

ENERGY AUDIT



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We hereby declare that this book is our original work. To the best of our knowledge. It contains no materials previously written or published by another person. However if there is any, due acknowledgment and credit are mentioned accordingly in the e-book.

PREFACE

Alhamdulillah, we are grateful to ALLAH for His abundance and grace, which has enabled us to complete this eBook.

Energy audit is a fundamental topic in the Energy Management System and Energy Auditing course. In this course, students will learn the principles of energy auditing, including the use of electrical and mechanical audit equipment, data analysis, and report creation.

We extend our heartfelt thanks to everyone who significantly contributed to the successful uploading of this eBook. We hope this eBook serves as a valuable resource and a stepping stone for students to become successful and skilled energy auditors.

Rozaini binti Rahi
Mohd Izham bin Ahmad

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UNDERSTAND THE ENERGY AUDIT



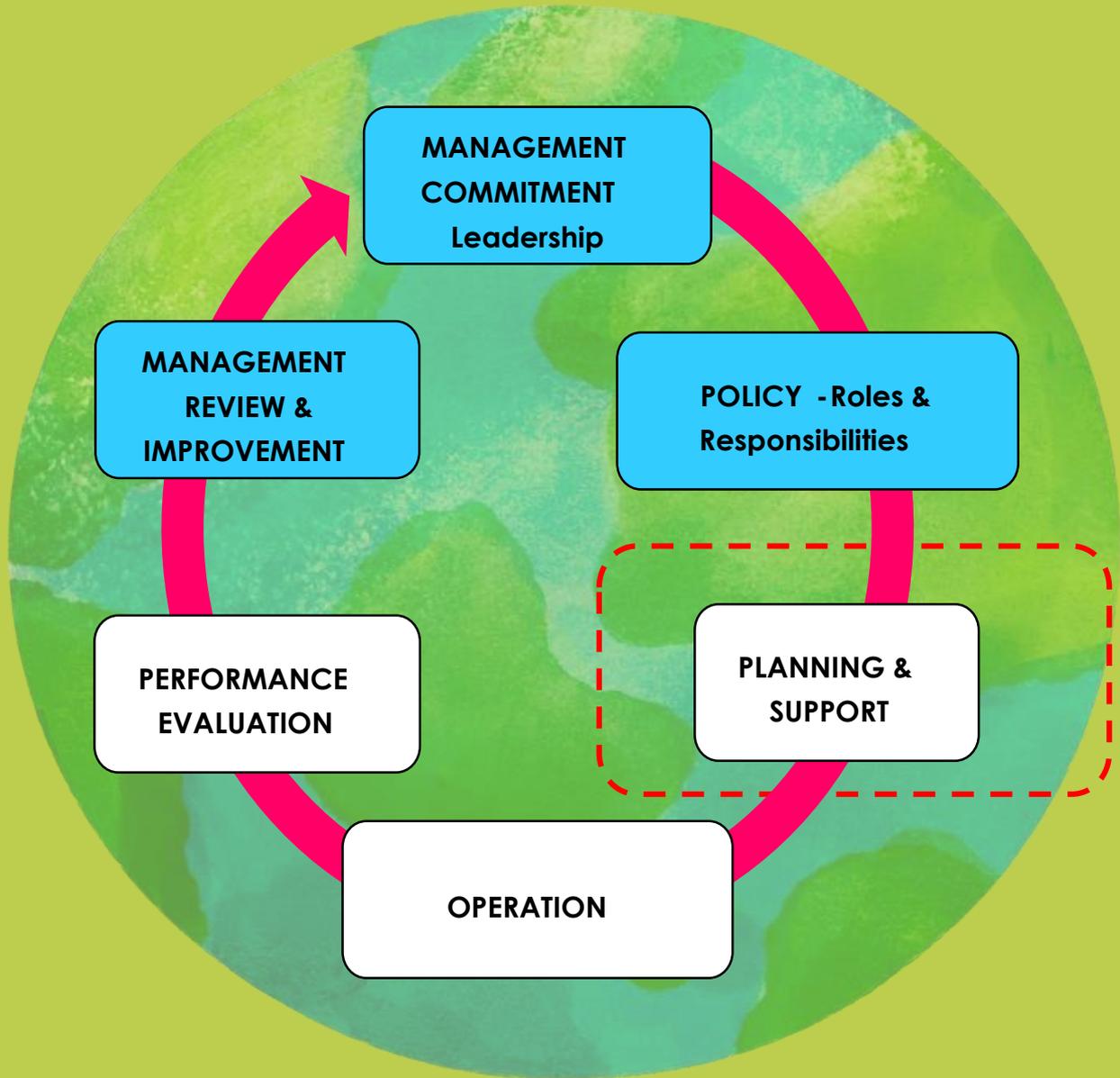


Energy audits are the initial step in enhancing the energy efficiency of buildings and industrial facilities.

