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KOLEJ KOMUNITI MALAYSIA

ENERGY EFFICIENCY & MANAGEMENT

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Table of Contents

01

SUSTAINABLE ENERGY MANAGEMENT

Learning Outcome

1

Remember sustainable EMS

- ✓ Define sustainable energy management
- ✓ Define energy manager
- ✓ List responsibilities of energy manager

2

Understand sustainable EMS

- ✓ Explain the needs for preparation of EMS
- ✓ Explain documentation needed in EMS

3

Analyze managing activities in sustainable EMS

- ✓ Explain process to set up energy target and plan
- ✓ Explain implementation of action plan
- ✓ Explain monitoring, measurement and verification
- ✓ Analyze energy management performance review

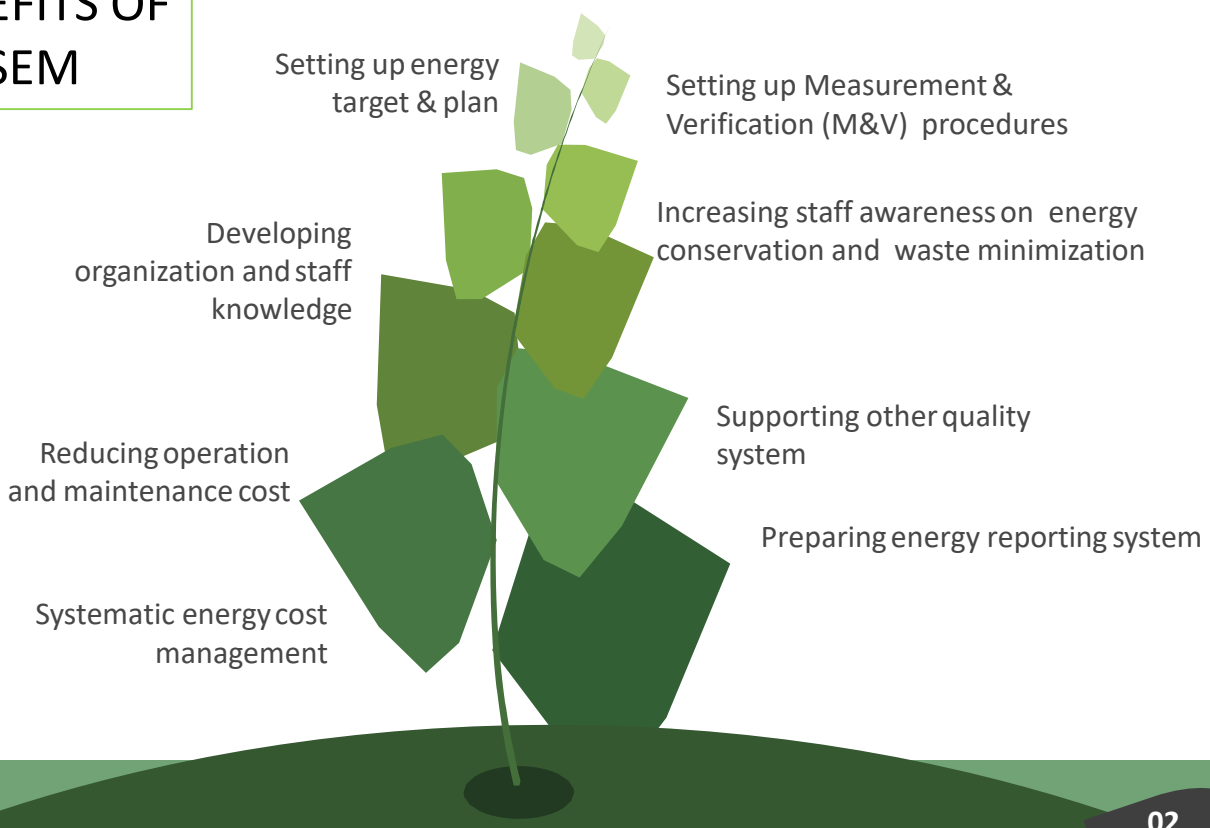
Definition of Sustainable Energy Management

The goal of managing the organization's energy usage is to ensure that energy is used efficiently.
Covers all areas of energy consumption in the company, not just energy-consuming devices or equipment, but also looks for the optimal performance from the workers.

Principle of Sustainable Energy Management

1. Comply with organizational objective/goal
2. Involves all staff in the organization
3. Develop organization and staff knowledge
4. Create the continuous improvement process
5. Integrate with standard working procedures

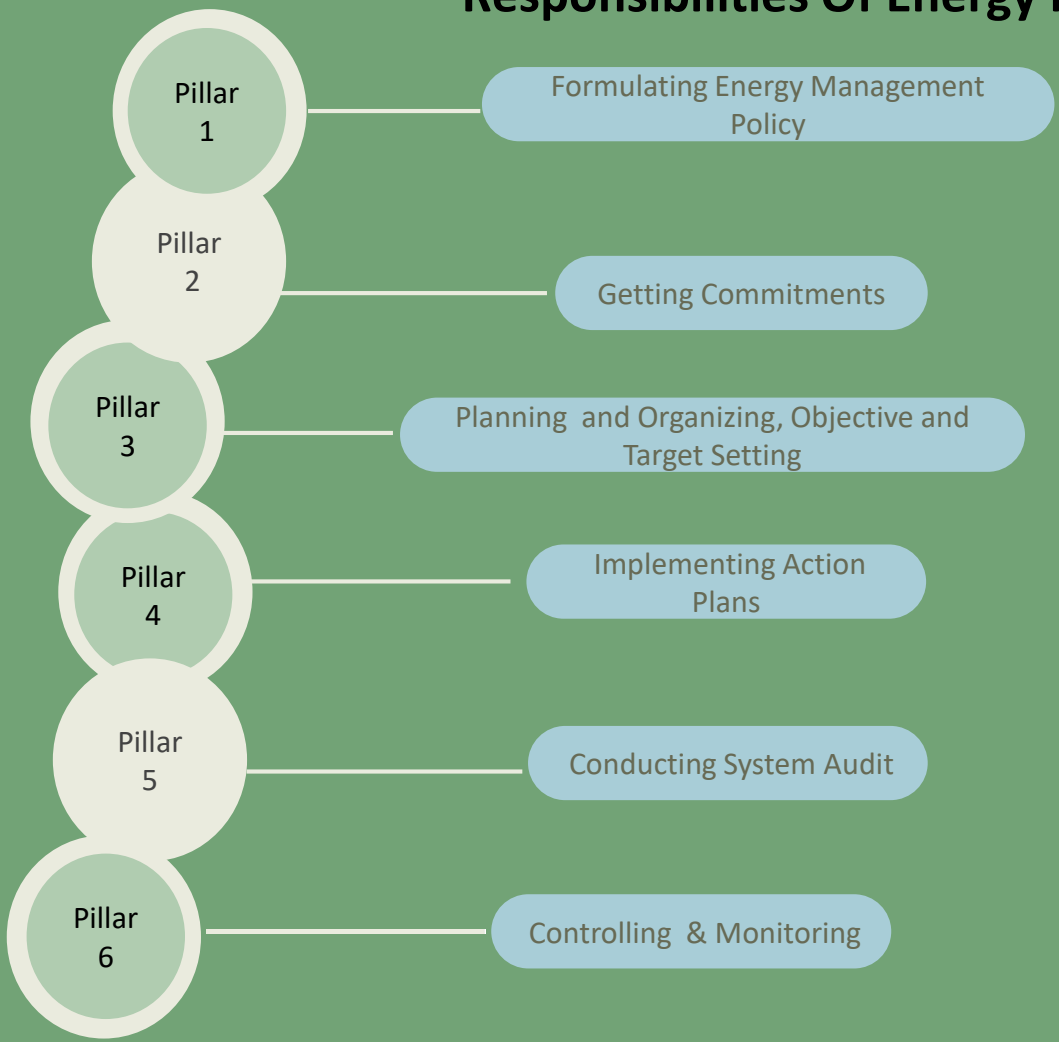
BENEFITS OF SEM



Definition of Energy Manager (EM)

EM is the person designated by top management to plan, lead, manage, coordinate, monitor, and evaluate the organization's adoption of Sustainable Energy Management (SEM).

Responsibilities Of Energy Manager



Responsibilities Of Energy Manager

Formulating Energy Management Policy

The objectives and policies of various departments within a company must be determined in accordance with the overall organization's energy policy in order to be effective.

Getting Commitment

The energy manager must persuade all relevant parties that their commitment would greatly benefit the organisation and will be consistent with their strategic business or service delivery objectives.

Planning & Organizing, Objective and Target Setting

Ta attainable un normal working conditions and reasonable.

Implementing Action Plans

Each line manager must understand the challenges to execution, and the energy manager must engage with them to develop appropriate solutions, targets, and reward measures.

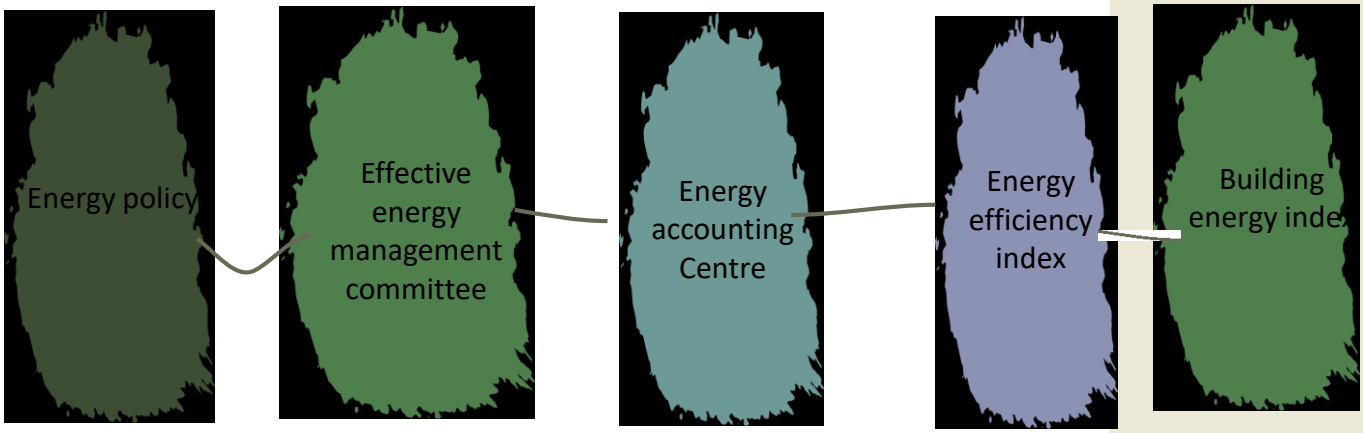
Controlling and Monitoring

The ener manager's job is to guarante that the barriers, objectives, and targets have been examined and that the solutions have been effectively integrated into the company's strategic approach to enhancing the organization's energy policy and action plans.

Conducting System Audit

An external audit shou conducted once a year evaluate the performa of the EMS

Preparation of Energy Management System



Energy policy

01 Characteristic

- ✓ Written statement of a commitment to managing energy and carbon emissions.
- ✓ Declare a goal – Set a clear, measurable goal that reflects the company's dedication, culture, and goals.
- ✓ Commit the organization to continuous improvement in energy performance by establishing a policy framework for setting energy objective and targets and regularly reviewed.
- ✓ Include provisions for evaluating and revising the policy as needs and priorities change.
- ✓ Indicates commitment from the top management.
- ✓ The format of the energy policy statement varies, but it commonly includes the company's aim or objective as well as more detailed energy management targets. The statement must be consistent with the company's mission statement or general management strategy.
- ✓ Establish accountability — Create a chain of command, identify positions within the organization, and give employees the power to carry out the energy management strategy.

02 Benefits

- ❑ Demonstrates company commitment.
- ❑ Assists in directing and focusing efforts to improve energy efficiency.
- ❑ It expresses your commitment to conserving energy both inside and outside your company.
- ❑ Motivates management and employees.
- ❑ Provides direction for a whole-of-organization approach to energy management.
- ❑ Establishes benchmarks against which performance can be measured.

