Grenada Capacity Building Programme for Energy Management and Energy Audits

Webinar II : **Save Energy, Save Money**

Target audience: Hotels and Financial Institutions

Date: 12- 13 April 2022
Time: 9:00 am to 12:00 pm Grenada Time

Day - 2

Content

- **Day-2: Energy Efficiency Measures & Financial Planning**
  - *Review of Energy Use*
  - *Activities to do During Site Assessment*
  - *Identification of Energy Conservation Measures*
  - *Energy Saving Calculations*
  - *Financial Viability of The Project*
  - *Energy Audit Report Format*
  - *Q&A*

Session II

Review of Energy Use and Site Assessment

Preliminary Review of Energy Use

Preliminary evaluation of energy use is important to know

- Energy End Use
- Yearly or Seasonal Variation in Power Consumption
- Energy Utilization Index (EUI) of Buildings
- Specific Energy Consumption (SEC) in Manufacturing Industries

$$EUI = \frac{Annual\ Energy\ Use}{Square\ Footage}$$

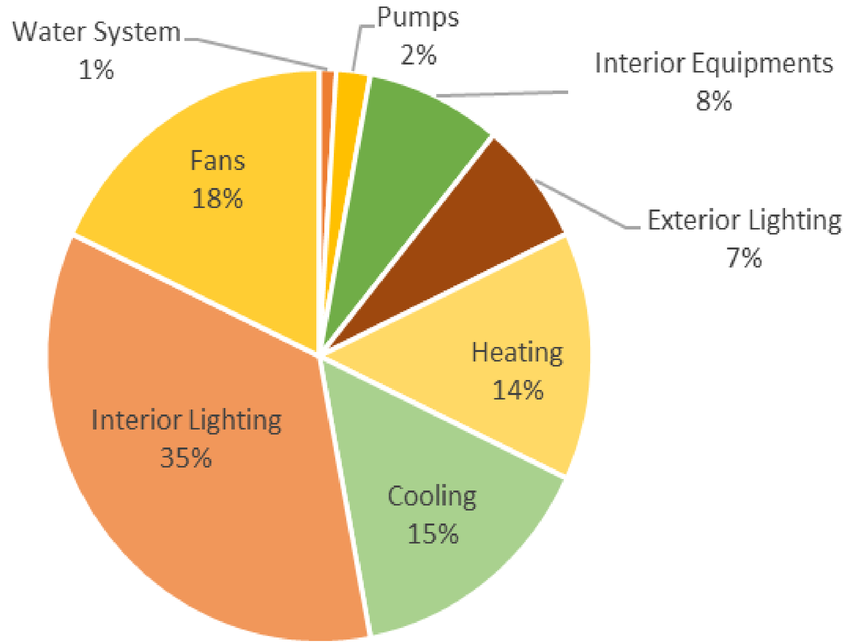
$$SEC = \frac{Annual\ Energy\ Use}{Annual\ Production}$$

EUI and SEC would help to **benchmark** the data against energy use in similar buildings or industries. This also helps to find the potential magnitude of **energy efficiency opportunities** and provide an early estimate of potential savings

Preliminary Review of Energy Use

Information required for preliminary review of energy use

- Monthly Utility Bill
- Building or System Schematics
- Equipment Lists
- Other Relevant Information's



Monthly utility bill would help to identify any changes in energy use over time and potential causes for those changes

Site Assessment

- After the preliminary review, the energy auditor will conduct a physical assessment of facility and its operations.
- The energy auditor will meet with key operations and maintenance staff to know about equipment performance and discuss any concerns or issues with the facility

On-Site Survey	
Monitor electrical energy use by equipment's	Monitor thermal energy use by equipment's
Heat balance of thermal energy	Electric energy balance
Calculate operating efficiency of different appliances/equipment's	Identify energy saving potential

Based on the requirement Energy Auditor will use energy audit instrument/meter to capture the usage electrical and thermal energy

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Following data was collected for the preliminary review of the energy use

- Equipment details
- One-year electric energy consumption detail (Monthly electricity bill)

Equipment	Quantity	Rating (Wattage)
Air Conditioner	35	1300
Centralized Electric Water Heater	2 (2x1000 L)	18000 (2 x 3 kW x 6 Coil)
Water Pump	2	7500
Lift	3	5500
Ceiling Fan	50	75
Exhaust Fan	8	200

Equipment	Quantity	Rating (Wattage)
Projector	2	150
Desktop Computer	8	200
CFL Lamp	940	5 8 14
FTL Lamp	71	36
Focus Lamp	2	65

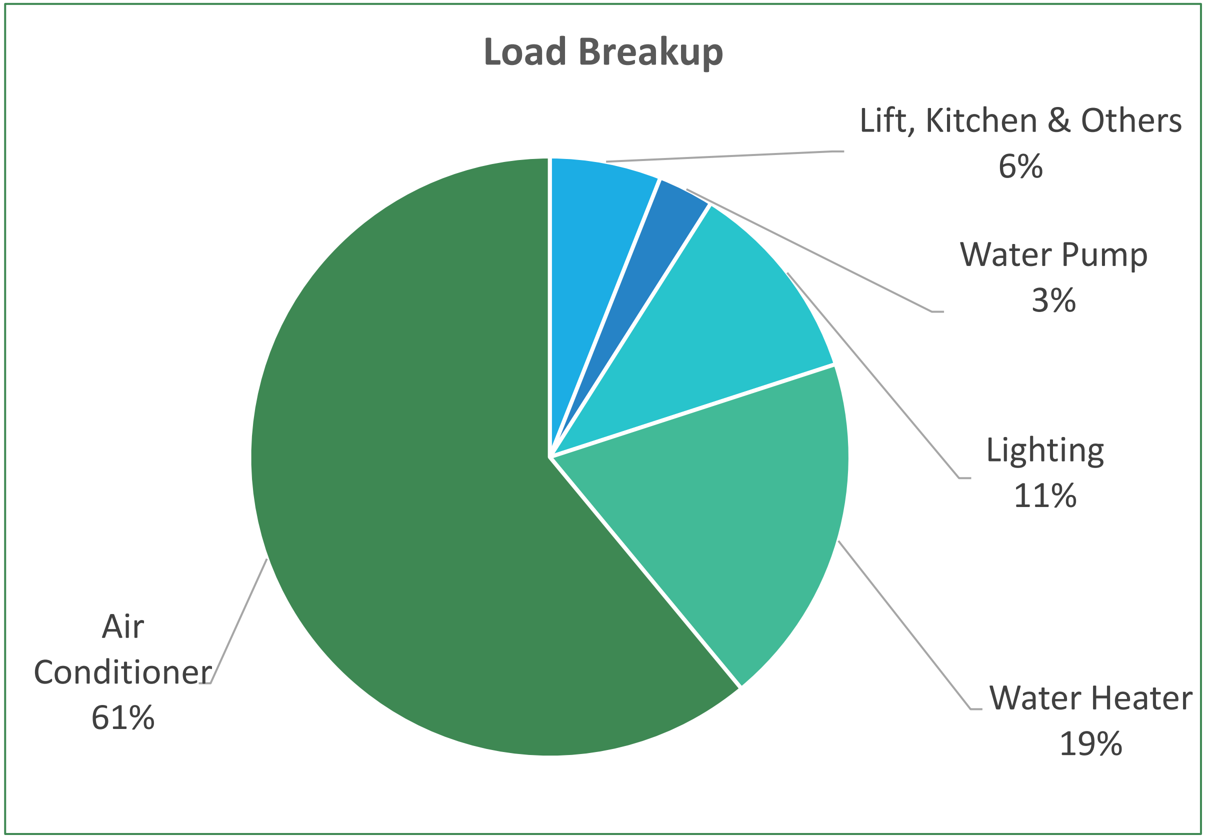
Information collected were **Location, Operating Hours in a year and Switching Mechanism** ***(Manual or Automatic)***

Equipment details would help to identify key energy consumption areas

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Conclusion from the preliminary review of the energy use