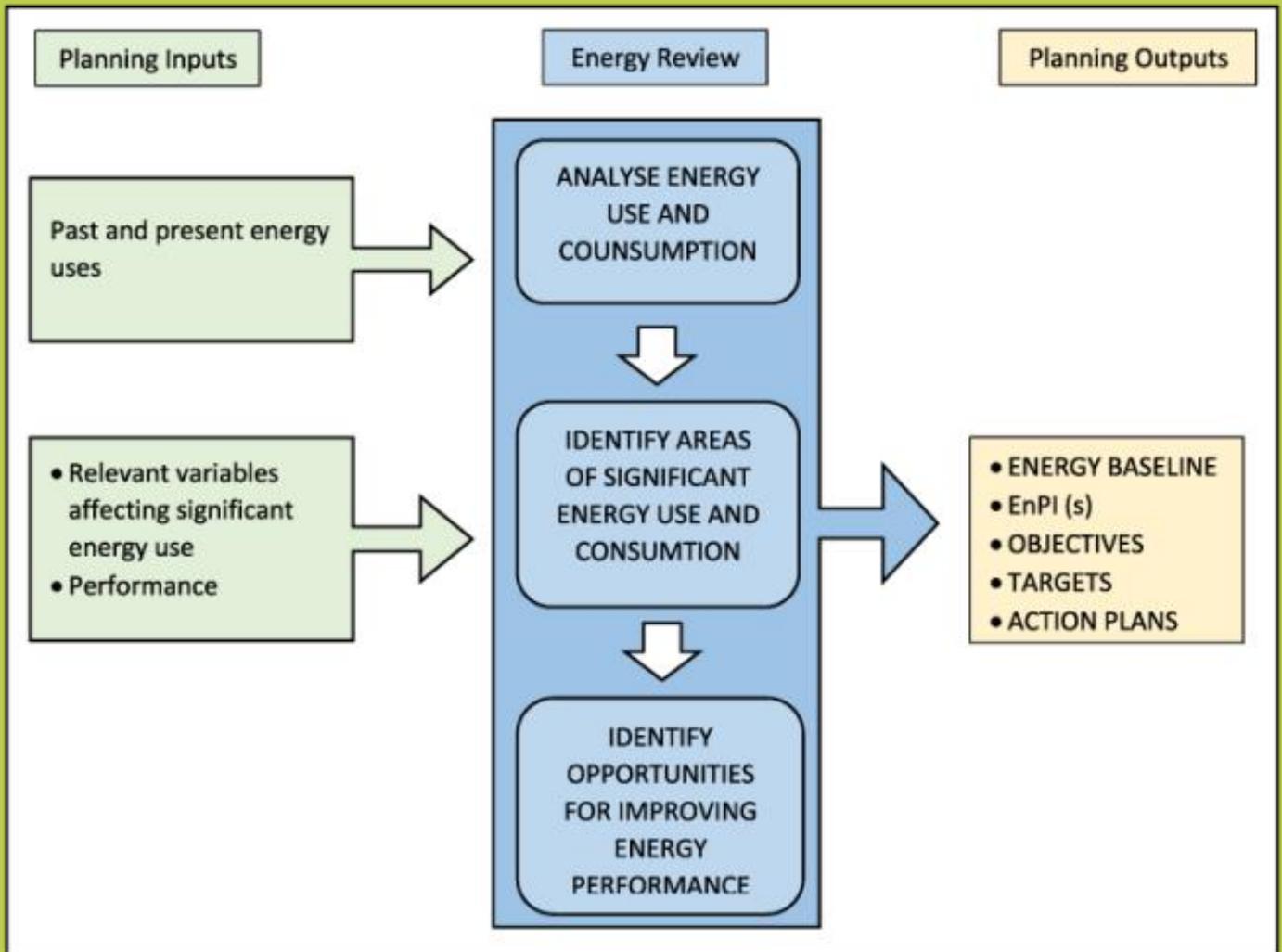
They are a key tool in energy management.



