Good colour rendering	Helps object appear more natural and pleasing to the public Allows better recognition of the environment, improves security
Short lamp restrike	Allows the lamp to quickly come back after a power interruption
Proper light distribution	Provides required light on the roads and walkways
Proper cut-off	Provides adequate optical control to minimize light pollution
Minimizing light pollution and glare	Reduces energy use
Automatic shutoff	Saves energy and maintenance costs by turning lamps off when not needed



Street Lighting Features (BIS, 1981)

A: Angle of Tilt Or: Outreach S: Spacing
W: Width H: Mounting Height O: Overhang

Result:- energy conservation measures taken in street lightning is studied

Experiment No: 6

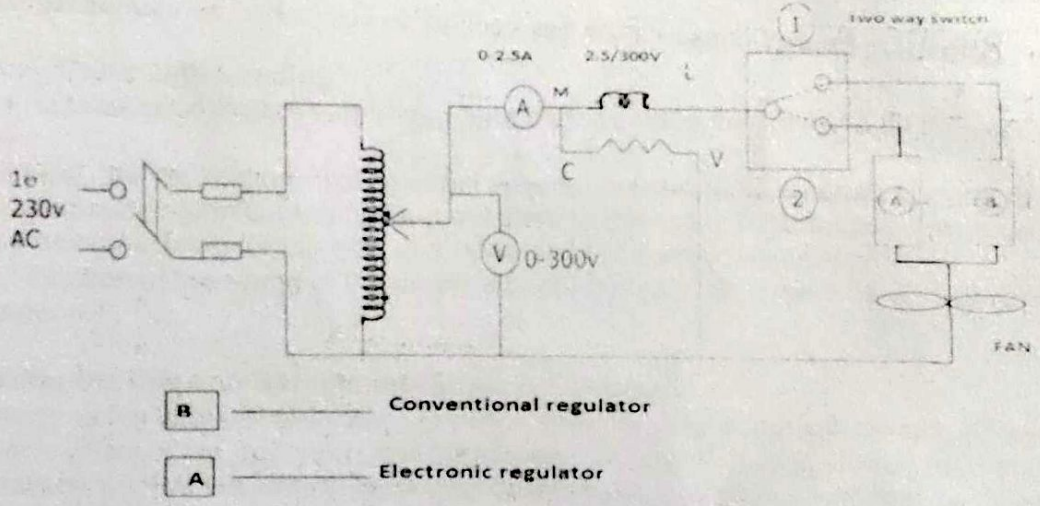
AIM :- Determine Energy conservation in Fan by using Electronic Regulator.

Apparatus Required: 1-Phase Auto Transformer, AC Ammeter, AC Voltmeter, Wattmeter, Conventional regulator, Electronic Tachometer Digital, two way piano switch.

Theory: The electrical diploma engineers are expected *to* know about the benefits of energy efficiency and the use energy efficient regulators to regulate the speed of electric fan. Able to select proper type of regulator based on the requirement and availability. This practical is expected to develop the skills of identifying the energy efficient fans and regulator from the catalogue of different manufacturers as well from the practical test data gear based on the test data.

Minimum Theoretical Background

Construction and working of different types of conventional an electronic regulator. Interpretation of their specification and technical features. Selection of regulators based on rating and type of fan. To connect the fan in the electric circuit with regulate the speed and connect proper meters to measure electrical power drawn.



Practical set-up/ Circuit diagram/ Work situation

Procedure

1. Make the connection as per the circuit shown in fig
2. Check and adjust the zero settings of all the meters.
3. Keep the auto transformer at zero output voltage position.
4. Switch on the supply.
5. Keep the two-way switch in position-1 to connect the convention regulator in the circuit.
6. Note down the meter readings and measure the speed.
7. Now keep the two way switch in position-2 to connect the electronic regulator in the circuit.
8. Repeat step-6
9. Observe the jerk operation of motor while change the steps of regulator.

Observations and Calculations

Comparison of power consumption in regulators.

Type of Regulator with specification	Steps	Current I in Amp	Voltage V in Volts	Power consumed in Watts	Speed in rpm
Conventional	1				
	2				
	3				
	4				
Electronic	1				
	2				
	3				
	4				

Result:- Energy conservation has been observed in Fan by using Electronic Regulator.

Experiment No: 7

AIM: case study on energy conservation techniques implemented in electrical motors.

Theory: there are some techniques for energy conservation in motors

(A) Improving Power Quality :

Motor performance can be increased by maintaining the voltage level within in BIS standards i.e within the tolerance limit of ± 6 % and keeping the frequency within the tolerance of ± 3 %. This is achieved by avoiding voltage unbalance, maintaining voltage and frequency values and avoiding harmonic distortion.

(B) Motor Survey :

- Motor survey is important aspect in energy conservation. Conducting a motor survey is the best way to correctly size a replacement motor.
- A motor survey should begin by reviewing and cataloging the nameplate information on the existing motor to obtain the parameters such as rating of motor, rated speed, efficiency, full-load current, etc.
- The motor nameplate is the first step of a motor survey. It gives available information, such as speed and full-load current, which is helpful while selecting the right size motor.
- Motors operate most efficiently near full load, so determining load requirements accurately is important.
- The highest efficiency is achieved above 80 percent of full load torque, below that efficiency starts to drop dramatically.