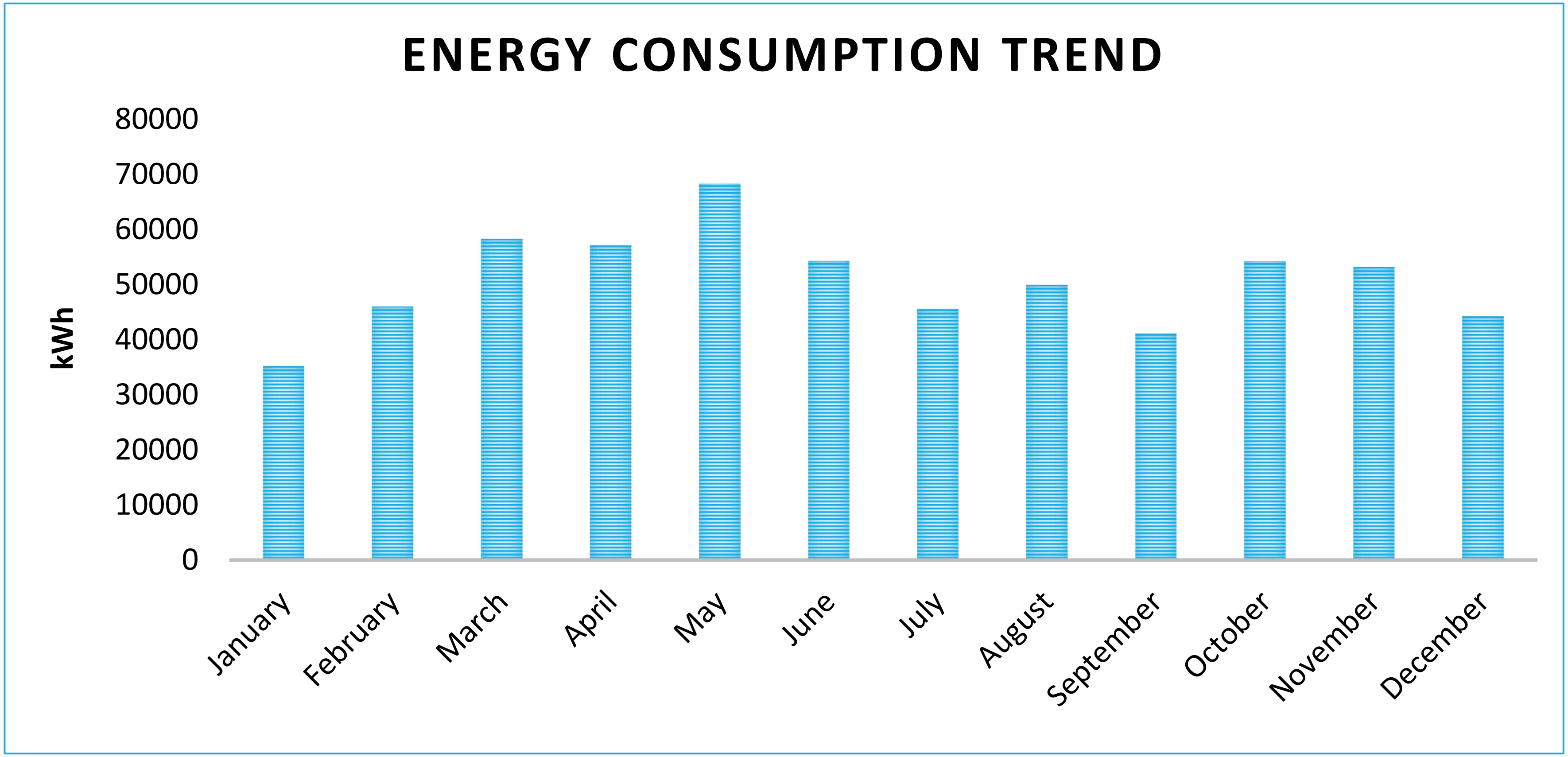
- Major energy consuming area
- Potential magnitude of energy efficiency opportunities.
- Provide an early estimate of potential savings
- Average daily electrical energy consumption
- Seasonal variation in load



*Calculated using equipment details provided by institute management

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Monthly Electrical Energy Consumption



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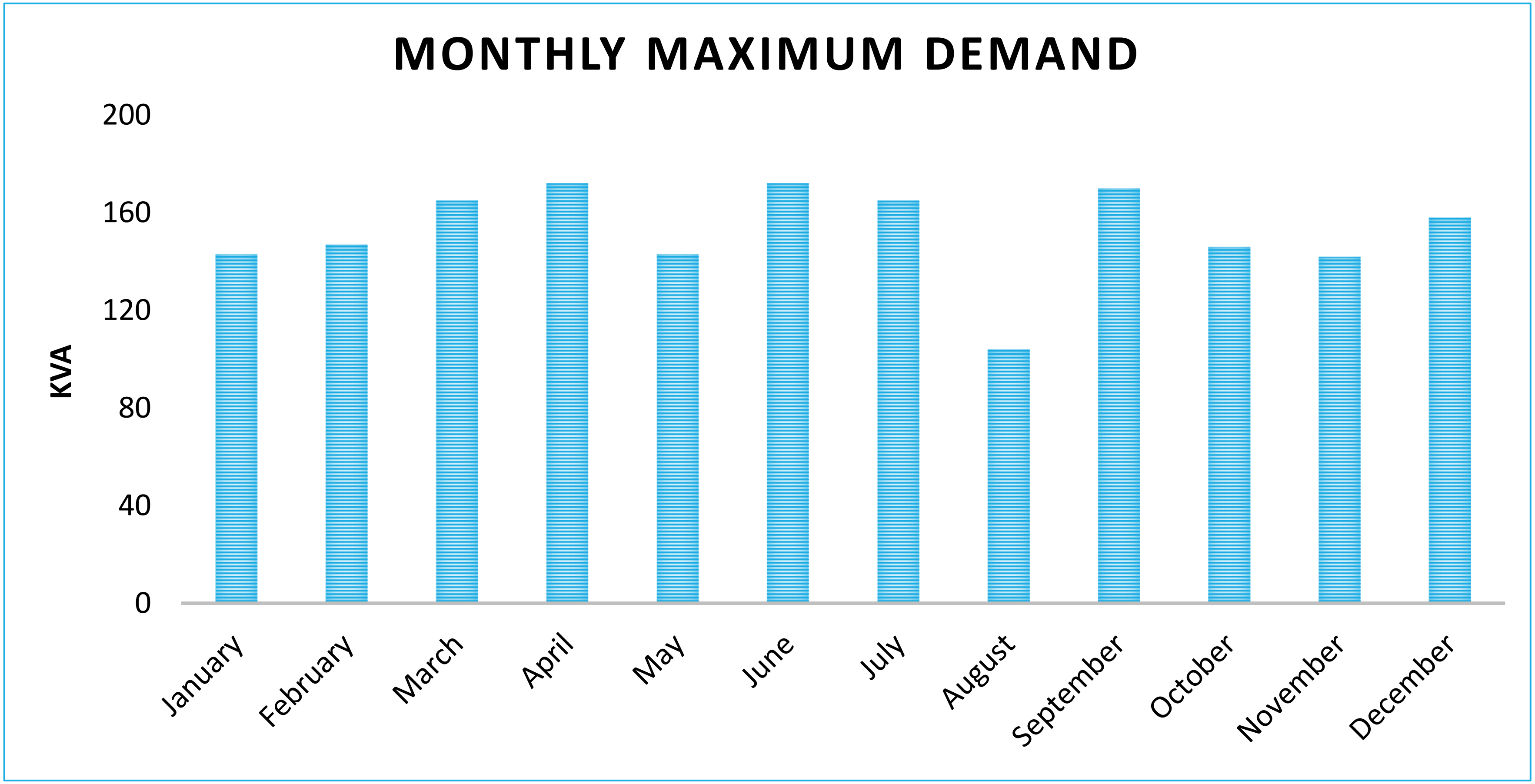
Monthly Electrical Energy Consumption



Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Site Assessment of a Resort

- Monitor load variation during day and night-time; using portable three phase power analyzer.
- Check load current variation in three phases and neutral
- Visual inspection of
  - Rated efficiency of the equipment's
  - Manual, timeclock or automated HVAC control methods
  - Interior and exterior lighting systems and related controls
  - Hot water systems
  - Operating practices of all equipment's

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Observation during site assessment

- Lights in office and common area was found ON during daytime. Sufficient daylight is coming in office space and common area.
- During night-time, all corridor lights were found to be switched ON.
- Projector & Desktop Computers was found to be in standby mode
- Installed air conditioner units was found to be inefficient (non-inverter type)
- Set AC temperature was found to be 20^{o}C
- In rooms individual switches were provided for each light and fan. This is a very good practice as it enables only the required number of lights and fans being switched ON

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure - 1 Replace the conventional Fluorescent Tube Light with energy efficient LED tube lights.