ENERGY MANAGEMENT SYSTEM (EnMS) CONCEPT



PLANNING AND SUPPORT



Energy Review is basically **energy audit**

In a nutshell, EA is about findings answers to the following questions :-

- How much energy are we consuming?
- Where and when is energy being used?
- Is our energy usage efficient and effective ?
- How can we improve our energy efficiency and effectiveness?



DEFINATION OF ENERGY AUDIT (EA)

A process which is very much central for conducting an energy management project or in general an energy audit is a study conducted to identify where, when and how much energy is being used in the business and how to reduce the cost of energy for the business

(Electrical Energy Audit Guidelines for Building, Malaysia)



A detailed review and analysis of energy use and consumption in audited entities to identify energy flows, discover potential opportunities, and perform monitoring and verification to improve energy performance and report findings

A systematic approach to measure and monitor, analyse and verify the consumption and energy efficiency of an installation or a facility and to submit an audit report containing recommendations for improving energy efficiency with cost-benefit analysis and a proposed action plan to reduce energy consumption and wastages.

Malaysia Association of Energy Service Companies(MAESCO), 2018





GOALS OF ENERGY AUDIT

1. To assess current energy management practices.
2. To lower energy consumption while maintaining safety, comfort, and facility quality.
3. To analyze energy usage within the building or industry.
4. To establish a baseline for energy performance.
5. To pinpoint areas of energy wastage and opportunities for improvement.
6. To conduct an economic analysis of potential alternatives and identify the most cost-effective options for the business or industry.





WHY DO WE NEED AN ENERGY AUDIT?



Types of Energy Audit (EA)

Various levels of EA commonly undertaken are classified as follow :-

**PRELIMINARY ENERGY
AUDIT / WALK THROUGH
AUDIT**

**DETAILED ENERGY
AUDIT (DEA)**

**INVESTMENT GRADE AUDIT
(IGA)**

1

2

3



PRELIMINARY ENERGY AUDIT / WALK THROUGH AUDIT

Main objective is for the energy audit team to be familiar with the designs of the buildings or factory, the facilities, operated and maintained, type of energy being consumed and its quantity and the environment to be audited.

Allows auditors to examine business or production processes, equipment, mechanical and electrical systems and utilities briefly.



Involves minimal interviews with site-operating personnel and a brief review of facility utility bills, equipment records, manuals and other operating data.

A walkthrough of the facility to become familiar with the building operation and to identify any glaring areas of energy waste or inefficiency

Typically, only major problem areas will be covered during this type of audit.



Preliminary Energy Audit

Get a comprehensive report on your energy usage



Corrective measures are briefly described, and quick estimates of implementation cost, potential operating cost savings, and simple payback periods are provided.

A list of energy saving measures requiring further consideration is also provided.

Carried out in one or two days by either Energy Manager alone or with a team, depending on the size, complexity of the building and the scope of audit.

Usually, simple instruments such as a clamp amp meter, thermometer, hygrometer (humidity meter) and lux meter will serve the purpose to measure on the spot



WALK THROUGH / PRELIMINARY AUDIT

Five steps involved in Walk through / Preliminary Audit

Facility Site Survey

Conduct a walk-through survey to the facility to be accompanied by the building operator or maintenance staff member to become familiar with its construction, equipment, operation and maintenance.

Identify major energy-using systems, processes, and equipment. Gather control strategies and equipment information of major components from nameplates, drawings or other means.

1

Benchmarking

Obtain Energy Use Intensity (EUI) and Energy Cost Index (ECI)

2

Benchmark the building's normalized energy consumption relative to that similar building for a minimum 12 consecutive months

Identify operating problems, malfunctioning equipment, maintenance costs and maintenance needs. Interview the owner and/or operator and occupants to identify current space usage etc.

WALK THROUGH / PRELIMINARY AUDIT

Five steps involved in Walk through / Preliminary Audit

3

Identify Low Cost & No Cost Energy

Changes to lighting and HVAC (e.g., thermostats) controls, to reduce lighting and HVAC in areas that are unoccupied or unused for substantial periods of time.

Implementation of routines (and logs) to improve the efficiency of operations, or maintenance of such improvements after tune-ups.