Energy Management Committee

Main responsibility - Set up and supervise the system's actions in accordance with the energy management plan that the entire company has agreed with.

Function of EM Committee

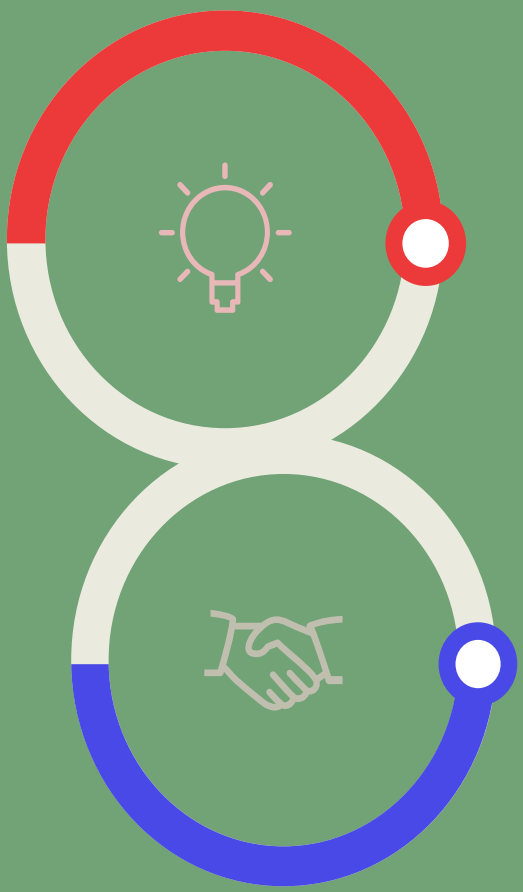
1. Assess the energy management performance
2. Analyses organization strength and weakness
3. Prepare energy policy
4. Define and set up energy accounting centres
5. Organize the preparation of EM-WP (working procedures)
6. Organize the preparation of energy target and plan
7. Monitor the implementation
8. Support the implementation
9. Organize the conducting of performance reviews
10. Review and adjust energy policy, energy target and plan.

Energy Management Committee

Recommended structure of EM committee

- ✓depending on the culture of the organization
- ✓The most important component of the senior management commitment and energy manager

Recommended Structure of EM committee



1. Chair person
2. Secretary
3. Technical staff (more than one person)
4. Administrative staff (more than one person)

01

Chairperson

Recommended required proficiency
- Having full authority
- Having good management and financial skill

Recommended resource
- Executive management

02

Secretary

Recommended required proficiency
- Understand overall energy consumption process
- Understand detailed implementation energy management system
- Having fair management and financial skill
- Having good communication skill

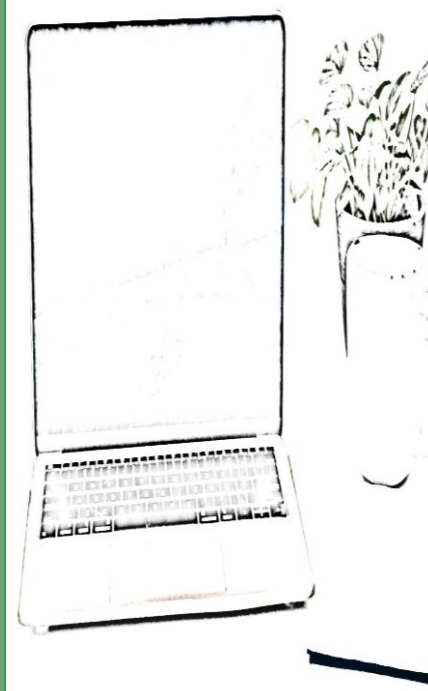
Recommended resource
- Energy manager (mid to senior management)

Energy Management Committee

03

Technical staff (more than one person)

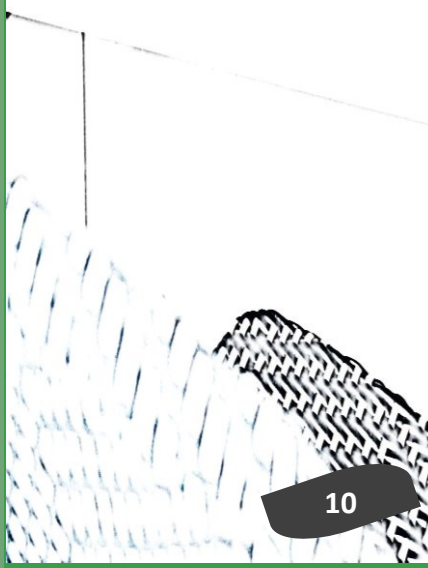
Recommended required proficiency
•Having authority to control the operation in their presented area or department
•Having good technical knowledge (machined, equipment and EE technologies)
•Understand energy consumption process of each area process
•Having fair communication skill
•Having fair management and financial skill
Recommended resource
•Production, utility & maintenance engineer



04

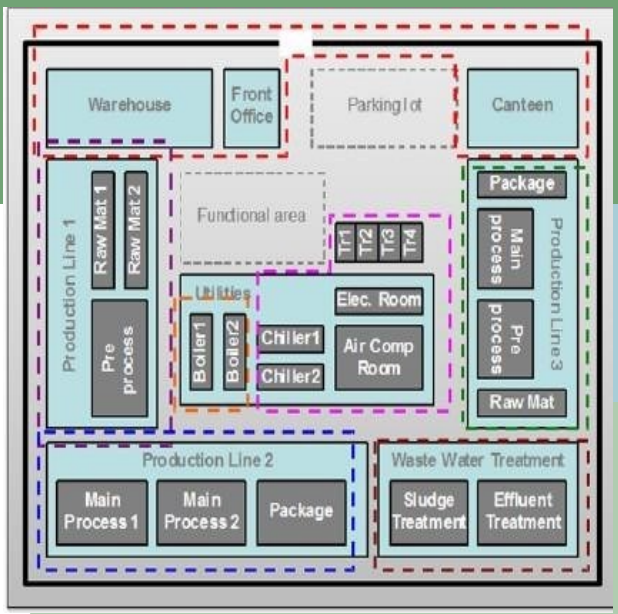
Administrative staff (more than one person)

Recommended required proficiency
•Having authority to control the operation in their presented area or department
•Having good marketing skill
•Having good communication skill
•Having good human resource development skill
Recommended resource
•Manager : Human resource, public relation, accountant and purchasing



Energy Accounting Centre (EAC)

- Why EAC?
  - ✓Energy has been consumed in all parts of the organization.
  - ✓It is tough to manage and control energy consumption only on the macro level especially to the large organization
- To efficiently control energy consumption in an organization, it is necessary to break it into small parts called subunits.
- The EAC structure is founded on the premise that if a department manager at a plant is held accountable for the department's energy costs and provided the relevant information on prices and consumption, there will be an incentive to develop ways to improve performance., there is an incentive to find ways of improving performance.
- **Identifying where management accountability is defined by location, installing meters on energy utilities at the point of entry to the area or department, and providing information on consumption and activity on a regular (daily, weekly, or monthly) basis are all part of implementing an EAC structure.**
- The number of EAC will be determined by the size and state of each organization.
- Each EAC should assign responsible person with adequate metering equipment - person who study existing data or information regarding energy consumption for each area, equipment or system.
- Each EAC should create EEI, target & plan budget and monitor the process.



EAC

Area\equipment/machine/system	Plant record data	EEI
1. Front office	Working hour per day - Monthly electrical consumption data	kWh/ working hour
2. Warehouse	Working hour per day	
3. Chiller1	Power consumption - Actual cooling production capacity	Kw/ ton (chiller) kWh/ unit of working hour
4. Chiller2	Power consumption - Actual cooling production capacity	
5. Electrical room	Daily electrical consumption	
6. Laboratory	Daily electrical consumption	

EAC & EEI

Energy Efficiency Index (EEI)

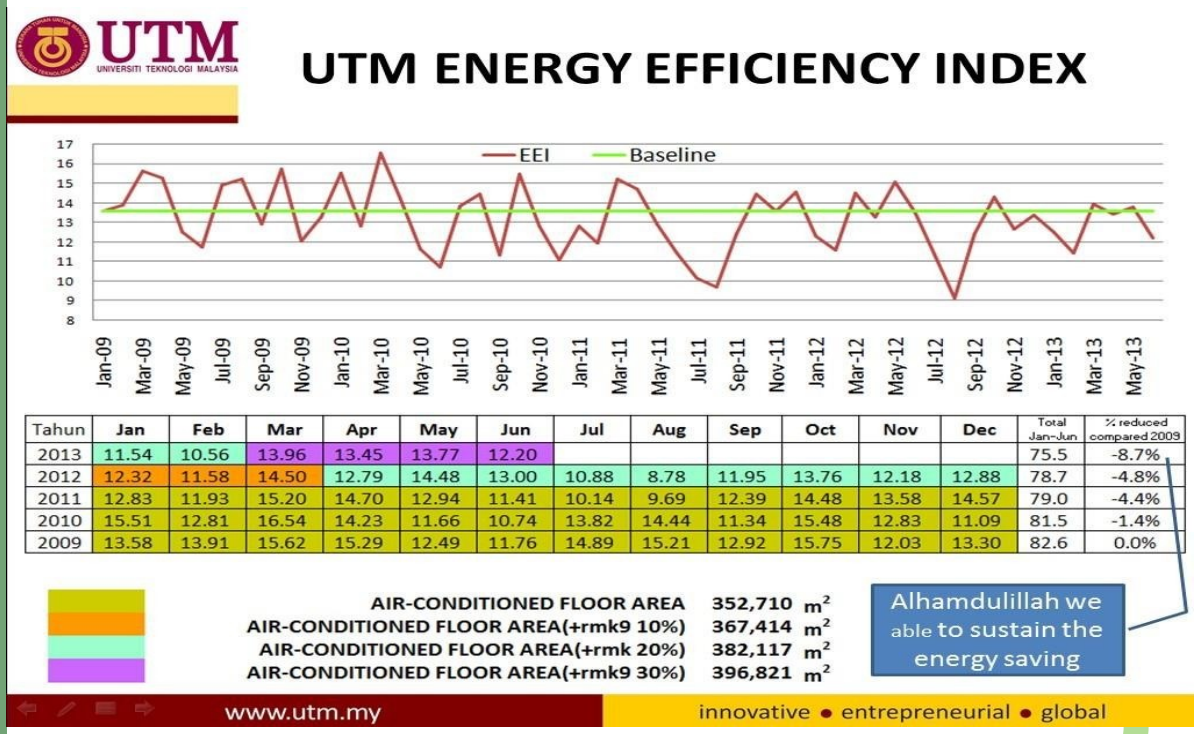
Definition: The factor that best reflects the real application of energy and provides the most accurate measure of energy performance.

$$EEI = \frac{Energy\ input}{Factor\ related\ to\ the\ using\ component}$$

For a building, EEI is a significant tool for tracking the performance of energy consumption in a building and serves as a Key Performance Indicator (KPI) .