FTL Tube Light		LED Tube Light
55W	→	22W
38W		20W
28W		18W

Energy Conservation Measure - 2 During day time, **switch OFF** the tube lights wherever not required and use **Natural Day Light** - Create awareness among students and staff to promote energy conservation

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure - 3 During night time, **switch OFF** alternate lights in corridor and maintain minimum lux level.

OR

Provide motion sensor to alternate lights in corridor. By doing so only alternate lights would be ON during night time and remaining lights would automatically switched ON during any movement.

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure - 4 Replace the conventional ceiling fan with energy efficient BLDC fan.

BLDC Fan	Traditional Fan
32 W	55 W

- BLDC motor fans consume less power as compared to the traditional ceiling fans.
- These fans come with a **remote control unit** thereby allowing you to switch ON and OFF the fans easily.
- BLDC motor fans come with a **Timer and Sleep mode** that will enable you to set a specific time limit (number of hours) while sleeping.

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure - 5 Set the default temperature of AC around 24 - 27 ^{o}C.

By doing so **3-4% power can be saved.** *(Savings in lower temp (<24^{o}C) – 6% for every rise in 1^{o}C and in higher temp (>24^{o}C) – 4% for every rise in 1^{o}C)*

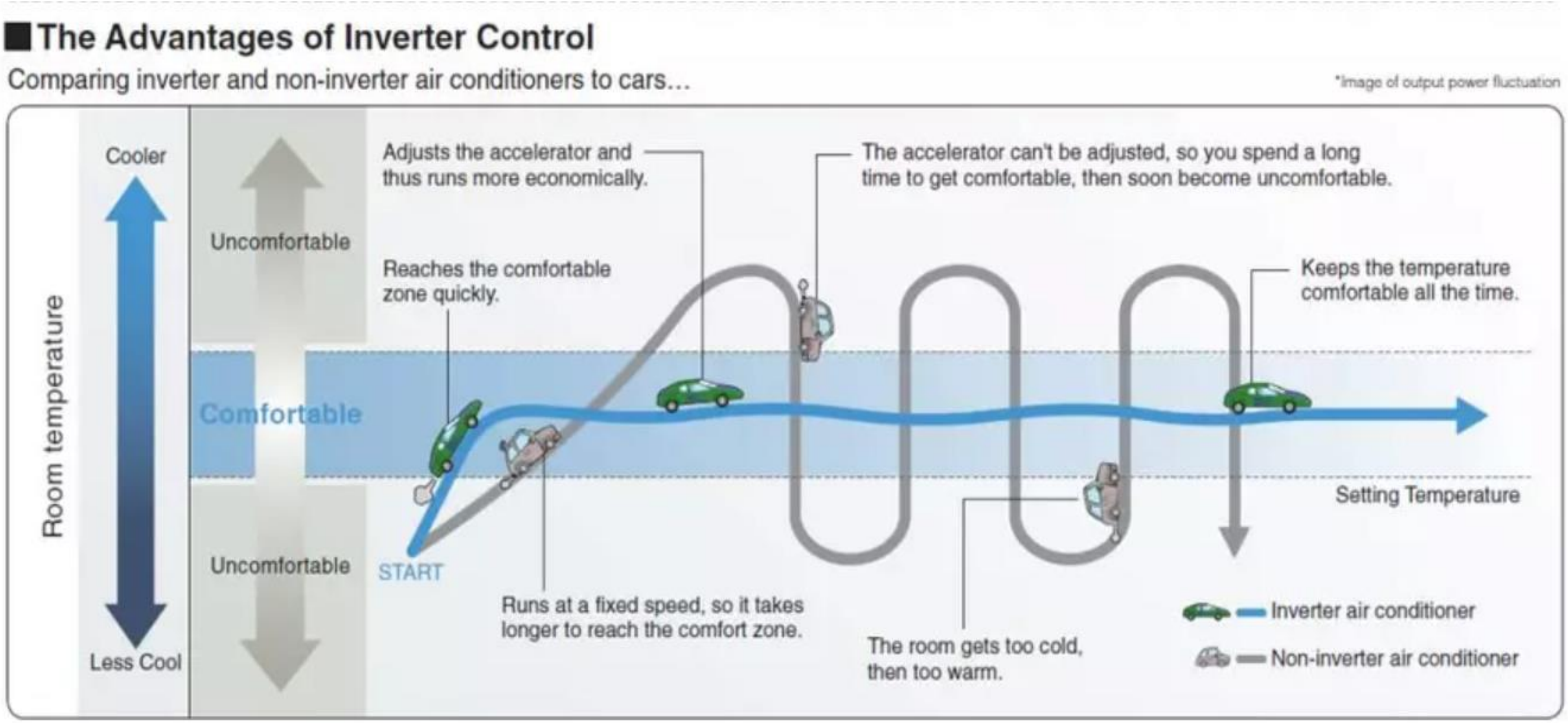
Feeling **HOT** at 27^{o}C

Set the temperature of AC at 27^{o}C and use fan at optimum speed.

Avoid using ceiling fans because hot air will be redistributed. Rather, use floor fans to provide better airflow for added comfort and cooling

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure - 6 Replace the old non-inverter AC with new energy efficient inverter AC.



Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure - 7 Reduce the heat load of room to reduce electricity consumption by Air Conditioner.

- By putting curtain on windows.
- Close door and windows.
- Arrest air leakage near door and windows.
- Avoid ironing of clothes in AC room.

Energy Conservation Measure – 8 Keep AC outdoor unit (Condenser Unit) in shade and ventilated area.

Energy Conservation Measure - 9 When ever not utilizing, switch OFF the desktop computer and projectors from main power supply. This will help to save **Stand-By** power.

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure – 10 Replace Electric Water Heater With Heat Pump Water Heater

- Heat-pump hot water systems works on a same principle of **Refrigerator – but in Reverse Way**.
- While a refrigerator pulls heat from inside a box and dumps it into the surrounding room, a heat pump water heater pulls heat from the surrounding air and dumps it — at a higher temperature — into a tank to heat water.”.
- Today most heat pump water heaters also include a **backup electric resistance heater** in case the surrounding air temperature isn’t warm enough to use.
- Heat-pump use electricity to operate the evaporator fan and compressor when they’re heating water.
- Heat-pump use around 60 to 75% less electricity than a conventional electric hot water system.