Education of building operators and/or occupants.

WALK THROUGH / PRELIMINARY AUDIT

Five steps involved in Walk through / Preliminary Audit

4

Identify Potential
Energy Conservation
Measures (ECM)
Capital
Recommendations

Identify potential capital-
expensed ECMs including a high
impact preliminary qualitative
estimate of the level of potential
costs and energy cost savings

5

Review ECMs with
Owner's
Representative

Provide to the owner or
their appropriate
representative a list of
identified measures, their
brief descriptions, their
qualitative impact, and
approximate level of
economic return.

Receive feedback.

DETAILED ENERGY AUDIT (DEA)

Detailed audit expands on the preliminary audit by collecting more detailed information about facility operation and by performing a more detailed evaluation of energy conservation and efficiency measures (low to high cost).

Utility bills are collected for a 6 to 12 months period to allow the auditor to evaluate the facility's energy demand rate structures and energy usage profiles.

In-depth interviews with facility operating personnel are conducted to provide a better understanding of major energy consuming systems and to gain insight into short and longer-term energy consumption patterns.

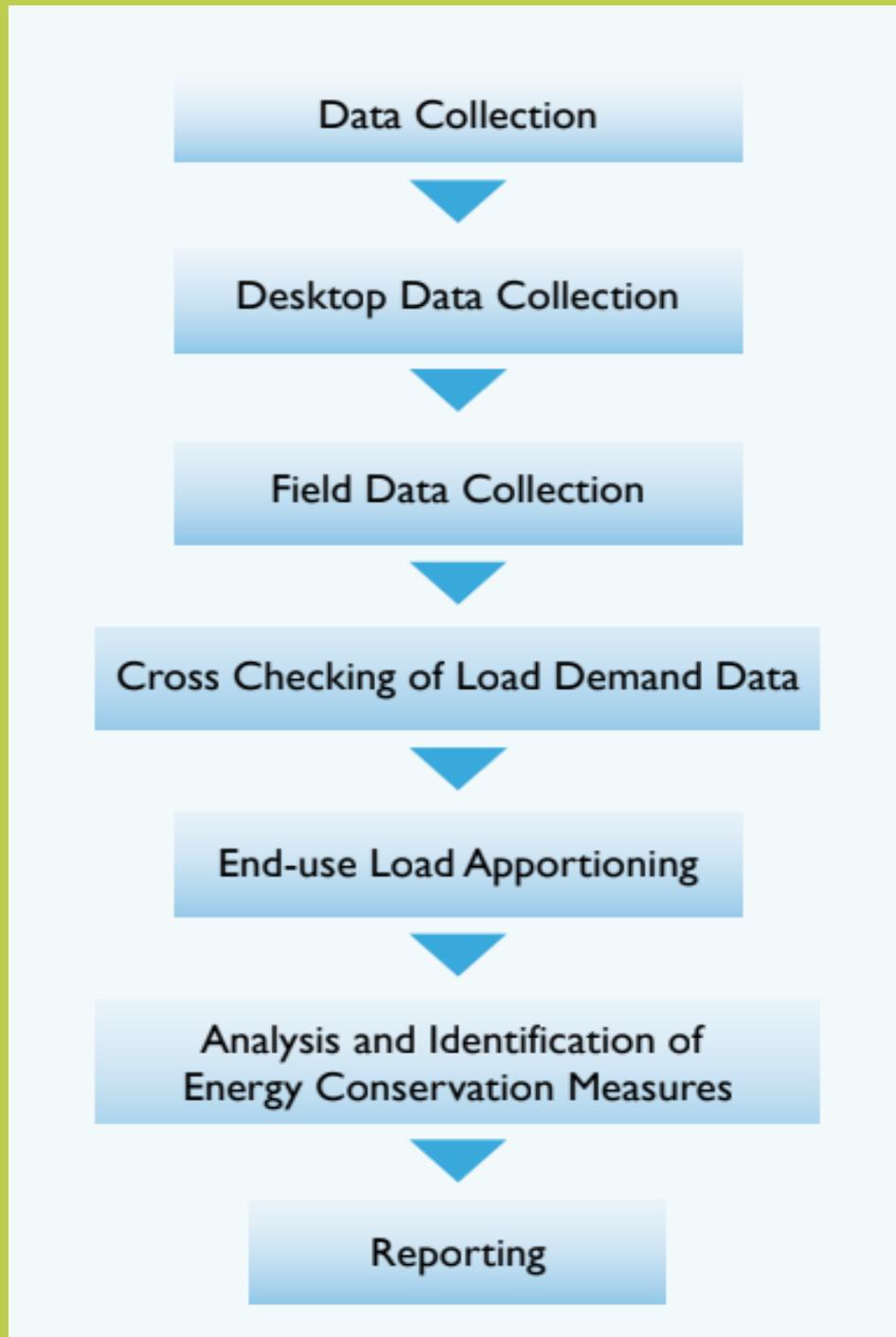
A detailed financial analysis is performed for each conservation/efficiency measure based on detailed implementation of cost estimates, site-specific operating cost savings, and the customer's investment criteria.