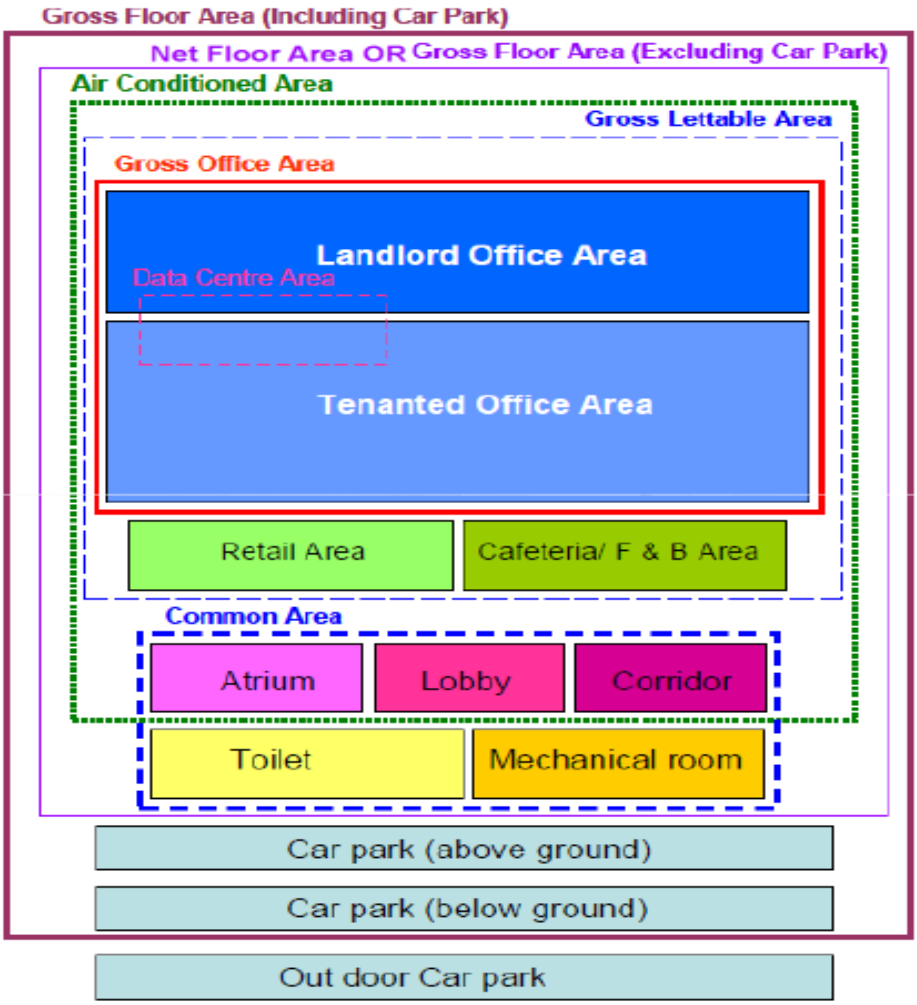
This index is usually expressed in kWh/m2 /year.

The EEI also serves as a standard against which organizations can track their energy use. Collecting baseline energy data is the initial stage in regulating energy in a building. An organization will be able to track energy performance and prepare for energy savings targets using this baseline data.



Tahun	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total Jan–Jun	% reduced compared 2009
2013	11.54	10.56	13.96	13.45	13.77	12.20							75.5	-8.7%
2012	12.32	11.58	14.50	12.79	14.48	13.00	10.88	8.78	11.95	13.76	12.18	12.88	78.7	-4.8%
2011	12.83	11.93	15.20	14.70	12.94	11.41	10.14	9.69	12.39	14.48	13.58	14.57	79.0	-4.4%
2010	15.51	12.81	16.54	14.23	11.66	10.74	13.82	14.44	11.34	15.48	12.83	11.09	81.5	-1.4%
2009	13.58	13.91	15.62	15.29	12.49	11.76	14.89	15.21	12.92	15.75	12.03	13.30	82.6	0.0%

GFA / NFA / ACA??



Definitions

Gross Floor Area (GFA):

Total area of all floors of a building as measured to the outside surfaces of exterior walls.

Net Floor Area (NFA):

Net-Usable Area or Occupied Area. *Gross Floor Area excluding Carparks & External Corridor;* The area enclosed in the surrounding walls of a building,

Air Cond Area (ACA):

Net-Floor Area which has air conditioning/ cooling spaces excluding toilet (for some buildings) and M&E rooms.

BEI LABEL CONCEPTS

Building Category & Name:
Office/ Hospital / University / School

Unit for Building Energy Performance:
kWh/m²/year

National Building Energy Intensity (BEI) Labelling for Government Building

1- Star	2- Star	3- Star	4- Star	5- Star
BEI > 250	120 < BEI ≤ 250	130 < BEI ≤ 160	100< BEI ≤ 130	BEI ≤ 130
Highly Inefficient	Inefficient	Moderate Efficient	Efficient	Very Efficient

Source: Energy Commission

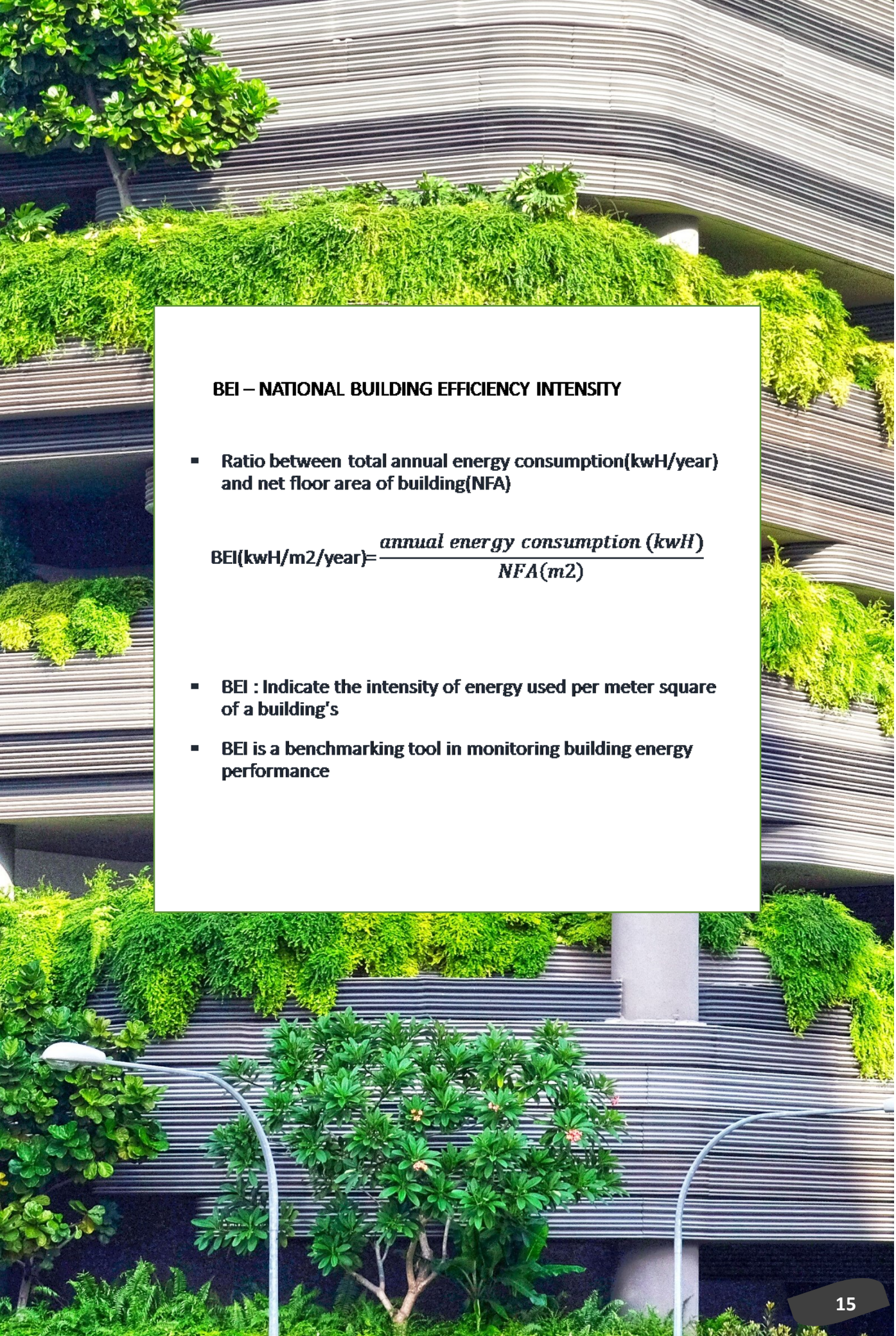
To ascertain energy performance of government buildings.

To accelerate efforts in making government buildings energy efficient through government lead by example.

To provide and disseminate information to occupants on the buildings energy consumption performance in comparison to energy efficient building.

To create healthy competition among building owners in improving energy use.

To help the government achieve national commitment to reduce GHG emissions Intensity of GDP by 45% by 2030.



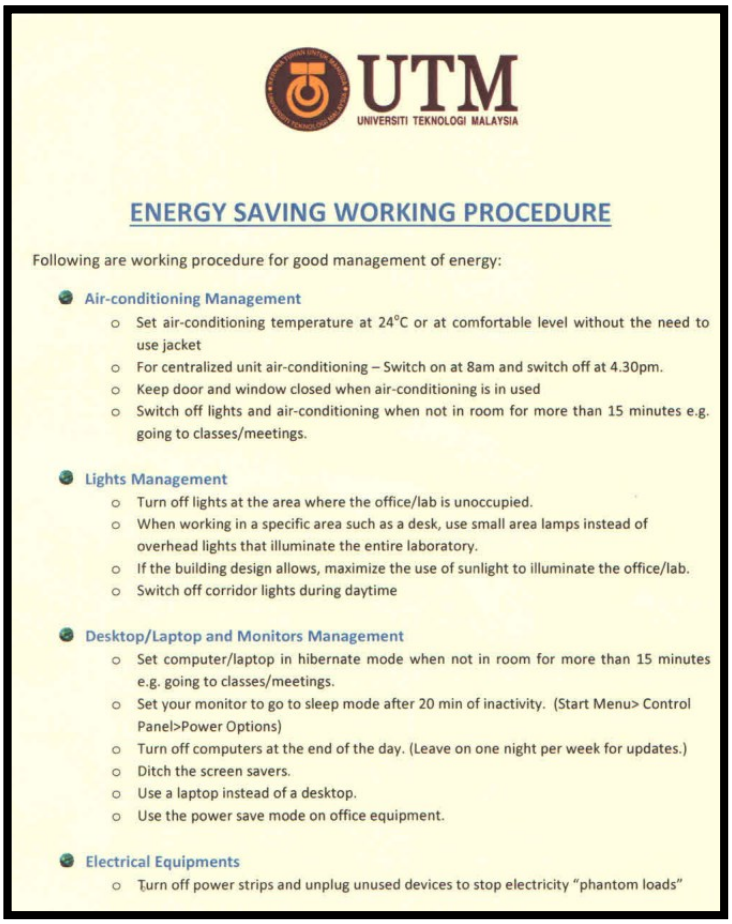
BEI – NATIONAL BUILDING EFFICIENCY INTENSITY

- Ratio between total annual energy consumption(kwH/year) and net floor area of building(NFA)

$$\text{BEI(kwH/m2/year)} = \frac{annual\ energy\ consumption\ (kwH)}{NFA(m2)}$$

- BEI : Indicate the intensity of energy used per meter square of a building's
- BEI is a benchmarking tool in monitoring building energy performance

Documentation in Energy Management System



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ENERGY SAVING WORKING PROCEDURE

Following are working procedure for good management of energy:

- **Air-conditioning Management**
  - Set air-conditioning temperature at 24°C or at comfortable level without the need to use jacket
  - For centralized unit air-conditioning – Switch on at 8am and switch off at 4.30pm.
  - Keep door and window closed when air-conditioning is in used
  - Switch off lights and air-conditioning when not in room for more than 15 minutes e.g. going to classes/meetings.
- **Lights Management**
  - Turn off lights at the area where the office/lab is unoccupied.
  - When working in a specific area such as a desk, use small area lamps instead of overhead lights that illuminate the entire laboratory.
  - If the building design allows, maximize the use of sunlight to illuminate the office/lab.
  - Switch off corridor lights during daytime
- **Desktop/Laptop and Monitors Management**
  - Set computer/laptop in hibernate mode when not in room for more than 15 minutes e.g. going to classes/meetings.
  - Set your monitor to go to sleep mode after 20 min of inactivity. (Start Menu> Control Panel>Power Options)
  - Turn off computers at the end of the day. (Leave on one night per week for updates.)
  - Ditch the screen savers.
  - Use a laptop instead of a desktop.
  - Use the power save mode on office equipment.
- **Electrical Equipments**
  - Turn off power strips and unplug unused devices to stop electricity "phantom loads"

Have 3 categories :

- Type A: working procedure

- Organization has to formulate working procedure as a guideline for all staff to practice in their daily work