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

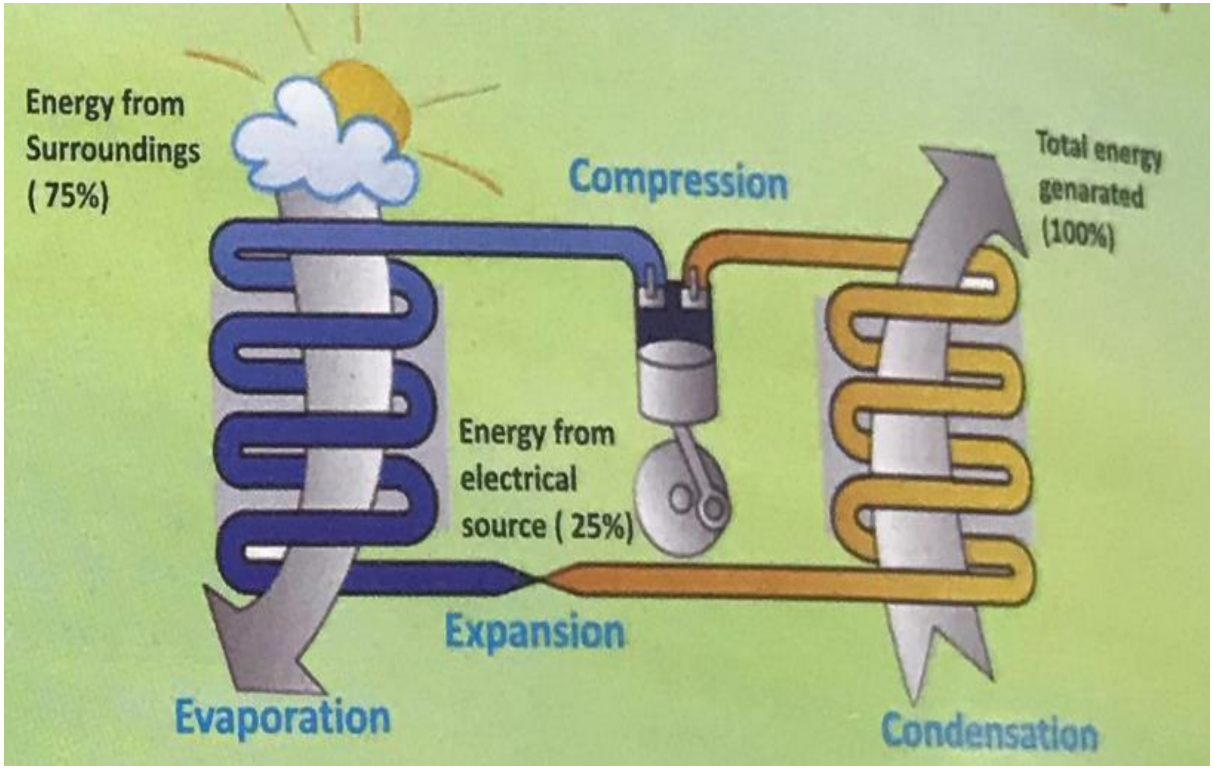
Energy Conservation Measure – 10 Replace Electric Water Heater With Heat Pump Water Heater

Pros:

1. Energy Efficient
2. Environmental friendly

Cons:

1. More expensive upfront cost
2. May create noise

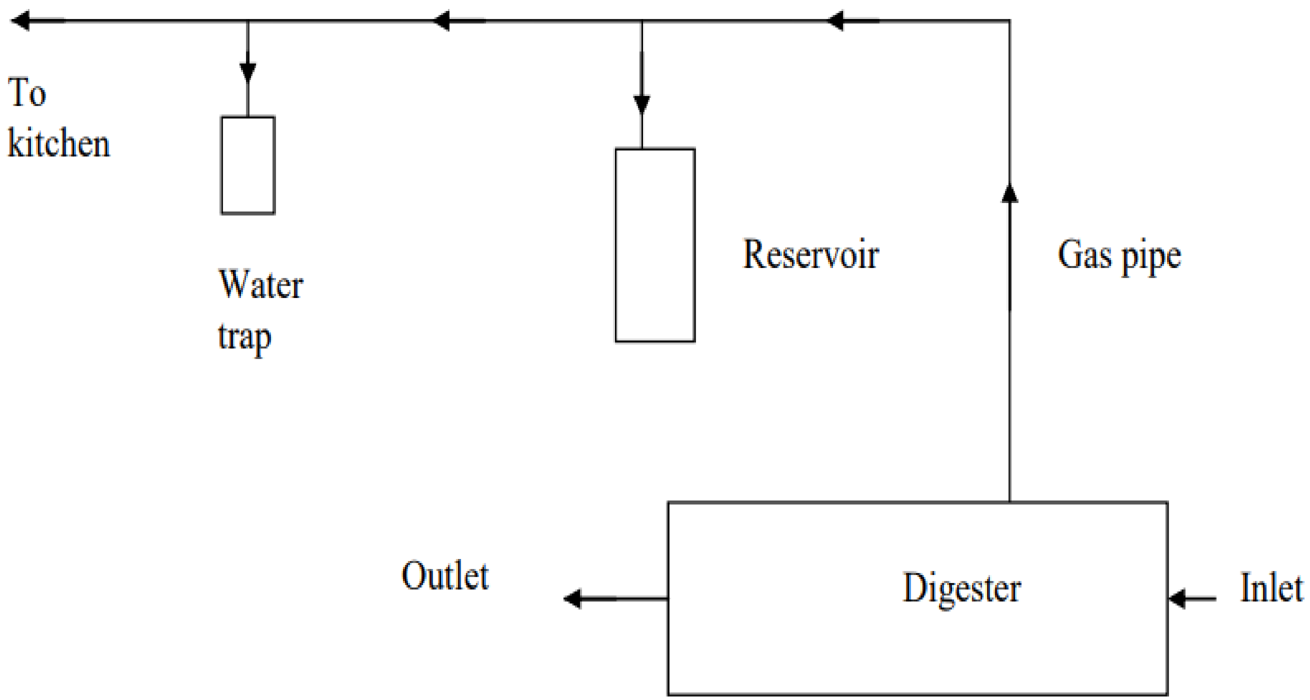


Energy Conservation Measure – 11 Production of Bio-Gas from kitchen waste.

- On daily basis significant amount of kitchen waste is generated in resort. The kitchen waste is collected by local Municipal Corporation and disposed in landfill which will eventually cause air and water pollution.
- Inadequate management of wastes not only leads to polluting surface and groundwater, it also emits unpleasant odour and methane which is a major greenhouse gas contributing to global warming.
- Alternatively, kitchen waste can be used to generate biogas. Biogas contains around 55-65% of methane, 30-40% carbon dioxide.
- Kitchen waste is organic material having the high calorific value and nutritive value to microbes, that's why efficiency of methane production can be increased by several orders of magnitude. It means higher efficiency of biogas digester and also installation cost will reduce.

Case Study – 1 Review of Energy Use and Site Assessment of a Resort

Energy Conservation Measure – 11 Production of Bio-Gas from kitchen waste.



Approximately, one person will generate one kg of kitchen waste and 20 kg of kitchen waste will generate 1.2 lb of LPG equivalent of biogas daily

Energy Audit of Water Treatment Plant

Objective

- Identify energy saving potential in water treatment plant.
- Prepare a comprehensive list of energy conservation measures and determine the energy savings due to the various measures.
- Estimate the costs required to implement the energy conservation measures including an evaluation of the cost effectiveness of each energy conservation measure using an economic analysis method.

Background

- Installed Capacity : 8,700 m^3 /month
- Capacity utilization factor : 40%
- Population served : 115,000

Case Study – 2 Review of Energy Use and Site Assessment of Water Treatment Plant

Preliminary Review of Energy Use

- Water treatment plant had not shared any preliminary data
- All required data were collected during site assessment

Site Assessment

Approach adopted during energy audit was

1. **Data Collection**
    - Monthly electricity consumption
    - Power supply details like operating voltage, power factor maintained, electricity cost etc.
    - Detailed information about all installed equipment's like pumps, motors, capacitor bank and other electrical devices.
    - Water supply input and output details
    - Water flow control mechanism like throttle valves

Case Study – 2 Review of Energy Use and Site Assessment of Water Treatment Plant

2. Facility Description

- Receive electricity through 11 KV HT overhead line.
- Stepdown to 415 V, using 315 KVA transformer.
- 25 kVAr capacitor bank is installed in all MCC.
- Facility has 3 numbers of water treatment pumps (1 Running and 2 Standby)

Particulars	P # 1, 2, 3
Rated Flow, m^3/h	215
Rated Head, meters	67
Connected Motor kW	90

Total operating hours of pump : 12 Hr/Day. (*4 Hour in each shift (Total number shift : 3 per day)***)**

- Two air blowers of 18.5kW is installed and operated only for 15 minutes in a day to aerate filter tanks
- 36 W Fluorescent tube light – 20 Number for indoor lighting
- 250 W HPMV lamp – 12 Number for outdoor street lighting

Case Study – 2 Review of Energy Use and Site Assessment of Water Treatment Plant

3. **On site measurement**

   - Daily total electricity consumption by water utility – 24-hour electrical logging of main incomer using 3 phase power analyser.