Sufficient detail is provided to justify project implementation.



DETAILED ENERGY AUDIT (DEA)

Flow charts of DEA process



INVESTMENT GRADE AUDIT (IGA)

Provides a detailed analysis of energy usage, the savings that can be made, and the cost of achieving those savings.

May cover the whole building or may concentrate on an individual item and/or system.

Involves long term detailed metering and data logging (minimum 14 days).

Annual building energy modeling is required using software analysis

Life Cycle Costing (LCC) is a method that compares project cost estimates over the lifetime of a project.

Life cycle refers to total time period between acquisition and the moment when the asset is either fully depreciated or discarded as waste.

Important tool to make investment decision in energy saving projects.

Provide satisfactory answer to essential question 'Which project are the most profitable from a long-term perspective'



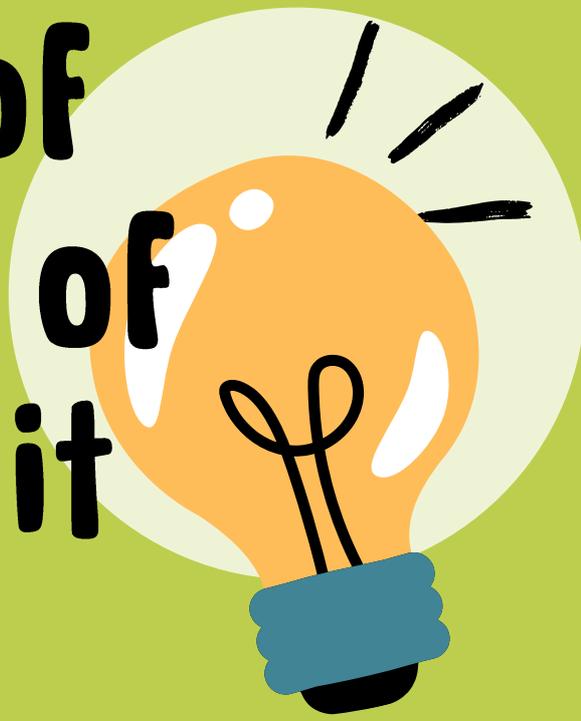
INVESTMENT GRADE AUDIT (IGA)



Software analysis for IGA



Summary of Three Types of Energy Audit (EA)



Type	Description
Preliminary audit	<ul style="list-style-type: none">- Evaluating energy consumption in general- energy bill analysis and determining BEI- Identifying areas for potential savings in general using experience and 'rule of thumb'- No systematic measurement
Detailed audit	<ul style="list-style-type: none">- Using input from preliminary audit- Identification of energy sources and end-users and apportionment- Determination of equipment and system performance- Performance evaluation with reference to design/standards- Investigation and measurement to identify potential savings- Analysis of saving measures using technical and economic evaluation.
Investment Grade audit	<ul style="list-style-type: none">- Input from detail audit- Involve high cost, complex system- Require financing- Longer period for investigation and monitoring



DETERMINING TYPE OF AUDIT NEEDED



Question to help you determine your audit needs	If your answer is "YES" the we recommend	If your answer is "NO" then we recommend.
Do you want to evaluate the overall opportunity potential in your facility?	DEA	Walk-through/preliminary or selected system/equipment energy audit
Do you already have an energy audit completed?	Updated the latest data to get project financing	Walk-through/preliminary energy audit
Have some energy efficiency projects been installed?	Perform M&V to verify the actual saving. If the energy target is not achievable medium / high cost ESM will be considered	Walk-through/preliminary energy audit