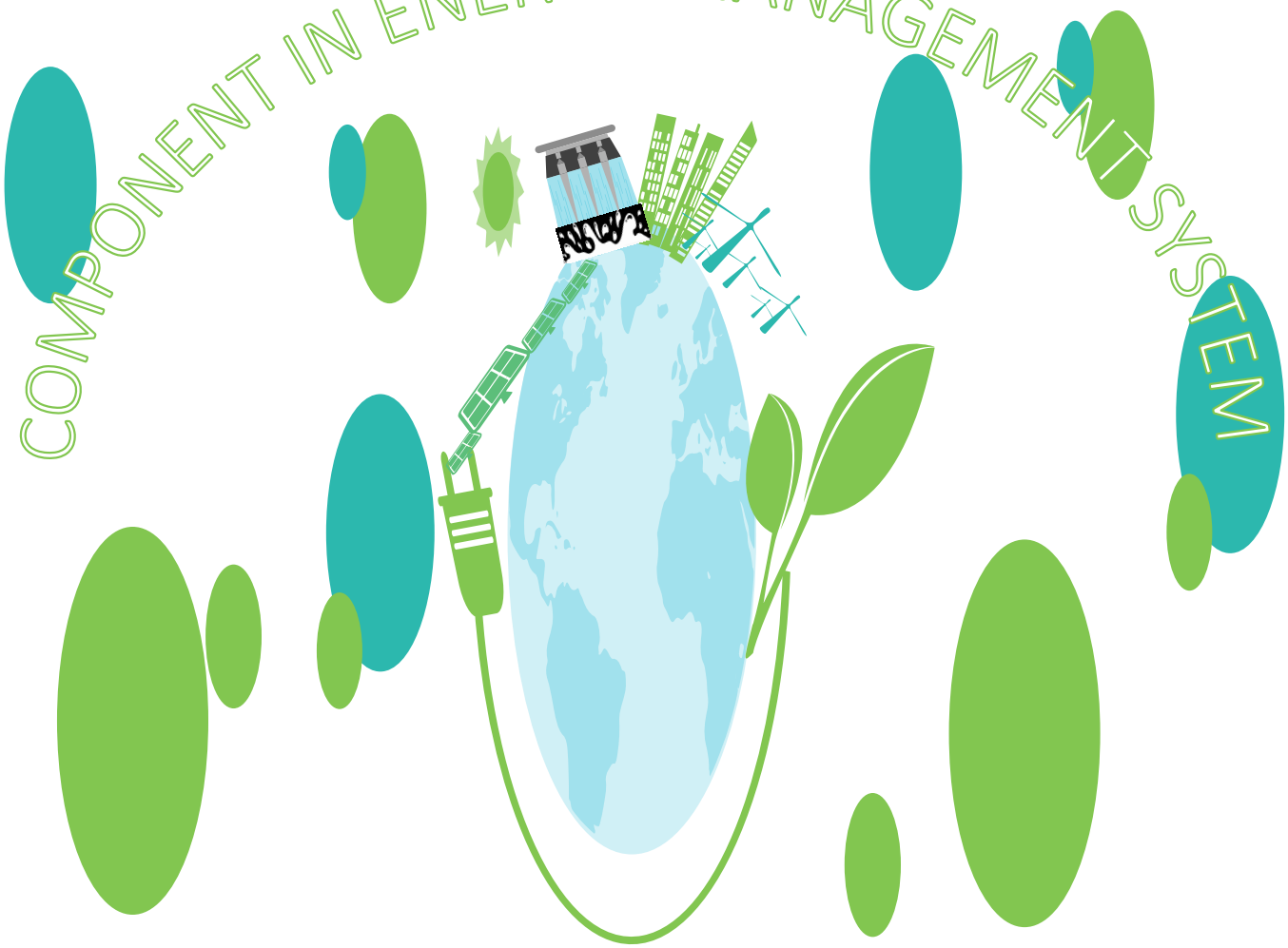
- Type B : working manual and tools
- Type C: monitoring document

Working manual and tools for energy management

- Established when a baseline EEI has been set and has common agreement among executive and the EM committee
- Each EAC has to prepare its own working manual tools for its staff to follow and use in daily work.
- Component of working manual and tools for EM:

1. Process mapping(PM)
   - tool for analyzing the characteristic of energy consumption of each EAC
   - indicate detail of all sub-process in EAC
2. Work Instruction (WI)
   - indicate to staff on what data needs to be collected and how it should collected
   - include trouble shooting
3. Log sheet (LS)
   - standard form for the operator to fill in all actual control parameters
4. Calculation Sheet (CS)
   - to analyze the meaning of the raw, such as the calculation of combustion efficiency of boiler, pump efficiency, etc.
5. Operational Guideline (OG)
   - indicates the energy management procedures for EAC
   - should be prepared by head of EAC

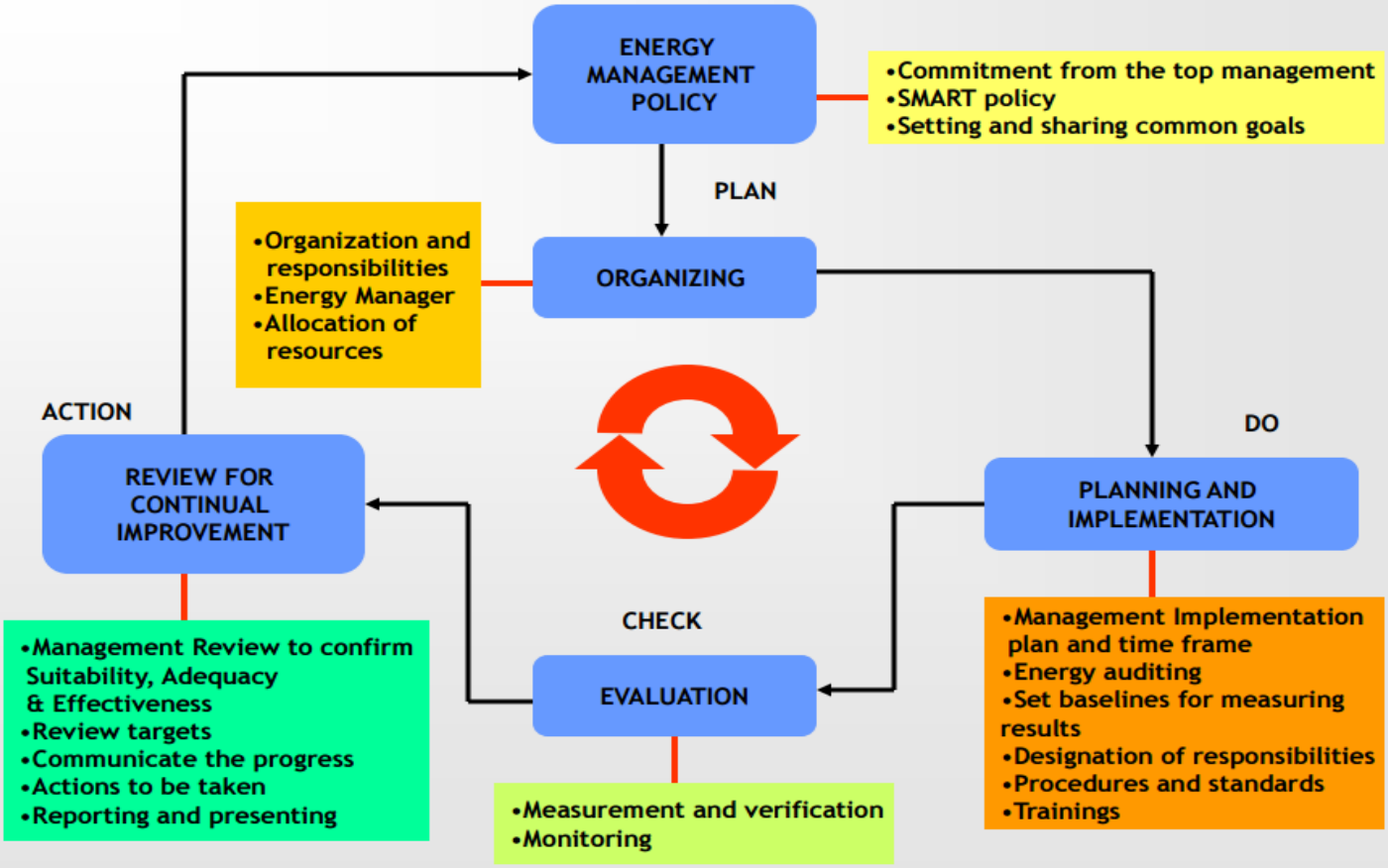
COMPONENT IN ENERGY MANAGEMENT SYSTEM



Students should be able to analyze managing activities in sustainable energy management system

- **Step to set up energy target and plan**
- **Implementation of action plan**
- **Monitoring, measurement and verification**
- **Analyze energy management performance review**

EMS Cycle



ENERGY MANAGEMENT POLICY

- Indicates commitment from the top management
- Set and share the same objectives and targets from the policy
- Committed to treat all energy related departments and processes
- Commit the organization to continual improvement in energy performance through policy framework for setting energy objectives and targets and regularly reviewed

ORGANIZING

- Indicates commitment to take actions
- Establish an organization for energy management and define responsibilities
  - Energy management team/committee, organization chart
- Allocate of resources
  - Budget, personnel, equipment
- Appoint an energy manager
- Understand and define the roles and responsibilities of energy manager

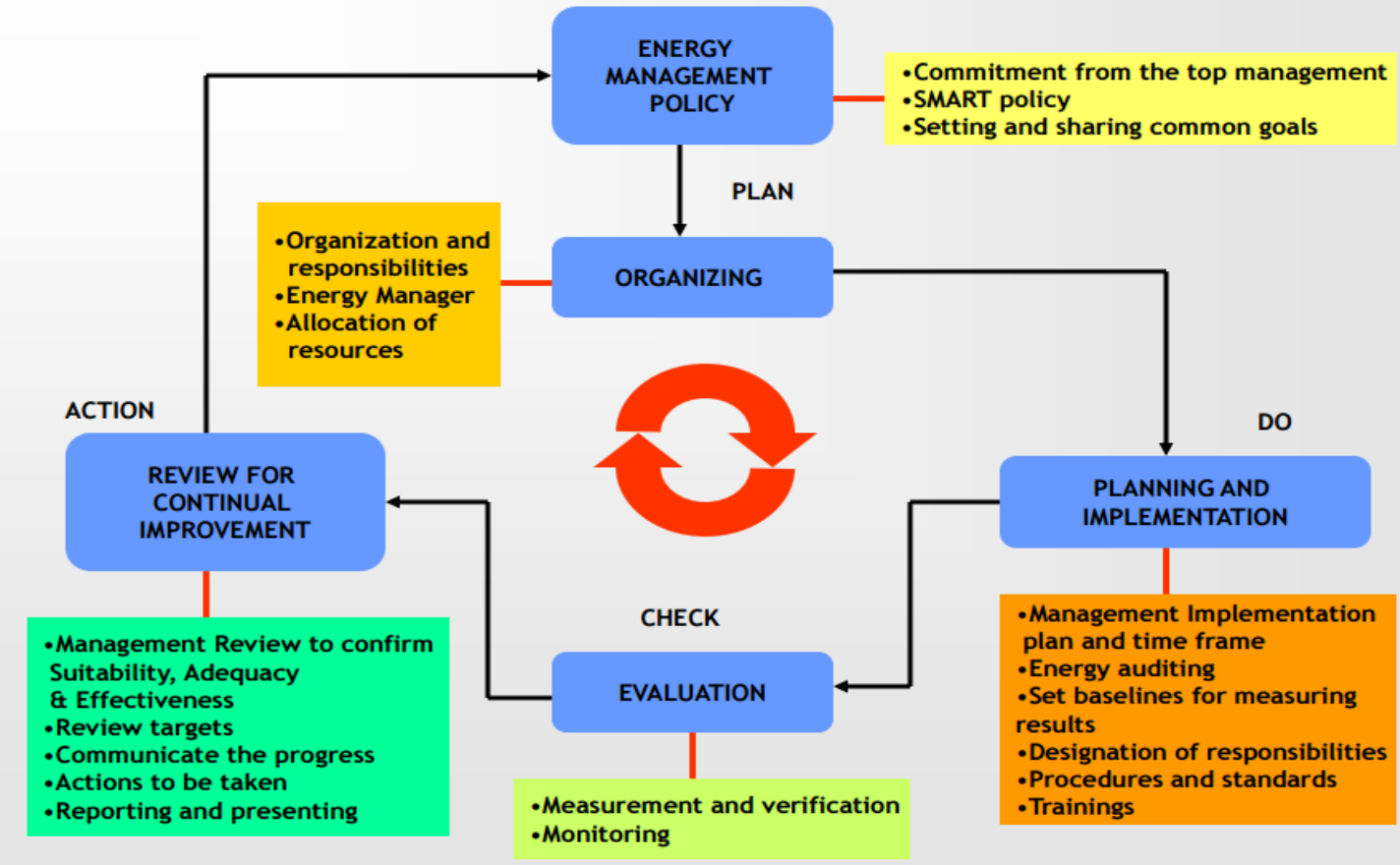
ORGANIZING

- Indicates commitment to take actions
- Establish an organization for energy management and define responsibilities
  - Energy management team/committee, organization chart
- Allocate of resources
  - Budget, personnel, equipment
- Appoint an energy manager
- Understand and define the roles and responsibilities of energy manager