Description	Phase	Voltage	Current	kW	PF	kVA	kVAr
Main LT PCC incomer	R	424	101	63	0.84	74	39.5
	Y	426	95	56	0.81	69	40.6
	B	423	94	59	0.85	69	35.8
Average		424	97	60	0.83	71	38.6

   - Power consumption by pump and other electrical devices using portable power analyser

Description	Rated kW	Voltage	Current	kW	PF	kVA	kVAr	%loading
Water pump motor #1	90	429	74	**49**	0.87	53	25	54.6%
Water pump motor #2	90	431	91	**56**	0.83	68	37	63.2%
Water pump motor #3	90	423	98	**57**	0.78	72	49	63.3%
Blower-2	18.5	428	15	**11**	0.99	11	0.59	62.2%

Case Study – 2 Review of Energy Use and Site Assessment of Water Treatment Plant

- Water flow measurement using ultrasonic water flow meter.

Particulars	P 1	P 2	P3
Flow, m^3/h	208	189	**187**
Head, m	**48**	**50**	**50**



3. Energy Conservation Measures

ECM – 1 Replace water pumps with new pumps to meet present operating parameters

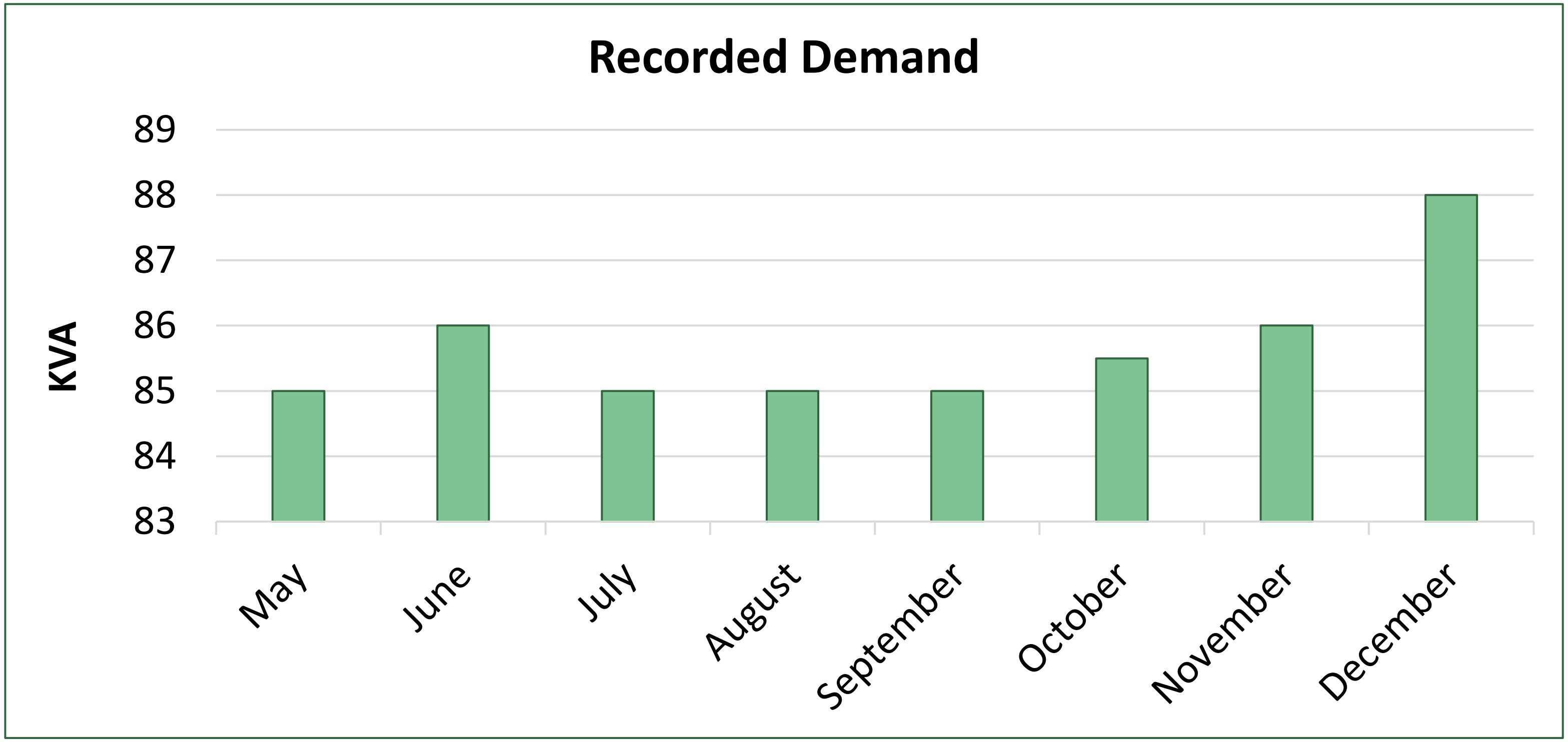
Particulars	P 1	P 2	P3
Rated parameter			
Flow, m^3/h	215	215	215
Head, m	67	67	67
Pump efficiency, %	82	82	82
Measured Parameters			
Flow, m^3/h	208	189	187
Head, m	48	50	50
Power, kW	49.1	56.9	57.8
Pump efficiency, %	61.5	49.4	49.0

New Pump Specifications	
Flow, m^3/h	Head, m
215	55

To minimize the investment cost, same motor of 90 kW can be used.

3. Energy Conservation Measures

ECM – 2 Demand reduction by installing capacitors with automatic power factor controller at main PCC incomer (LT Side)



3. Energy Conservation Measures

ECM – 2 Demand reduction by installing capacitors with automatic power factor controller at main PCC incomer (LT Side)

- Even though a capacitor of 25kVAr is provided at each pump starter the power factor is observed to be below 0.90 lag,
- It is recommended to install 30 kVAr of capacitors with automatic power factor controller at main LTPCC incomer and maintain power factor near 0.99 lag