(C) Matching Motor with Loading :

- The characteristics of motors vary widely with their load and the type of duty they are expected to perform.
- For example, the applications like constant speed, constant torque, variable speed, steep/ sudden start, continuous/ intermittent duty, frequent start/ stops, etc. should be taken into consideration carefully when deciding for the type of a motor for that specific application.
- Proper selection of the range of the motor according to load requirements will reduce the power consumption.

(D) Minimizing the Idle and Redundant Running of Motor :

- By minimizing the idle and redundant running of motors, prolonged idle running of machine tools, conveyors, exhaust fan, lights etc. can be avoided. Idle running of auxiliaries like cooling towers, air compressors, pumps etc. during prolonged stoppage of production machines can be avoided.

(E) Operating in Star Mode :

- In loads operating at less than 30 % of the full load, i.e. at light loads, operation of "Delta' connected motor in "Star' connection can save energy. If a motor is over sized and continuously loaded below 30 % of its rated shaft load , energy can be saved by permanently connecting the motor in Star.
- In many cases, the load is below 30 % most of the time, but sometimes the load exceeds 50 % in this condition automatic Star-Delta changeover switches can be installed.
- This can save upto 5 to 15 % of the existing power consumption.

(F) Rewinding of Motor :

- Rewinding of electric motors when they fail can be a cost-effective option in man ways.
- While the rewinding process is expected to be extensive and capable of bringing the motor back to a like-new condition, most rewinders do not follow every step or the precision needed to be followed in every step of rewinding.
- This has major impact on the efficiency of a rewound motor. Rewinding will decrease the efficiency by 2-5% in most of the motors.
- A common problem occurs when heat is applied to strip old windings : the insulation between lamination's can be damaged, thereby increasing eddy current losses.

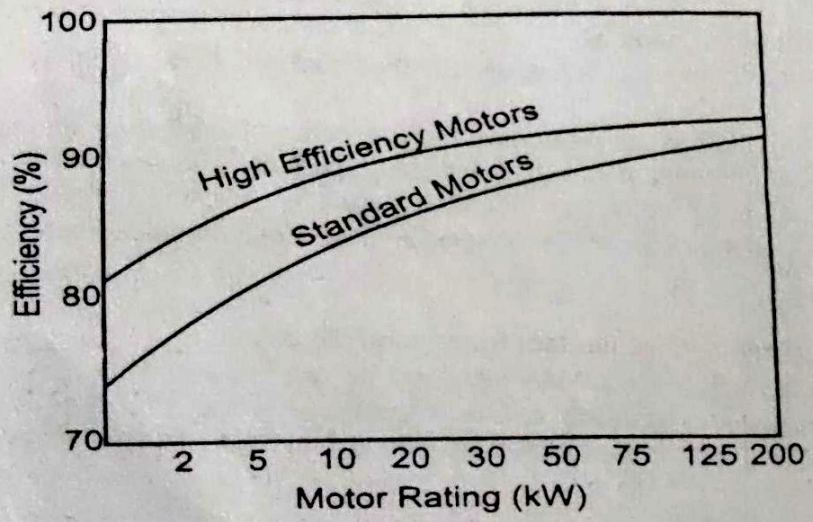
- A change in the air gap may affect power factor and output torque.
- Efficiency an be improved by changing the winding design though the power factor could be affected in process.
- Using wires of large cross section would reduce stator losses thereby increasing efficiency.

(G) Energy Efficient Motor

- An EEM generates the same shaft output power, but uses less input power than a standard efficiency motor.
- Energy efficient motors apply less electricity and last longer than standard motors of the same size.
- Energy-efficient motors are defined as the motor in which design improvements are incorporated specifically to increase efficiency of motors.
- Design improvements focus on reducing intrinsic motor losses.
- Improvements include the use of lower-loss silicon steel, a longer core to increase active material), thicker wires (to reduce resistance), thinner laminations, smaller air gap between stator and rotor, copper instead of aluminium bars in the rotor, superior bearings and a smaller fan, etc.
- Energy-efficient motors now available in India operate with efficiencies that are typically 3 to 4 percentage points higher than standard motors.

(H) Periodic Maintenance

- **Machine cleaning :** To ensure that ventilation and motor cooling is proper.
- **Machine set up and alignment :** To ensure that the belt drives and couplings are set up properly.
- **Bearing lubrication :** Verify that they are lubricated and sealed properly
- **Condition assessment :** Vibration, unusual temperature rise etc. indicate problems.
- **Performance assessment :** Regularly measure supply voltage variations. Voltage imbalance lea to high losses.
- **Maintenance of electrical connections in the starter and motor terminal box :** The loose connections unsafe and source of heat losses.



Experiment No: 8

AIM: Analyze the specification of a energy efficient motor .