DETERMINING TYPE OF AUDIT NEEDED



Question to help you determine your audit needs	If your answer is "YES" the we recommend	If your answer is "NO" then we recommend.
Do you have limited funds to spent on an audit?	Walk-through / preliminary energy audit	DEA
Do you know what projects you want to implement?	Walk-through / preliminary energy audit / DEA	IGA
Do you plan to have comprehensive energy target and plan for your facility?	DEA	Walk-through / preliminary energy audit
Are you concerned about accuracy of energy project savings and cost?	DEA	Walk-through / preliminary energy audit



Video of Energy Audit



April 26

Energy Audit Required Tasks

In further detail, each level has a set of tasks to be conducted, but if done in sequence, each level will address the part of the requirements of the next one

	Level 1	Level 2	Level 3
Conduct PEA	✓	✓	✓
Conduct Walk-Through Survey	✓	✓	✓
Identify low cost/no cost measures	✓	✓	✓
Identify Capital Improvements	✓	✓	✓
Review Mechanical and Electrical (M&E) design and condition and O&M practices		✓	✓
Measure Key Parameters		✓	✓
Analyze Capital Measures (savings & Costs, including Interactions)		✓	✓
Meet with Owner/Operator to review recommendations		✓	✓
Conduct additional testing/monitoring			✓
Perform detailed system modeling			✓
Provide Software Outputs for Recommendations			✓

Source: ASHRAE (Process for Commercial Building Energy Audit, 2nd edition)



EXERCISE



Question

There are THREE (3) types of energy audit. One of energy audit types is Preliminary Audit. Write in details about Preliminary Audit. Your answer should include name of TWO (2) others types of energy audit.

Answer

- Evaluating energy consumption in general
- Energy bill analysis and determining BEI
- Identifying areas for potential savings in general using experience and 'rule of thumb'
- No systematic measurement performance evaluation with reference to design / standards

Others energy audit types

1. Detailed audit
2. Investment Grade audit



APPLICATION OF ENERGY AUDIT



INTERNAL PERSONEL



Energy Manager with the Energy Management Team

Employees working in the energy using process / equipment

EXTERNAL PARTIES



**External experts / consultants
(if needed)**

Advantages of Internal Personnel and External Parties for Performing EA

	INTERNAL PERSONEL	EXTERNAL PARTIES
Advantages	<p>Minimize time to familiar and understand the plant operational conditions</p> <p>Easy access to information & data</p> <p>Familiar with energy related issues, processes, equipment & company's level of expectations</p> <p>Minimize costs</p>	<p>Can facilitate the Energy Management Team/EMWG</p> <p>Energy management team can learn about new knowledge and technologies in saving energy</p> <p>Minimum time to be spent by employees (focus to main duties)</p> <p>Timeliness of the completion, reporting, preparation & presentation of findings.</p>

Disadvantages of Internal Personnel and External Parties for Performing EA

	INTERNAL PERSONEL	EXTERNAL PARTIES
Disadvantages	<p>Limited allocation of time other than main duties</p> <p>Limited expertise and knowledge in specific energy saving methods, analysis & technologies</p>	<p>Generally very costly</p> <p>Various level of supervisory and reporting (energy manager-auditor, management-auditor)</p> <p>Difficult to predict the quality of audit (no local accreditation for energy auditor)</p> <p>Tendency to push for certain products instead of solutions to save energy</p>

Pre-Requirements for EA

The commitment from the top management to implement energy saving measures

Allocation of resources (auditor, budget)

Availability of information and data (records)