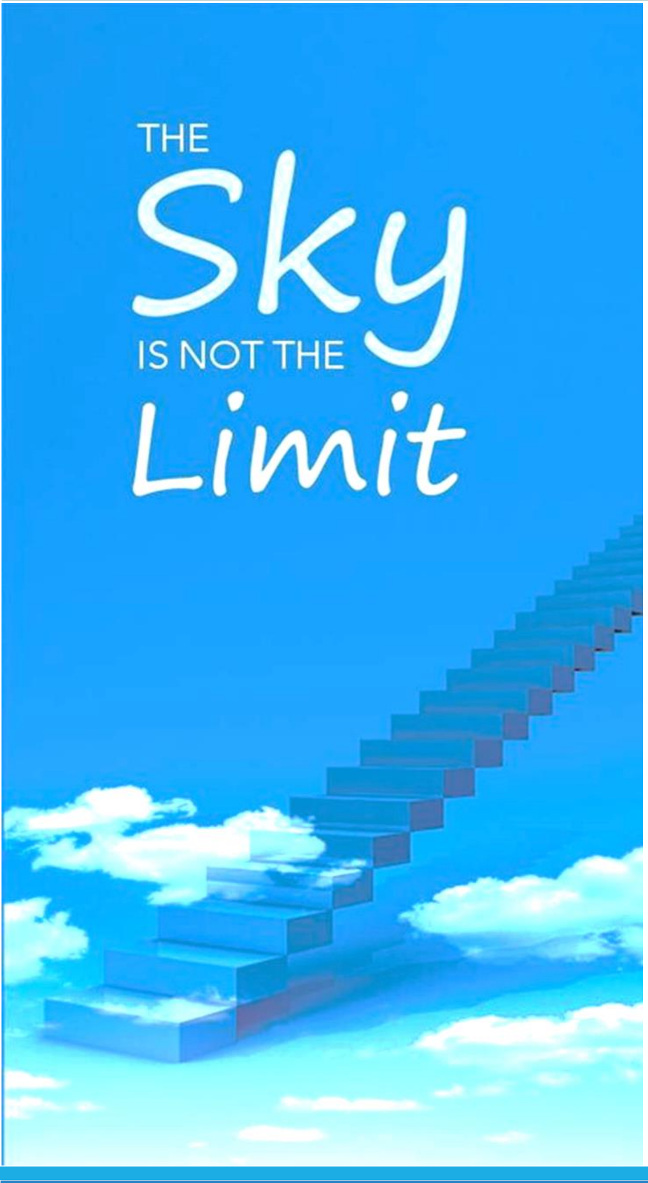
3. Energy Conservation Measures

ECM – 3 Replace existing 250 W HPMV streetlights with Solar powered LED streetlights and 36 W FTL with 20 W LED tube lights.

Session III

Data Analysis and Audit Report

Energy Data Analysis



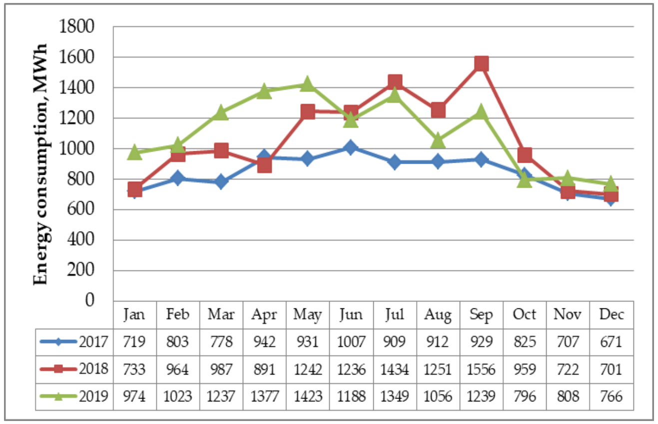
- Energy data analysis methodology varies with respect to the **type of facility** and **study objectives to be achieved.**
- Analysing the collected information will help in understanding the historical and present performance level of the respective facility.
- In order to manage day-to-day energy consumption efficiently, it is highly essential to analyse the energy consumption data, benchmark energy use and set targets that can result in significant energy cost savings along with carbon emission reduction.

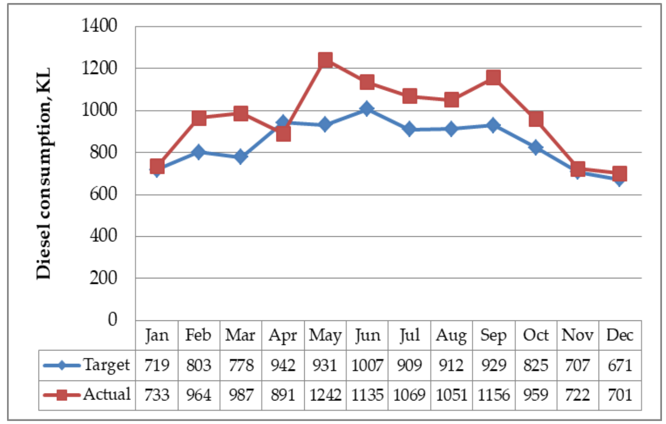
"we can't manage what we can't measure"

Energy Data Analysis

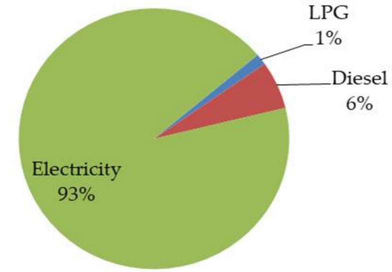
- Typical Analysis methods:
  - Spreadsheet based analysis using engineering formulae taking into account time variation based analysis.
  - Analysing hourly, daily, weekly and seasonal load variation pattern of the incomer – Activity based and Equipment based.
  - Simulation based analysis by incorporating sensors with data loggers.
  - Develop performance metrics using some key performance indicators (KPIs) such as
    - Energy intensity (kWh/Sq.m)
    - Energy Utilization Index
    - Specific energy consumption
    - Specific water consumption
- Benefits: Not just identifying energy savings
  - Develop a complete insight of the facility on use of various resources
  - Helps in detecting anomalies
  - Develop awareness and engage the end user
  - Impact the culture positively