Theory: **Equipment/ technology specification :-** The energy efficient motors that need to be used depend upon necessity. Some are of 2 kW rating and some as high as 90 kW. Detailed technical specifications of energy efficient motors are furnished in

S. No.	Parameter	Detail
1.	Manufacturer	KIRLOSKAR
2.	Model	PM160L
3.	Operation	Continuous
4.	Capacity	15 kW
5.	Efficiency	91.8%
6.	Motor type	Induction motor
7.	Voltage rating	415 V +/- 10 V 3 Phase, 50 Hz +/- 5%.
8.	Ambient temperature	max 50 Deg C
9.	Max altitude	1000 m above MSL
10.	Number of poles	4
11.	Speed	1440 rpm

Efficiency of electric motors

Motor Capacity	Standard motor (IS 8789)				Energy efficient motor (IS 12615)	
	Motor load				Eff1	Eff2
kw	100%	75%	50%	25%	Motor load 100% to 60 %	
0.37	64	64	64		73	
0.55	69	69	69		78	
1.1	73	73	73		83.8	76
1.5	76	76	76		85	78
2.2	79	79	79		86.4	81
3.7	83	83	83		88.3	84
5.5	84	84	84		89.2	85.7
7.5	85	85	85		90.1	87

Result: energy efficient motor specification is analyzed.

Experiment No: 9

AIM: Prepare a sample energy audit report of your workshop/ lab, by using various energy audit instruments.

Theory: The energy audits aim at identifying energy saving opportunities both, in the process lines and the energy utilities of the facility. However, the main purpose of the audits is to analyse concrete cost- effective energy efficiency investments. The auditor should adapt this sample energy audit report to the particularities of each audit case, as required. Finally, this template should be seen in conjunction with the training for concerned company during which, specific methodological issues and auditing techniques will be analysed and presented to participating company, hose energy auditing is required.

	Electric			Natural Gas			All Other Fuels			Total Site Energy			
END USE CATEGORY	Baseline Use (kWh)	EEM Savings (kWh)	EEM Savings/ Baseline End Use (%)	Baseline Use (therms)	EEM Savings (therms)	EEM Savings/ Baseline End Use (%)	Baseline Use (MBtu)	EEM Savings (MBtu)	% Savings of Baseline End Use	Baseline Use (MBtu)	End Use % of Baseline Total	EEM Savings (MBtu)	EEM Savings/ Baseline End Use (%)
Space Cooling													
HVAC Pumps/Auxil.													
HVAC Fans													
Interior Lighting													
Exterior Lighting													
Misc. Equip./plug loads													
Other Electric (incl. refrig.)													
Space Heating													
Domestic Hot Water													
Other Fossil Fuel Use													
TOTAL													

Procedure

1. Make a list of different kind of fuels used in different facilities.
2. Check and adjust the zero settings of all the meters prior to measurement.
3. Calculate cost of consumption on a daily basis.
4. Make the observation in a tabular form as seen in figure above.

Result:

Thus, a sample energy audit report of workshop/ lab has been successfully prepared.

Experiment No: 10

AIM: Prepare a sample energy audit questionnaire for the given industrial facility.

Theory:

Practical Significance

Energy audit questionnaire aims at interpreting the existing energy consumption pattern and identify the potential for energy saving. It is very important to have a well-structured questionnaire to understand the pattern of energy consumption.

Minimum Theoretical Background

- Location of the industry.
- Type of the Industry.
- Connected Load.
- Electrical energy consumption.

WORK SITUATION:

Visit any nearby industry/Institution/Workshop/Residential Building and inspect it for Energy audit purpose. Draw table below which includes general energy audit questionnaire

Name of the Company			
Contact Person & Designation			
Address			
Phone No.		Cell No.	
Fax No.		Email	
Operation	One/Two/Three Shifts per day &6/7 days per week		
Fuel Consumption (per month) for DG set.			
Description	Unit Rate	Consumption	Total Amount
Fuel 1			
Fuel 2			
Fuel 3			
Electricity Bill Detail (If possible, please attach a copy of the recent bill)			
Connected Load, KVA		Contract Demand, kVA	
Actual Demand, kVA		Power Factor	
Type of supply			
Power (Minimum of Six month) Consumption, kWh/month	KWH Month-1: Month-2: Month-3: Month-4: Month-5: Month-6:	Tariff structure and schedule rate	Total Amount, Rs

Data collection of various appliances/Machines

A: Motors: (Use similar sheets for different motors)

Facility/Location: _____

Department: _____

Process and Nature of Load: _____

Motor Type: _____

Motor Purchase Date / Age: _____

Coupling Type: _____

Method of starting _____

Duty Cycle _____

Rewound _ Yes _ No

Motor Nameplate Data/ History

1. Manufacturer: _____
2. Motor ID Number: _____
3. Rating in (HP/ kW):_____
4. Enclosure Type: _____
5. Synchronous Speed (RPM) :_____
6. Full-Load Speed (RPM) :_____
7. Voltage Rating: _____
8. Full-Load current: _____
9. Full-Load Power Factor: _____
10. Full-Load Efficiency (%) _____
11. Insulation Class: _____

Result:

Thus, a sample energy audit questionnaire for the given industrial facility has been prepared successfully.