PLANNING AND IMPLEMENTATION

- Establish and maintain energy management action plans to achieve its objectives and targets:
  - Designation of responsibility;
  - Set baseline to measure results
  - The means and time frame by which individual targets are to be achieved; and
  - A statement of the method by which improvement in energy performance will be verified-procedures/management standards
- Energy auditing
- The energy management action plans must be documented, and updated from time to time
- To identify personnel and trainings needed to ensure sustainability of the measures

EMS Cycle



EVALUATION

- **To evaluate and verify results from measures taken**
  - To perform measurements for each parameter that is required for energy saving measurements and calculations.
  - To quantify energy saved from each energy saving measure

REVIEW RESULTS FOR CONTINUAL IMPROVEMENT

- Analysis of operability of the operational and organizational structure (at least once in a year)
- Review of the energy performance indicators (energy intensity) that will be used to communicate the progress of energy performance to the organization
- Comparison of target and actual value of
  - The operational energy use
  - Energy saving measures
- Management Review to confirm
  - Suitability, Adequacy & Effectiveness
  - Actions to be taken based on results

01 ENERGY MONITORING, TARGETING AND REPORTING (EMTnR)

- Establish an energy monitoring and reporting system to collect, analyze and report on energy costs and usage.
- The process of acquiring and analyzing data on energy usage on a regular basis is known as energy monitoring. Its purpose is to give a foundation for management control, to identify when and why energy consumption deviates from a specified pattern, and to provide a basis for remedial action when needed.
- Targeting is the process of determining the levels of energy consumption toward which it is desirable to work as a management goal.
- Reporting closes the loop by transforming management data into a format that enables for continuing energy consumption monitoring, reduction target attainment, and savings verification.

Benefits of Energy Monitoring, Targeting and Reporting (MTnR)

02

- As a direct result of the MT&R program, energy costs are often reduced by 5 to 15%, with CO2 and other pollutant emissions reduced as well.
- Coordination of energy management policy by focusing on activities that offer the most benefit and long-term savings.
- Assisting with the finance of energy efficiency projects by precisely calculating baseline energy use levels and validating savings for energy efficiency project proposals.
- By defining the energy content of items and services, improved product and service costs can be achieved.
- Improved budgeting by providing a foundation for more accurate future energy use forecasts based on activity levels.
- By expanding the availability of performance data on energy systems, better preventative maintenance may be achieved.
- Product quality has improved as a result of increased control over manufacturing processes..
- Application of MT&R principles to other aspects of environmental management, such as water usage, materials management, and plant downtime, among others, results in waste avoidance.

Energy Management Performance Review

01

- Implement evaluations as a management tool for monitoring and analyzing energy performance and ensuring effective implementation.
- Provide data to formulate new energy target and plan for improvement of energy management performance.
- Ascertain that the system is properly established, implemented, maintained and improved on a long-term basis.

Energy Management Performance Review

02

- Review of energy policy, objectives and targets as well as an assessment of overall progress.
- Findings of previous management review in Energy Management System audit.
- Evaluation of the effectiveness and energy efficiency of the Energy Management System.
- Changes in rules, expectations and requirements of interested parties, organization's products/activities, technical advancements, market preference, and so on are all reviewed.
- Evaluation of non-conformity-related follow-up actions.
- Energy performance forecast for the upcoming period.
- If necessary, make changes to policies, objectives, targets, resources, or other aspects of the Energy Management System.
- Examining resource allocation and identifying areas for improvement.

1. State TWO (2) benefits for an organization that applies sustainable energy management.

2. Discuss TWO (2) characteristics for a perfect energy policy.

3. Define energy manager.

4. Explain THREE (3) benefits having an energy policy for an organization.
Benefits having an energy policy for a company.

Tutorial Answers

1

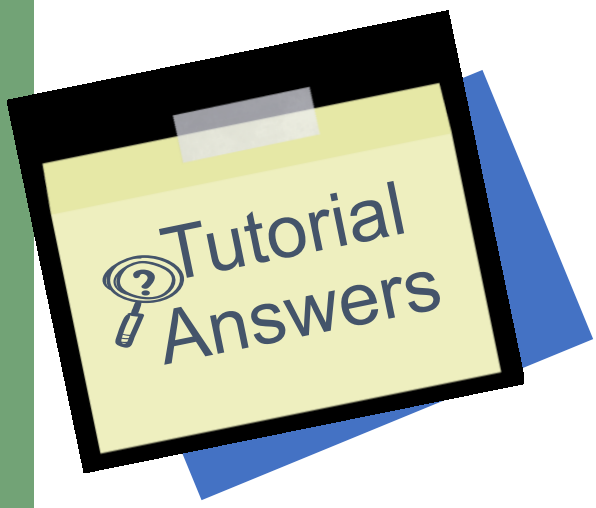
- Demonstrates company commitment
- Helps guide and focus efforts for improving office energy efficiency
- Communicates your commitment to saving energy inside and outside your organization
- Motivates management and staff
- Provides direction for a whole-of-organization approach to energy management
- Sets targets against which performance can be judged

Choose 2 from answers above

2

State an objective	Establish accountability	Ensure continuous improvement	Promote goals
Have a clear, measurable objective that reflects the organization's commitment, culture and priorities.	Institute a chain-of-command, define roles in the organization, and provide the authority for personnel to implement the energy management plan.	Include provisions for evaluating and updating the policy to reflect changing needs and priorities.	provide a context for setting performance goals by linking energy goals to overall financial and environmental goals of the organization.

Choose 2 from answers above



3

Energy Manager

- EM is the person designated by top management to plan, lead, manage, coordinate, monitor, and evaluate the organization's adoption of Sustainable Energy Management (SEM).

4

1. Sets a simple process in place
2. Demonstrates company commitment
3. Helps guide and focus efforts for improving office energy efficiency
4. Communicates your commitment to saving energy inside and outside your organisation
5. Motivates management and staff
6. Provides direction for a whole-of-organisation approach to energy management
7. Sets targets against which performance can be judged

02

ENERGY AUDIT

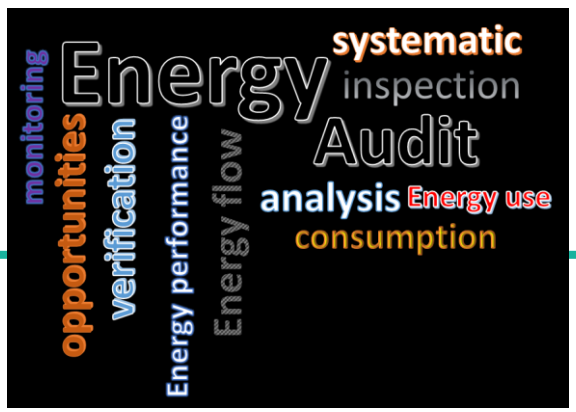
02

Energy Audit

Definition of energy audit
Objectives of energy audit
Needs of energy audit
Energy audit instruments
Types of energy audit
Preliminary energy audit process
Detailed energy audit process
Energy audit report
Benchmarking and energy performance

Definition

- Energy audit is one of the tools of energy management.
- Energy audit provides a “bench-mark" for managing energy in the organization and also provides the basis for planning a more effective use of energy throughout the organization.
- In general, an energy audit is a study undertaken to determine where, when, and how much energy is used, as well as how to cut energy costs in order to find opportunities for energy reduction.
- The energy audit will identify energy waste and losses, as well as techniques and methods for reducing them.



PLEASE!! NOTE

Energy Audit

Systematic inspection and analysis of energy use and consumption of audited objects to identify energy flows, potential opportunities and monitoring & verification for improving energy performance and reporting them

Objective

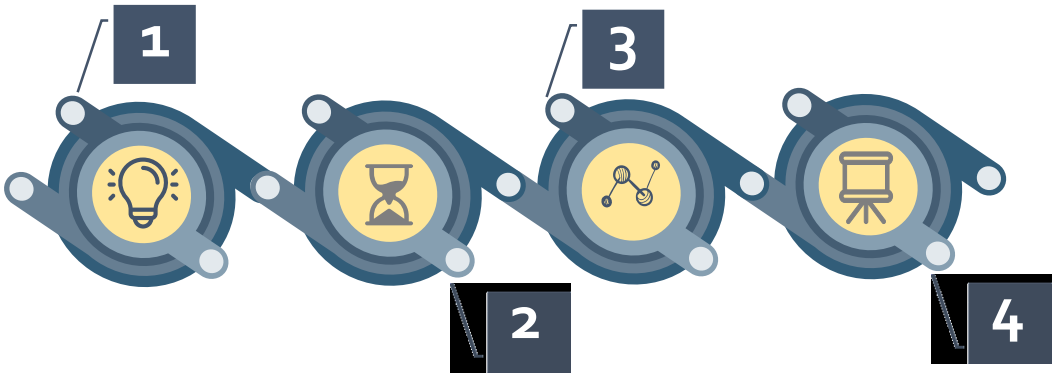
- The main objective of an Energy Audit is to find ways of reducing operating costs or energy use without compromising comfort and quality :

  - per unit of product output (industry)

  - ft^2 or person (commercial/building)

to minimize costs for energy

improve the quality of the working environment, resulting in increased productivity



to reduce on operating costs

to reduce repair and reconstruction cost to a minimum

Tools or Resources

Needed for Energy Audit

Instruments

Permanent and Portable

- Involves using various measuring equipment depending on the investigation being carried out.
- Instruments are usually portable.

Energy Records

Energy records is a process of collecting, organizing and analyzing energy data.