Typical Energy Performance Assessment Dashboard

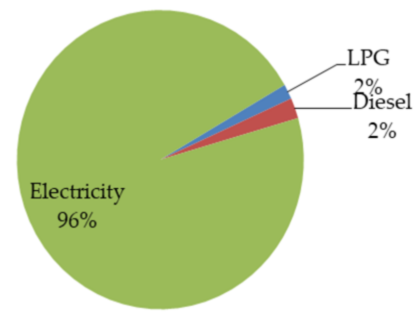


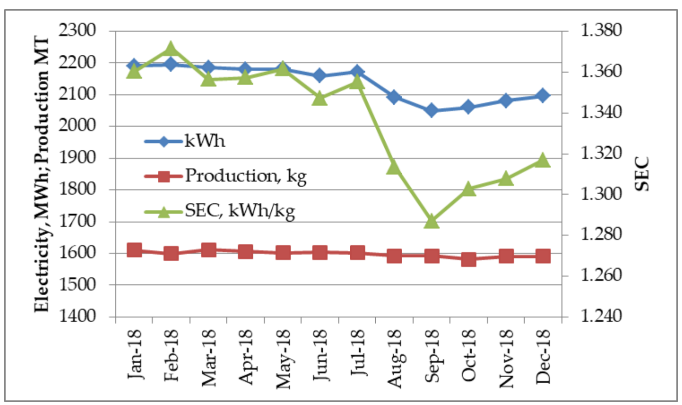


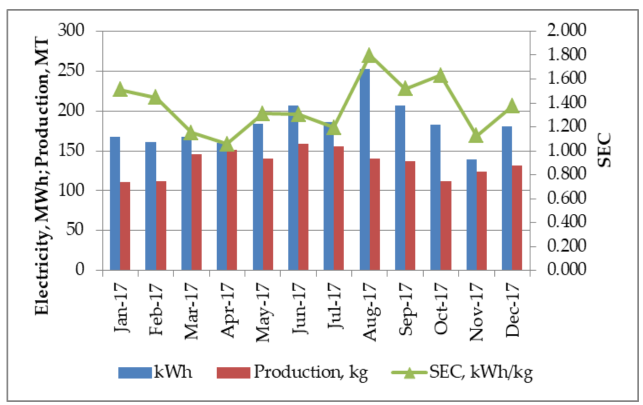
Break-up of energy consumption



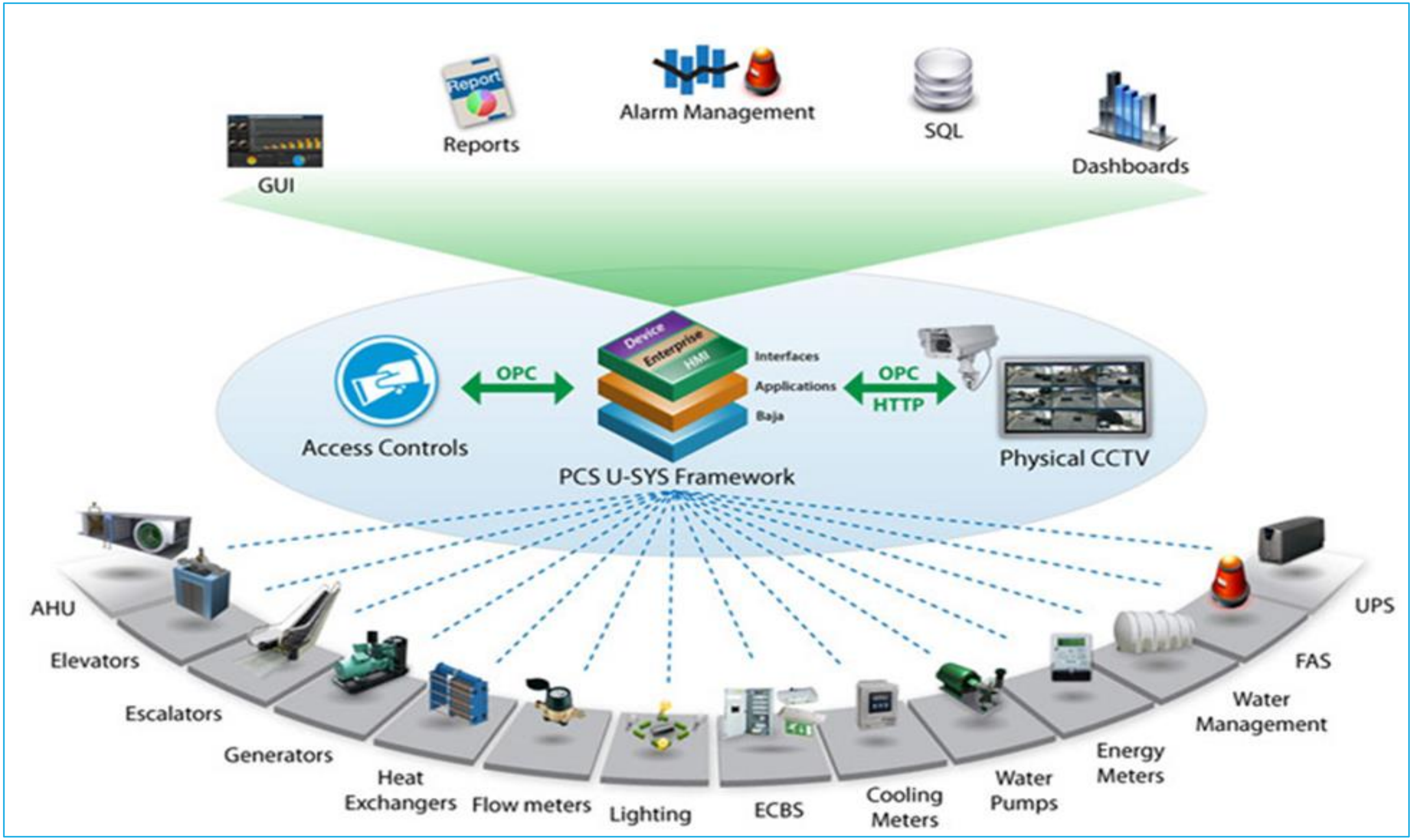
Break-up of energy cost



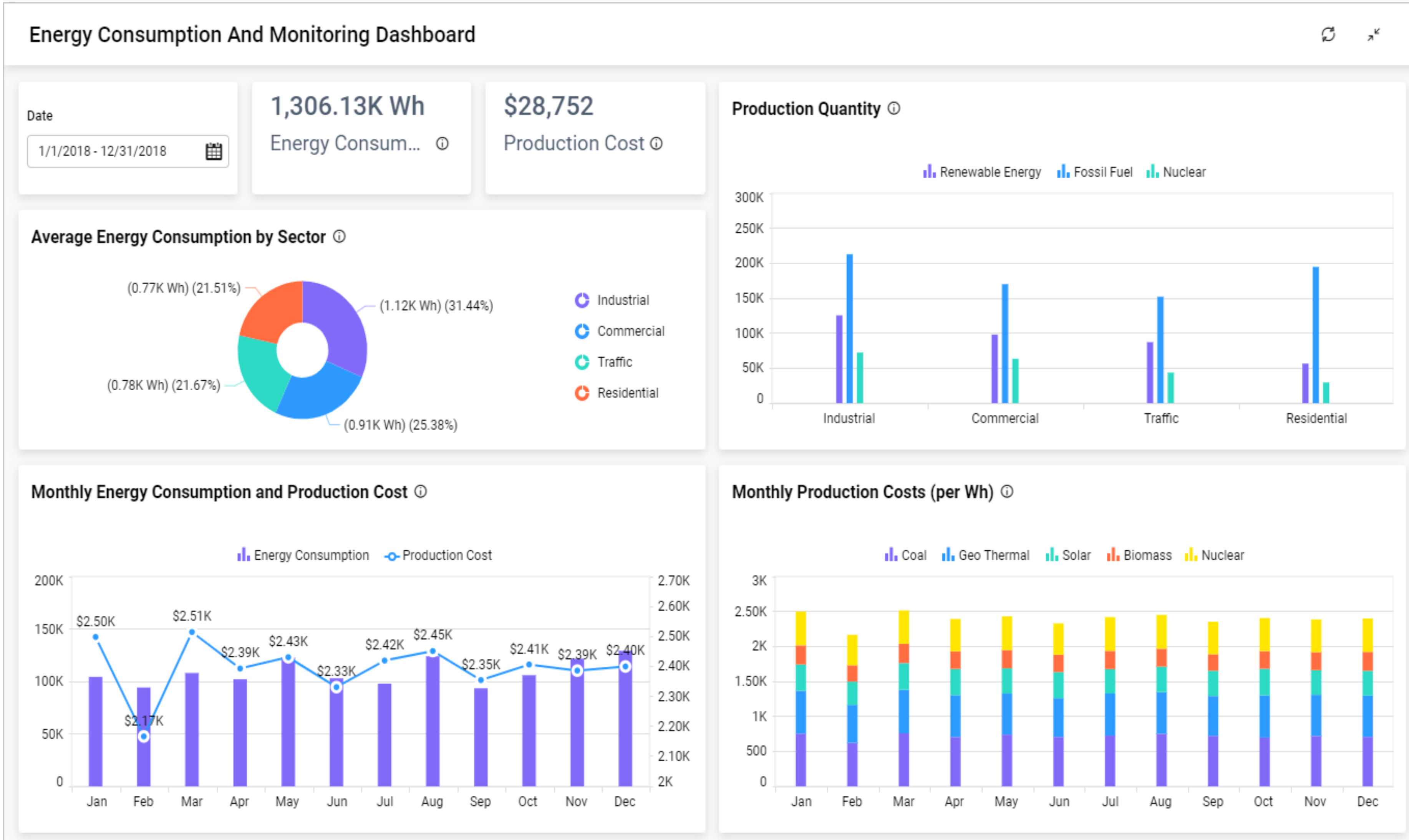




Typical Energy Management System



Typical Energy Performance Assessment Dashboard



Economic Analysis

- ❑ Current Energy cost(Utility rates per unit of Electricity or Diesel) is used for estimating the annual energy cost savings of identified ECMs.
- ❑ Investment for implementation of measures depends on the type of the ECMs:
  - O & M (Operational and Maintenance)
  - Retrofitting
  - Technology upgradation

ATTRACTIVENESS OF THE INVESTMENT FOR A PARTICULAR ECM DEPENDS ON THE PROJECT VIABILITY PRACTICALLY AS WELL AS FINACIALLY.

- ❑ Tools for evaluating financial viability:
  - Simple Payback period
  - Return on Investment (ROI)
  - Lifecycle analysis
  - Internal Rate of Return (IRR)
  - Net present Value

- ❑ ***Accurate Investment cost data*** *to avoid underestimating or over estimating of funds.*
- ❑ ***Detailed cost analysis*** *to ensure valid economic analysis for high investment EC projects.*

Economic Analysis

❑ Tools for evaluating financial viability:

Name	Usage	Application areas
Simple payback period (SPB)	SPB is a simple analysis tool used frequently in energy efficiency project upgrades and maintenance activities to calculate energy payback period.	Home energy assessment, Industries & Businesses (Small or big) depending on the type of investment. ***"Smaller the SPB, the attractive is the investment."***
Return on Investment (ROI)	ROI is a Profitability metric used to evaluate the attractiveness of an investment. Majorly useful for measuring success over time and making investment decisions by apple-to-apple comparison.	Factory expansion, Stock market investments, Real estates, commercial vehicle procurement etc. ***"A Positive ROI indicates profit and a negative ROI indicates loss."***
Net Present Value (NPV) & Internal Rate of Return (IRR)	NPV is the difference between the present value of cash inflows and the present value of cash outflows over a period of time. IRR is a calculation used to estimate the profitability of potential investments.	NPV and IRR concepts are applied majorly in Capital budgeting for large and long term projects. ***"If a project's NPV is above zero, then it's considered to be financially worth considering.*** *And* ***IRR generates the percentage return that the project is expected to create."***
Life cycle cost analysis (LCCA)	LCCA is a tool to determine the most cost-effective option among different competing alternatives to purchase, own, operate, maintain and, finally, dispose of an object or process	Asset monitoring, Large infrastructure projects etc.

- ❑ ***Accurate Investment cost data*** *is needed to avoid underestimating or over estimating of funds.*
- ❑ ***Detailed cost analysis*** *to ensure valid economic analysis for high investment EC projects.*

Important Aspects to be considered

While analyzing potential analyzing energy saving opportunities:

- ❑ *Feasibility of system replacement*
- ❑ *Ease of implementation*
- ❑ *Risk of failure*
- ❑ *Improved system reliability*
- ❑ *Positive or Negative impact on the operational and maintenance costs*

Energy Saving Calculations

Calculations for some of the frequently used measures were listed below:

- *Type-1**: Operational and maintenance***
  - ✓ *Switching OFF devices (eg: lights or fans) when not in use or reduced hours of operation*
    - *Manual operation*
    - *Automatic operation using sensors and actuators*
- *Type-2: **Energy improvement payback calculator for retrofit opportunities***
  - ✓ Changing old inefficient devices with new efficient devices
    - ✓ Example: Old inefficient lights with new energy efficient LED lights
    - ✓ Conventional fans with BLDC fans
    - ✓ Old Air conditioning units with latest technology AC units

Energy Saving Calculations - Switching Off (or) reduced operation hours of equipment

Sl.No.	Description	Old value	New value	Unit
	Name of Equipment: Fluorescent tube light (T8)			
A.	Power Consumption (Watts* or kW)	36	36	Watts
A1.	Rated power details on name plate	36	36	Watts
A2.	Actual Measured power	36	36	Watts
A3.	Instrumentation Display reading of Power	36	36	Watts
B.	Operating Hours (hr) per year	4500	3000	Hours
B1.	Continuous (24 X 7)	NA	NA	Hours
B2.	Partial operation	✓	✓	Hours
B3.	On and off operation	15	10	Hours
C.	Number of Equipment (nos)	5	5	Nos.
C1.	Installed	5	5	Nos.
C2.	Switched on /off	5	5	Nos.
D.	Annual Energy consumption [D=(A*B*C)/1000]	810	540	kWh
E.	Reduction Energy consumption ($E = D_{old} - D_{new}$)	270		kWh
F.	Energy cost	0.78		EC$/kWh
G.	Annual Energy Cost Savings (G = E X F)	210.6		EC$
H.	Annual maintenance cost (H=I1+I2+I3)	50		EC$
I.	Net Annual Cost savings (I = G - H)	160.6		EC$
I1.	Cost of materials/Equipment/Machine	NA		EC$
I2.	Cost of Labor for project implementation	NA		EC$
I3.	Cost of manpower training	NA		EC$
J.	Total investment of ECM	150		EC$
K.	Simple payback period (K = J/I)	0.93		Years

- Consider minimizing the operating hours of 5 lights with each having operating load of 36 Watts in a meeting hall.
- Operating hours/year = 15 hours/day and 300 days per year.
- By using either manual switching-OFF method or using sensors to minimize 5 hours of operation per day.
- GRENLEC Energy cost = 0.78 EC$/kWh

Energy Saving Calculations - Retrofit opportunities

Details	Old	New
Name of the Equipment	Split AC	
(A) Rated Capacity, Tons	2.0	2.0
(B) Rated Power, kW	2.6	2.6
(C) Average Measured Power, kW per hour	1.32	0.69
(D) Operating hours/year	2500	2500
(E) Calculated Annual Energy consumption, kWh [(E)=(C) *(D)]	3300	1725
(F) Measured Energy consumption, kWh (From instrument)	NA	NA
(G) Annual Energy savings, kWh [(G)=(E_{Old})-(E_{New})]	1575	
(H) Annual Energy cost savings, EC$ [(H)=(G)*(Energy cost per kWh)]	1228.5	
(I) Annual O & M Costs, EC$	50	
(J) Total energy cost savings, EC$/year [(J)=(H)-(I)]	1178.5	

- Consider retrofitting of <u>old Split air conditioning unit</u> with <u>latest inverter controlled energy efficient air conditioning unit</u>.
- Quantity = 1
- Operating hours/year = 12 hours/day and 250 days per year.
- GRENLEC Energy cost = 0.78 EC$/kWh

Investment cost for implementing Energy conservation measures:

Description	Cost, EC$
(A) Cost of materials/Equipment/Machine	2500
(B) Cost of Labor for project implementation	250
(C) Cost of manpower training	NA
(D) Total investment of ECM [(D)=(A)+(B)+(C)]	2750

Simple Payback in years:

$$\text{Simple Payback period, years} = \frac{\text{Total investment cost of ECM}}{\text{Total Energy cost savings}}$$

Simple payback period	2.33	Years

***Note**: Average measured load of Air conditioning unit varies with respect to ambient air and operating conditions*

Energy Audit Reporting – Table of contents

Sl.No	Content	Coverage
	Executive Summary	✓ Brief description of the facility ✓ Overall Energy use ✓ Summary of energy conservation measures ✓ Overall energy saved and energy cost savings ✓ Major Energy saving areas ✓ Energy conservation measures implementation strategy
1.0	Introduction	✓ Detailed background of the facility
2.0	Methodology	✓ Detailed list of areas being covered for the energy audit study in the facility ✓ Details of energy audit tools used for the study ✓ Audit Approach being followed
3.0	Energy Consumption Profile	✓ Details of Energy sources being used in the facility (like Electricity, Diesel etc) ✓ Annual Energy consumption ✓ Annual Production (if it is a Processing Industry) ✓ Area and occupancy (If it is a commercial building) ✓ Energy Tariff (Cost of electricity and fuel)
4.0	Measurements – Observations & Analysis	✓ Electrical System and distribution ➢ Background – Source of electricity, Electrical infrastructure ➢ Electricity Tariff and bill analysis ➢ Load profile of the incomer – Measurements and Analysis ➢ Power quality, Electric drives analysis ✓ Mechanical Equipment like fans, pumps, Air conditioning units ➢ Background – Equipment details and user areas identification ➢ Measurements and analysis of performance and end use practices ✓ Thermal Equipment – Boilers for hot water and cooking purposes ➢ Facility description – Equipment details and user areas identification ➢ Measurements and analysis of performance and end use practices

Energy Audit Reporting – Table of contents

Sl.No	Content	Coverage
5.0	Energy Conservation measures	✓ Identified Energy Conservation measures on Electrical, Mechanical and Thermal areas ❖ Background ❖ Recommendation ❖ Economic Analysis
6.0	Summary of potential energy savings	✓ Identified Energy Conservation measures are segregated as per the Simple payback period (SPB) ❖ Short term measures – SPB < 1 year ❖ Medium term measures – SPB > 1 year and < 3 years ❖ Long term measures – SPB > 3 years

Thank You

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