Computer and Software Tools

Audit tools mesh with the other software, hardware and network systems

Budget and Time

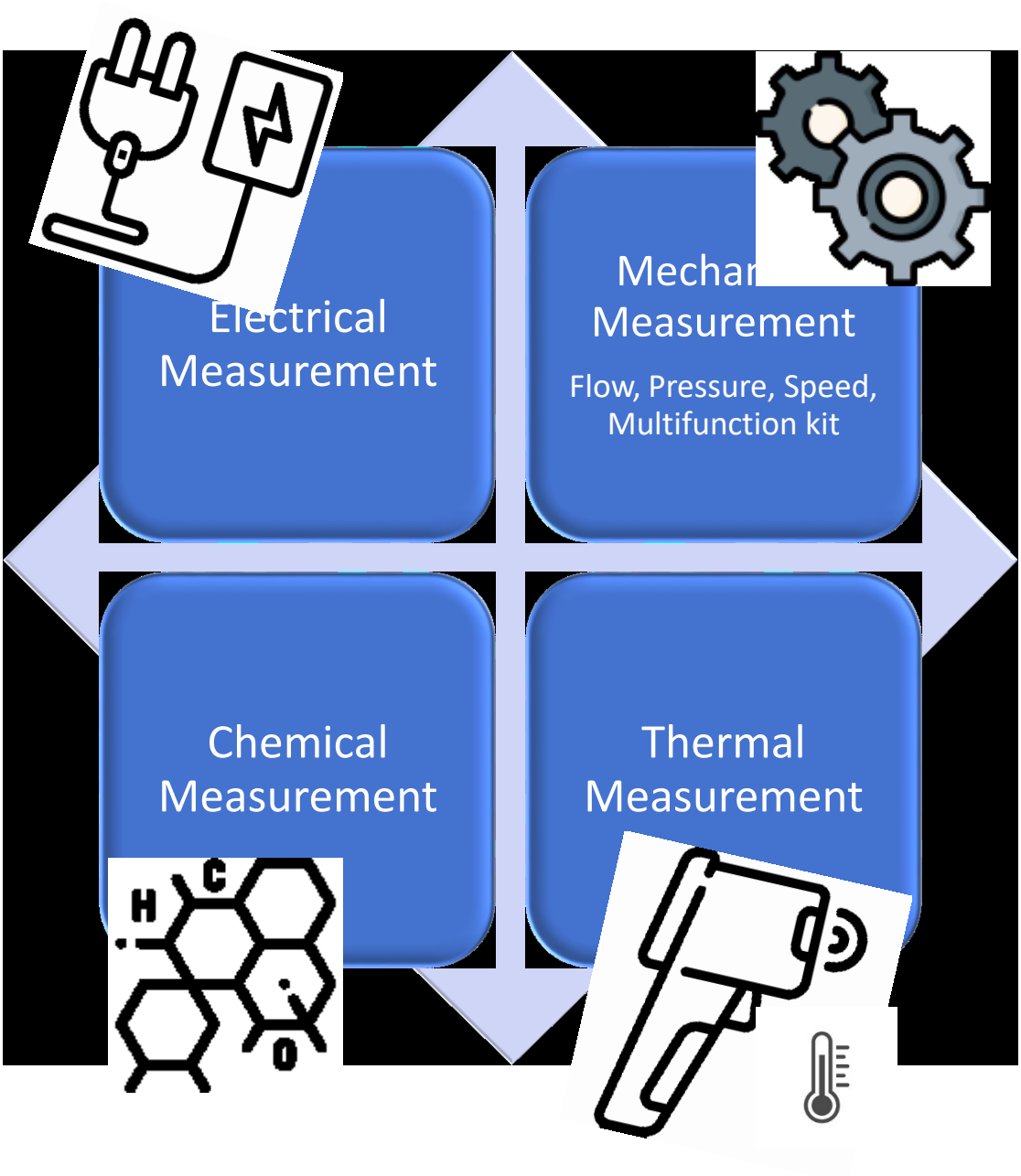
Based on available resources, the time frame and the budget can be established.

Auditors

Company staff or external auditor

The number of auditors required is determined by the audit's scope and objectives.

Energy Audit Instruments



Energy Audit Instruments

Instrument	Function
Electrical measuring instrument	• measure electrical parameter such as kW, kVA, kVAR, PF (power factor), phase angle (Φ), hertz, kWH, kVAH, amp and volt.

Power analyzer

Power meter

Digital multimeter

Energy Audit Instruments

Instrument	Function
Combustion analyzer  Combustion analyzer	• measure the combustion efficiency boilers, furnaces or other equipment with fuel combustion systems. • measure oxygen, carbon monoxide, stack temperature, and ambient temperature.
Flue Gas Analyser  Flue Gas Analyser	• measure the combustion efficiency of a boiler or furnace. carbon monoxide, carbon dioxide, and oxygen monitoring in ppm. • It is important to identify loss due to incomplete combustion or excess air supply.

Energy Audit Instruments

Instrument	Function
Contact thermometer  Contact thermometer	• Conventionally temperature indicator with a probe is used for accurately measure process temperature. • These are thermocouple which measure for example flue gas, hot air temperatures by insertion of probe into the stream.
Infrared thermometer  Infrared thermometer	• To measure non-contact surface temperature. • Applicable in electrical panels and wiring, mechanical, HVAC, and predictive maintenance areas.

Energy Audit Instruments

Instrument	Function
Pitot tube  Pitot tube	• measure air velocity in the ducts and tubes.
Manometer  Manometer	• Measure the pressure acting on a column of fluid. • it is commonly used to measure the draft pressure of the combustion system, flue gas path, fans, etc.

Energy Audit Instruments

Instrument	Function
Water flow meter  Ultrasonic flow meter	• measure flow of water and other liquids through pipelines. • measure velocity of fluid without actual fluid contact by measuring the ultrasonic sound from the pipe surface of the moving fluid. • Measure flow for calculating pumping efficiency.
Speed measurement  Tachometer	Tachometer • measure speed of rotating equipment's both by contact and non-contact. • It is ideal for measuring rotational speeds of machines, motors, conveyor belts and other moving parts.
 Anemometer	Anemometer • measure air flow and velocity. • Measure wind speed and direction. • It is commonly used to measure the velocity of the fan and calculate air flowrates.

Energy Audit Instruments

Instrument	Function
Leak detectors  Ultrasonic Leak detectors	• used to easily detect leak in compressed air or vacuum system. • Ultrasonic leak checker. • It operates by generation of ultrasonic waves and is used to check compressed air and gas leakage.
Lux meter  Lux meter  Lux meter	• measure illumination level, for analyzing lighting requirement. • It is made up of a photo cell that detects light and converts it into electrical impulses that are calibrated in lux.

Preparation for the Energy Audit

Define audit criteria

The following criteria should be established before the energy audit begins: • Objective of the audit• Type of audit• Standards and methods for auditing • Staff involvement • Boundary of the site or utility • Timeline of audit • Reporting requirements

Define audit scope

The scope of the audit will be determined by the audit's objectives. The audit scope must take consideration available resources such as staff, time, audit limit, level of analysis, expected results, level of detail, and budget for completing the energy audit.

Selection of energy audit team

The company’s top management must decide whether the audit will be carried out by internal workers or by an outside consultant. The audit team leader determines the roles and responsibilities audit team members.

Make an audit plan

The audit strategy and procedure are outlined in an audit plan. The followings should be included in the audit plan: • Scope of the audit • Time frame for the audit process • High-priority audit elements • Each audit team member's responsibilities and tasks • The outline and format of the audit report

Prepare an audit checklist

The audit checklist helps in the systematic and consistent conduct of the audit. The following items should be included in the checklist: • Energy auditing steps • Information and data that needs to be gathered • The data recorded and the measurement instrument that is currently in use • Required measurements and a list of parameters to be measured during the energy audit • Major equipment will be examined in greater depth. • Other important aspect and considerations

Types of Energy Audit

The type of energy audit conducted depends on the function, size, and type of the building/industry, the depth to which the audit is needed, and the potential and magnitude of energy savings and cost reduction desired.

1

- Known as ‘walk-through audit’
- A walk-through audit is a method of determining the potential for energy savings.
- Recommendation :no-cost/low-cost improvement

2

- involves in-depth investigations
- Recommendation : no-cost and low-cost improvement, operational changes, modifications to system controls and building automation, and potential capital upgrades

3

- Some of the 'Detailed Energy Audit level' recommendations may require a large investment in capital, labour, and other resources.
- Before making such a large investment, the owner of a facility should obtain expert advice and conduct a more detailed cost-benefit analysis.
- Installing renewable energy systems or a combined heat and power system (cogeneration) are examples of investment-grade audits.

Preliminary Energy Audit

- The preliminary energy audit, often known as a 'walk-through audit,' gives a clear picture of a facility's current energy condition.
- Preliminary Energy Audit typically involves brief interviews, review of utility bills, operating data, technical catalogues, equipment rating and walk-through of facilities.
- In a preliminary energy audit, data that is readily available is mostly used to do a basic energy usage and performance analysis.
- In a Preliminary Energy Audit, auditors typically use available data, visual observations to identify energy losses, and use energy conservation rules-of-thumb.
- In Preliminary Energy Audit, simple instrument are used to do simple measurement for example clamp amp meter, lux meter, hygrometer and thermometer.
- These audits take less time and produce more general results.
- The audit's results could lead to immediate estimations of possible energy and cost-saving measures.
- This preliminary audit includes no-cost and low-cost improvements/savings, as well as the requirement for a detail energy audit analysis based on the findings made during the walk-through.

Detailed Energy Audit

- More detailed data and information are needed for detailed energy audits.
- As a result, this type of audit requires more time than preliminary audits.
- These audits generate more detailed and useful results because they provide a more accurate picture of energy performance as well as more specific recommendations for improvement.
- The complete energy audit entails in-depth investigations into how energy is being used, current system performance, and the identification of various potential energy conservation measures (ECMs).
- It also gives the estimated cost and simple payback periods for all recommended ECMs.
- No-cost and low-cost initiatives, operational changes, system controls and building automation modifications, and potential capital upgrades could all be suggested.
- Detailed energy audits are often a major criterion when a company applies for funding, certification, or an award.

Detailed Energy Audit

Phase 1 Pre Audit Phase

- An initial walk-through assessment should always be conducted, as good preparation is a must for an effective audit.
- An initial walk-through visit should allow the energy auditor to get to know the people involved, familiarise themselves with the location, and assess the procedures needed to complete the energy audit.
- The initial walk-through visit is aimed to familiarize the energy audit team with the facility that will be examined.
- The auditors might go over the procedures and utilities that will be thoroughly examined later.
- Throughout the audit, the audit team can look at the existing measuring instruments on the equipment as well as the data recorded to identify what additional measurements and data collection are required.
- If the auditors aren't facility employees, this phase of the audit is incredibly useful.
- The audit team can also meet with the managers of the areas to be examined to give them an overview of the audit process
- During the walk-through inspection, the auditors can get input from facility staff and collect available data.

Detailed Energy Audit

Phase 1

Pre Audit Phase

Step 1

Plan of Action	Purpose/Result
➢ Plan and organize ➢ Walk-through Audit ➢ Informal interview with Energy Manager, Production/Plant Manager	▪ Resource planning ▪ Establish/organize the energy audit team ▪ Organize instrument – identify existing instrumentation and additional metering required ▪ Organize time frame ▪ Macro data collection (industrial audit) –energy resources, major energy consuming equipment ▪ Familiarization of process/plant activities –obtain site drawing (plant/building layout, steam distribution, compressed air distribution, electricity distribution) ▪ First-hand observation and assessment of current level operation and practices

Step 2

Plan of Action	Purpose/Result
➢ Conduct a meeting/ awareness programme with all head of department and person in charge	▪ Cooperation development ▪ Make a survey for each department. ▪ Raising awareness and support for an effective energy audit

Detailed Energy Audit

Phase 1

Pre Audit Phase

The following are some of the questions that an energy auditor should ask.

- What is the purpose of this system and how its function?
- How much energy did this system consume?
- What are the signs that this system is in good functioning order?
- How can this system be made to work again if it isn't working?
- What can be done to lower the system's energy consumption?

Detailed Energy Audit

Phase 2

Audit Phase

- At the beginning of the audit, energy bills, as well as Other energy and production-related statistics and information, both current and historical, should be collected.
- The following are the list of data can be collected:
  i. Energy bills and invoices from the previous two to three years (electricity and fuels).
  ii. Data on monthly production for the last two to three years
  iii. Data on the climate for the time period in which the audit is being carried out
  iv. Existing energy related data & key operating parameters records-to confirm site data measurement needed
  v. Architectural drawings & building construction details
  vi. List of energy using equipment with rated power, quantity with operating status &hours
  vii. As-built mechanical services & other energy using systems
  viii. Details on interior & exterior lighting system
  ix. Operating & Maintenance manuals
  x. The current state of energy management and any efforts to reduce energy consumption were made.
  xi. Information on the facility in general (the year in which the building was built and renovated, product types, schedule of operations and operating hours.)

Detailed Energy Audit

Phase 2

Audit Phase

- The preliminary analysis aids the energy auditor in gaining a better understanding of the facility by providing a general picture of the plant/energy building's use, operation, and losses.
- A process flowchart can be created during the preliminary analysis to show the energy flows of the system being audited.
- At each process stage, the auditor must be able to recognize the various inputs and outputs as well as any energy waste or leakage.
- The preliminary flowchart is simple, but more specific information and data about the input and output streams can be added when the detailed energy audit is completed.

Step 3

Plan of Action	Purpose/Result
➢ Primary data collection, a flow diagram of the process, and a diagram of the energy utility	▪ For the purpose of establishing a baseline energy consumption, historical data must be collected and analyzed. ▪ Make flowcharts for the processes. ▪ All utility system diagrams, including single-line electricity distribution, water, compressed air, and steam distribution. ▪ Design, operational data, and operation schedule ▪ Refer to the manual, log sheet, name plate, and interview for an annual energy bill and consumption pattern.

Detailed Energy Audit

Phase 2

Audit Phase

Step 4

Plan of Action	Purpose/Result
➢ Conduct a survey and monitoring	▪ With portable measurement devices, conduct a motor survey, insulation survey, and lighting survey. ▪ Collect accurate data, double-check it, then compare it to the design data.

Step 5

Plan of Action	Purpose/Result
➢ Detailed testing of chosen major energy equipment	▪ Trial/tests : - within 24 hours, monitor power– electrical demand profile in KW for daily/weekly/monthly - Load variations trends in fan, pumps and compressors - Trials of boiler efficiency - Trials of furnace efficiency - Test of equipment performance

Detailed Energy Audit

Phase 2

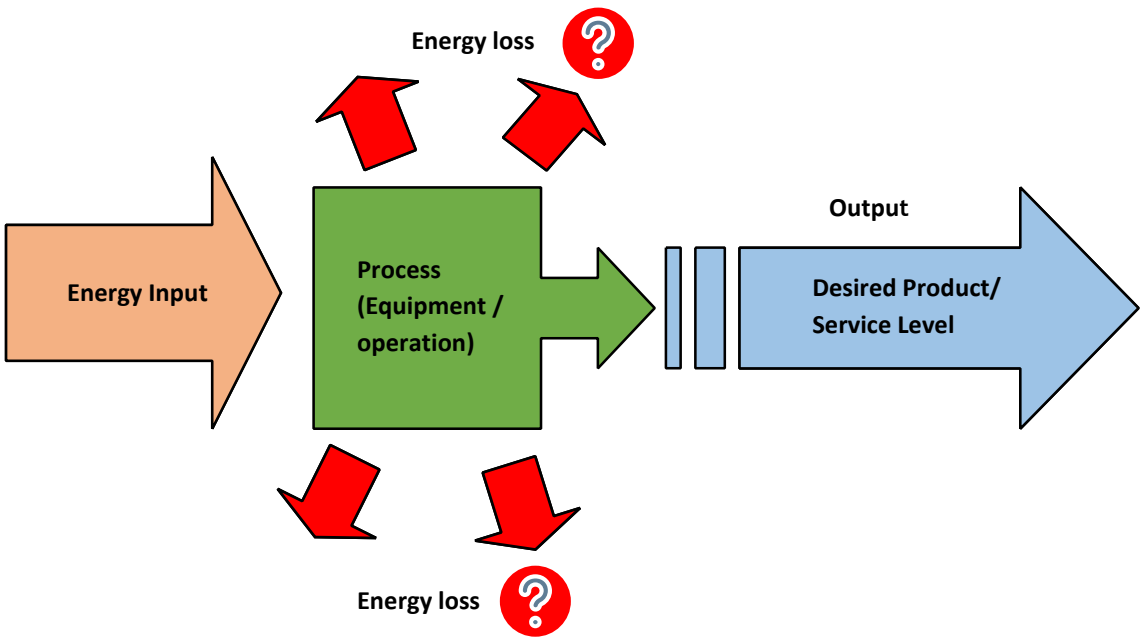
Audit Phase

Step 6

Plan of Action	Purpose/Result
➢ Analysis of energy use	▪ Analysis of energy and material balances as well as energy loss

Analyze Energy Balance & Energy Performance Data

- Analysis of energy and material balances as well as energy loss
- Identify areas where energy is being or possibly wasted



Detailed Energy Audit

Phase 2

Audit Phase

Factors to be considered by the energy auditor

01

CONDITION
Age, physical condition & remaining service life

02

SPECIFICATION
Name plate kW rating, loading &operating hours

03

DESIGN
Deficiencies that will contribute to inefficient operation

04

OPERATION
Is it functioning according to the design intention?

05

EFFICIENCY
Obvious maintenance problems & energy wastes

Detailed Energy Audit

Phase 2

Audit Phase

Step 7

Plan of Action	Purpose/Result
➢ Energy Conservation Measures identification and development	▪ Review any previous suggestions made by the unit's personal and energy auditor. ▪ Use approaches like brainstorming and value analysis. ▪ Find new or efficient technology through vendors.

Analysis and Identification of Energy Conservation Measures (ECMs)

- ECMs are also known as Energy Management Opportunities (EMO) / Energy Saving Measures (ESMs) / Energy Conservation Opportunities (ECO).
- An energy audit is used to find opportunities for energy conservation measures in a systematic way. Opportunities can be identified at any point during the audit report's development and completion.

Detailed Energy Audit

Phase 2

Audit Phase

Categories ECMs

Identification of energy saving measures to eliminate/minimize energy wastage to improve energy performance

No/low cost measures

No/low cost investment and uninterrupted operation of the building

Example :

- Adjustment of space temperature
- Keeping door and windows in air-condition space closed
- Switching off unnecessary lights

Medium cost measures

Medium cost investments with little disruption to building operations

Example :

- Replace with energy efficient lamp
- Use of energy efficient motors
- Maximizing daylight
- Chiller optimization

High cost measures

High cost investments with greatly disrupts building operations

Example :

- Chiller replacement
- Retrofit of lighting system
- Building envelop retrofit

Detailed Energy Audit

Phase 2

Audit Phase

Example of ECMs

For Main Incoming

• Ensure appropriate electricity tariff • Power factor improvement
• Maximum demand control

For Lighting System

• Equipment maintenance (periodical cleaning, ballast replacement with more efficient alternatives)
• Use of daylight in conjunction with lighting control
• Equipment replacement with more energy efficient alternatives
• Install automatic control equipment (e.g. Dimmers, occupancy sensors, Photo/ Daylight sensors cells, time clock)

For Air Conditioning System

• Equipment tuning • Manual/ automatic equipment control
• Equipment replacement
• Equipment maintenance
• Limit outside air intake to minimum requirements or use air quality sensors (CO2 sensors) to control outdoor air intake according to occupancy level • Use of ice storage for peak load reduction • Improve piping insulation

For Other Electrical Equipment

• On - off system
• Maintain ventilation at optimum requirements
• High efficiency motors
• Use of variable speed drive to reduce fan and pump loads
• Use of equipment control for equipment start and stop

Heating and boilers

• lowering the hot water boiler's temperature setting and insulating high-temperature pipelines, valves, and flanges
• Installing temperature controls that compensate for the weather

Detailed Energy Audit

Phase 2

Audit Phase

Step 8

Plan of Action	Purpose/Result
➢ Analyze the cost-benefit.	▪ Evaluate the ENCON options for implementation in terms of technical feasibility, economic viability, and priority. ▪ Priorities based on short, medium, and long-term measures

Technical Feasibility

In the technical feasibility study, the following should be addressed:

- Availability of technical, skill manpower, space
- The effect of energy efficiency measure on safety, quality, production or process
- Service concerns, maintenance needs, and spare parts availability

Economic Viability

Management approval is typically based on economic viability. Many methods can be used to undertake economic analysis. The low-investment, short-term payback option is appropriate for low-investment, high-economic sustainability projects.

Detailed Energy Audit

Phase 2

Audit Phase

Prioritization of ENCON Options For Implementation

There are three types of potential energy saving measures.:

i. Low cost – high return
ii. Medium cost – medium return
iii. High cost – high return

Proposed prioritized options available with the projected savings, costs & detailed economic analysis. Projects with low-cost, high-return are usually prioritized. Other projects need to be assessed, engineered, and budgeted in order to be implemented in phases. Projects involving equipment and process changes nearly usually come at a high cost with a high return, and they must be carefully evaluated before being performed. They're complicated, and they'll take a long time to implement.

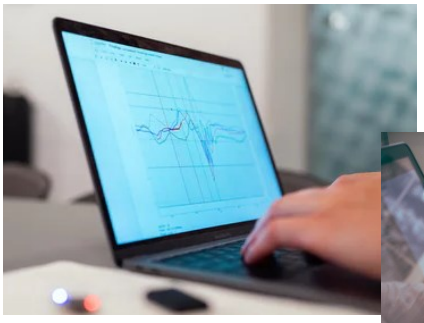
Detailed Energy Audit

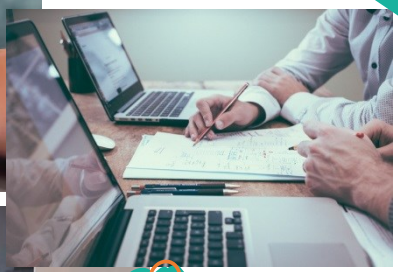
Phase 2

Audit Phase

Step 9

Plan of Action	Purpose/Result
➢ Prepare a report and make a presentation to the top management	▪ Documentation, present draft report to the top management ▪ Final report preparation on feedback





Make the findings from energy audit useful!

Detailed Energy Audit

Phase 3

Post Audit Phase

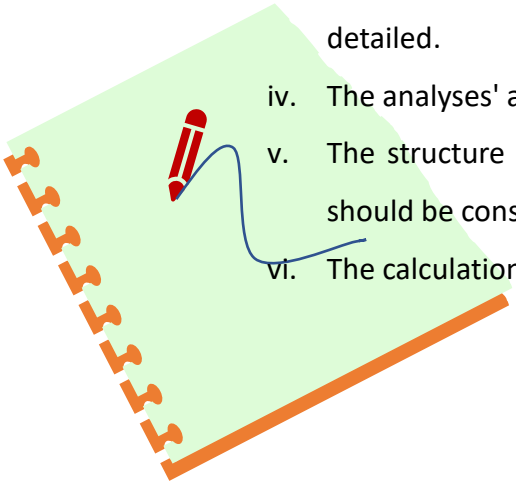
Step 10

Plan of Action	Purpose/Result
➢ Implementation of ENCON measures and follow up	▪ Implement ENCON recommendation measures and monitor the performance ▪ establish a plan of action and a timeline for implementation ▪ follow up on the implementation and conduct periodic reviews

- An action plan ensures that ENCON measures are implemented in a systematic manner.
- The action plan identifies which ENCONs should be implemented first and provides a timeline for their implementation.
- The action plan can be revised on a regular basis, most typically once a year, to reflect recent achievements, performance changes, and changing priorities.
- Without monitoring and the feedback that comes with it, an energy audit is incomplete.
- Analysis, action and monitoring are a cyclic process.

Energy Audit Report

- After the energy audit is completed, the audit team should create an energy audit report.
- The auditors should provide a well-structured report that explains their work and results.
- Audit Report should be based on data collection.
- Any recommendations proposed in the Audit Report should be supported by reliable technical calculations.
- The length and level of detail in an energy audit report are determined by the audited facility.
- The energy audit report should be concise and precise, and written in a clear and understandable manner for the target audience. The following are some crucial considerations to keep in mind when preparing an audit report:
    i. The audit report should be using a direct language that is easy to understand.
    ii. When presenting data, results, and trends, use graphs rather than tables.
    iii. The section on recommendations should be specific, clear, and detailed.
    iv. The analyses' assumptions should be presented in detail.
    v. The structure of an energy audit report and terminology used should be consistent.
    vi. The calculations used in the analysis should be clearly explained.



Energy Audit Report

- The Audit Report must present the full description of the audited building/industry, historical and current energy consumption status, observations, findings and Energy Conservation Measures (ECMs) identified.
- The Audit Report EM should consist of the following main topics; however should not be bound with the sample framework mentioned in the following details:
    i. The report should begins with an executive summary that gives the audited facility's management a brief synopsis of total savings and highlights of each energy-saving measure.
    ii. The main report should start with general description of the process or facility.
    iii. The annual energy consumption and bills should be presented with tables and graphs.
    iv. Following that, a description of energy inputs and outputs by major department or major process, as well as an assessment of the efficiency of each stage in the process, should be provided.
    v. recommended Energy Conservation Measures should be provided with cost and benefit calculations, as well as the estimated payback on any capital investment.
    vi. The audit report should conclude with specific recommendations for detailed engineering studies and feasibility analyses, which must then be carried out to justify the implementation of high-investment conservation measures.
- The following energy audit report contents and format is applicable to most buildings and industries.
- The report's format can be modified to meet specific needs for a certain industry or energy audit.

Energy Audit Report

Sample for Building

REPORT ON
DETAILED ELECTRICAL ENERGY AUDIT

1. EXECUTIVE SUMMARY

2. INTRODUCTION
   - 2.1. Audited Building Details
   - 2.2. Objective of the Audit
   - 2.3. Study Scope of the Audit
   - 2.4. Energy Audit Measurement Tools
   - 2.5. Brief Description on Electricity Distribution and Background

3. DESCRIPTION OF THE EQUIPMENT / SYSTEM AUDIT
   - 3.1. Main Incoming Description
   - 3.2. Lighting System Description
   - 3.3. Air Conditioning System Description
   - 3.4. Other Electrical Equipment Description

4. OBSERVATION & FINDINGS
   - 4.1. Load Apportioning
   - 4.2. Main Incoming
   - 4.3. Lighting System
   - 4.4. Air Conditioning System
   - 4.5. Other Building Electrical Equipment

5. ANALYSIS AND IDENTIFICATION OF ENERGY CONSERVATION MEASURES (ECMS)
   - 5.1. ECMs at Main Incoming
   - 5.2. ECMs at Lighting System
   - 5.3. ECMs at Air Conditioning System
   - 5.4. ECMs at Other Electrical Equipment
   - 5.5. ECMs Categories
     - 5.5.1. No Cost
     - 5.5.2. Low Cost
     - 5.5.3. High Cost

6. CONCLUSSION

Source : National Certification Examination for Energy Manager and Energy Auditor (2015)

Energy Audit Report

Sample For Industry

REPORT ON
DETAILED ENERGY AUDIT

TABLE OF CONTENTS

Source : National Certification Examination for Energy Manager and Energy Auditor (2015)

Benchmarking

- Benchmarking indicates how businesses use energy, where they use it, and what drives them to use it.
- It's an important first step in identifying ways to increase profits by reducing energy and operating costs.

- For successful energy management, benchmarking is required.
- Energy benchmarking makes it simple to identify inefficient areas, determine potential improvements, and make informed long-term energy management decisions.

Energy benchmarking in building?

- Building energy benchmarking is assessing and analysing a building's energy use and then comparing it to the building's previous performance, similar buildings, or modelled simulations of a reference building at a specific standard.

An example of a benchmarking tool in Malaysia :

BUILDING ENERGY INTENSITY (BEI)

- The intensity of energy used per meter square area of the building is used as a benchmarking tool in monitoring building energy performance.
- The Index is determined by taking the ratio of a building's yearly energy usage (kWh/year) to its net floor area (NFA).

$$\text{BEI (kWh/m}^2\text{ /year)} = \frac{Annual\ Energy\ Consumption\ (kWh)}{NFA\ (m^2)}$$

Benchmarking for Industrial

- Benchmarking for industrial is a technique that compares the energy performance of a single plant or a group of similar plants to a common metric that represents standard or optimal performance. It could also mean comparing the energy efficiency of several plants.
- Benchmarking can be a useful tool for determining energy consumption patterns in the industrial sector, as well as for taking the necessary steps to improve energy efficiency.
- Benchmarking energy consumption both internally and externally is a useful tool for evaluating performance and rationally developing opportunities for improvement.

Internal Benchmarking

- Use historical data and trend analysis as reference where no external benchmark data is available.
- Energy consumption and cost patterns can be identified using well-documented historical data.
- Trend analysis of energy consumption, costs, important production aspects, and specific energy consumption can help to understand the implications of capacity utilization on energy usage efficiency and costs on a larger scale.

External Benchmarking

- relates to a group of similar units being compared to find best practices. (across similar businesses)
- The following are a few comparison considerations to consider:
  - ✓ Operational size
  - ✓ Vintage of technology
  - ✓ Raw material specifications and quality
  - ✓ Quality and product specifications

Benchmarking for Industrial

Benchmarking energy performance allows :

- Quantification of fixed and variable energy consumption patterns in relation to production levels.
- Energy performance of the industry at various stages of production is compared (capacity utilization).
- Based on external benchmarking data, best practises are identified.
- The scope and margin available for reducing energy consumption and costs.
- Monitoring and goal-setting exercises are based on this foundation.

The following are some examples of benchmark metrics or units of measurement that adequately represent the plant's energy performance in several sectors:

- Gross production related
  - Textile industry - kWh/kg
  - Paper plant - kWh/MT, k Cal/kg
  - cement plant - kWh/MT
  - Foundry industry - kWh/MT
  - Fertilizer plant - Million kilocals/MT

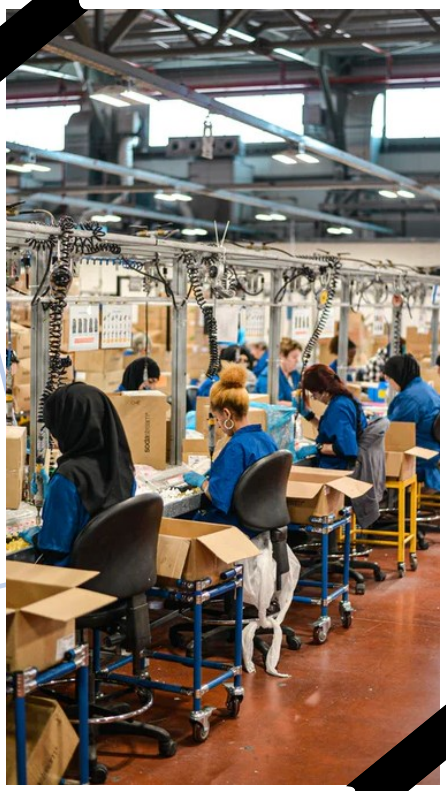
- Equipment / utility related
  - kW/ton of refrigeration
  - kWh /litre in a diesel
  - % thermal efficiency of a boiler plant
  - % cooling tower effectiveness

While such benchmarks are stated, the following important process parameters must be mentioned for meaningful peer comparison.

Plant Energy Performance

Plant Energy Performance

- is a measure that determines whether a plant uses more or less energy to produce its products presently than it did previously.
- a measure for determining how effective the energy management programme is.



- Plant Energy Performance measures how much energy is used by plants in a given year and subsequent years, taking into account production output, to evaluate whether there has been an improvement or deterioration.
- However, because a plant's output changes from year to year, it has a big impact on how much energy it uses.
- For a valid comparison, the energy required to create current-year production output if the facility had operated in the same way as it did during the reference year must be determined.
- The calculated value can then be compared to the actual value to see whether there has been an improvement or deterioration from the reference year.

Plant Energy Performance

Production Factor

- used to determine how much energy would have been needed to create this year's output if the plant had functioned in the same way as the previous year.
- It is the ratio of current-year production to reference year production.

$$\text{Production factor} = \frac{\text{Current year's production}}{\text{Reference year's production}}$$

Reference year equivalent energy use

- or **reference year equivalent** is the amount of energy that would have been used to produce the current year's product output.

$$\text{Reference year equivalent} = \text{Reference year energy use x Production factor}$$

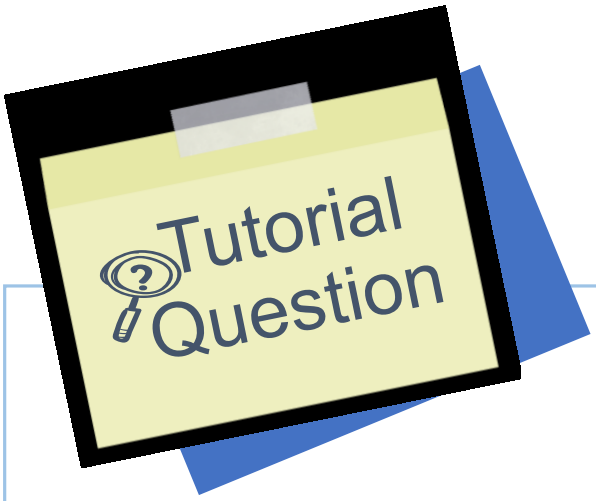
Plant Energy Performance

Plant energy performance

- improvement or deterioration compared to the reference year. This is a measure of a plant's energy progress.

$$\text{Plant energy performance} = \frac{\text{Reference year equivalent - Current year's energy}}{\text{Reference year equivalent}} \times 100$$

- The energy performance is the percentage of energy saved compared to the reference year's rate of use. The higher the number, the better the improvement.
- Plant energy performance is the starting point for evaluate energy performance.
- It does not require detail calculation of the energy used every place of equipment, the energy use of every process or the energy use of building.
- It utilizes the most effective measure of energy saving, the actual measurement of energy consumption compared to production output.



1. Identify two energy audit instruments for electrical measurements and describe its function.

2. Describe two needs of conducting energy audit .

3. With your own words, interpret the purpose of Pre Audit phase (initial site visit).

4. Detailed energy audit is carried out in 3 phase. Name that phases and list steps involved in each phase.

5. Identify two types of benchmarking.

6. Interpret the importance of plant energy performance.

Tutorial Answers

1 **Identify two energy audit instruments for electrical measurements and describe its function.**

a. Portable Power Analyzer – used for power measurement. Measure, record the V, A. pf, Frequency, kVA, kVAr, kW, KWh, KVA, harmonics etc.

b. Digital clamp-on ammeter - Measures AC/DC current, AC/DC voltage, resistance, capacitance, diode, frequency and continuity.

c. Luxmeter - measure illumination level, for analysing lighting requirement

 # your answer should be only TWO point

2 **Describe two needs of conducting energy audit** .

a. Auditors- can be Company staff or external auditor.

b. Instruments -Permanent and Portable that Involves using various measuring equipment depending on the investigation being carried out.

c. Energy Records - Energy records is a process of collecting, organizing and analyzing energy data

d. Computer and Software Tools which is audit tools mesh with the other software, hardware and network systems already in place

e. Budget and Time - The time frame and budget can be determined based on available resources.

your answer should be only TWO point

Tutorial Answers

3 **With your own words, interpret the purpose of Pre Audit phase (initial site visit).**

Purpose pre audit phase (initial site visit) are to let an energy auditor to meet with the persons involved, familiarise themselves with the location, and assess the procedures required to do the energy audit. The auditor can identify the main energy consuming areas/plant items to be surveyed during the audit, any existing instrumentation/additional metering required, whether any meters will have to be installed prior to the audit, and the instrumentation required for carrying out the audit from the initial site visit.

4 **Detailed energy audit is carried out in 3 phase. Name that phases and list steps involved in each phase.** .

A detailed energy audit is carried out in 3 phases:
a) Pre-audit phase b) Audit phase & c) Post Audit phase

a) Pre Audit Phase:
- Plan and organize
- Walk through audit
- Informal interview with Energy Manager, production/plant manager
- Conduct a meeting/ awareness programme with all head of department and person in charge

b) Audit Phase:
- Primary data collection, a flow diagram of the process, and a diagram of the energy utility
- Conduct survey and monitoring
- Detailed testing of chosen major energy equipment
- Analysis of energy use
- Energy Conservation Measures identification and development
- Analyze the cost-benefit.
- Prepare a report and make a presentation to the top management

c) Post-Audit Phase:
- Implementation of ENCON measures and follow up

Tutorial Answers

5 **Identify two types of benchmarking.**

a. Internal benchmarking
b. External benchmarking

6 **Interpret the importance of plant energy performance.**

Plant energy performance is the starting point for evaluate energy performance of the plant. It is a measure of whether a plant now uses more or less energy to manufacture its products than it did previously, and it is calculated by comparing the change in energy consumption from one year to the next while considering production output to determine whether there has been an improvement or deterioration from the reference year.

The energy performance is the percentage of energy saved compared to the reference year's rate of use. The higher the number, the better the improvement. It does not require detail calculation of the energy used every place of equipment, the energy use of every process or the energy use of building. It utilizes the most effective measure of energy saving, the actual measurement of energy consumption compared to production output.

End of chapter 2

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