Energy audit equipment

Allocation of time

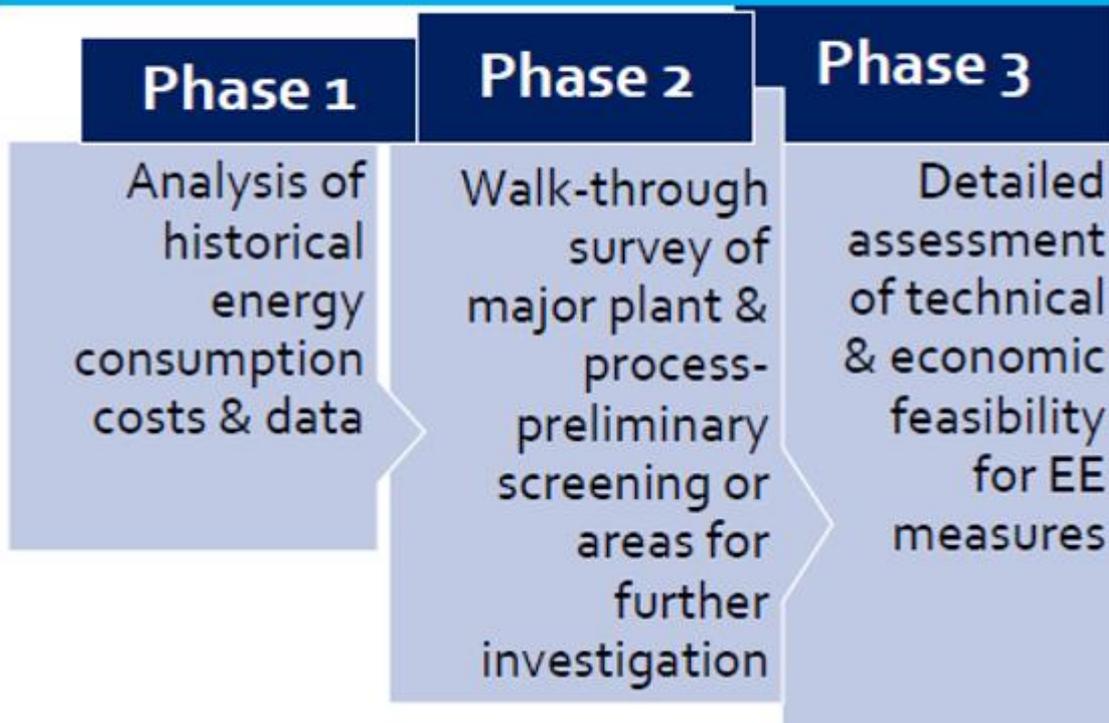
Hardware and software for data analysis

Previous & existing energy saving initiatives information & results

Regulatory compliance

A fundamental element of an energy efficiency program is providing information to decision-makers.

ENERGY AUDIT PROCESS FLOW



Key activities

- Data gathering
- Data analysis
- Presentation of options to improve EE

Phase 1 - Analysis of historical consumption.

Analyze trends in consumption patterns and costs for various energy sources, such as electricity, gas, and fuel oil.

Evaluate energy indices or identified Energy Performance Indicators (EnPIs).

Identify inefficient systems and operational procedures.

Verify that each energy source is procured at the most economical rate from the utility.

Get some idea to prioritize –energy form with the highest costs!

Phase 1 - Simple Tariff Analysis

Review historical billing data from the past 12 months.

Estimate or measure the facility's peak and off-peak kWh usage, if applicable.

Estimate or measure the Maximum Demand (MD) in kW, if relevant.

Compare energy costs across available tariff options.



Phase 1 - Simple Tariff Analysis

HOW TO READ YOUR ELECTRICITY BILL

MP KUALA LUMPUR

Jumlah Perlu Dibayar RM 158.45

Tarikh Bil 17 Julai 2019

	Amaun	Bayar Sebelum
Tunggakan	RM 0.00	Terima Kasih
Caj Semasa	RM 158.45	
Penggenapan	RM 0.00	
Jumlah Bil	RM 158.45	16.08.2019

	Amaun	Tarikh
Bil Terdahulu	RM 69.30	17.06.2019
Bayaran Akhir	RM 69.30	23.06.2019

Jenis Bacaan

Bacaan Sebenar

Billing cycle

Tempon Bil 18.06.2019 - 17.07.2019 (30 Hari)

Tarif A: Kedah Faktor Prorata 1.00000

Blok Tarif (kWh)	Blok Prorata (kWh)	Kadar (RM)	Amaun (RM)
200	200	0.218	43.60
100	100	0.334	33.40
300	153	0.516	78.95
Jumlah	453		155.95

Tariff blocks

<https://www.mytnb.com.my/residential/understand-your-bill/bill-layout>

Phase 1 - Plan of action / report to the management

Results

Consumption & cost for each major energy form used.

Index / EnPI which relates the energy use to an energy-efficient target level.

A discussion on any potential energy wastage / inefficiencies.

Preliminary assessment of cost savings through alternative tariffs (if applicable).

Phase 1 - Plan of action / report to the management

Recommendations

Recommendations – not lengthy / detailed but clearly indicating:

The ramifications of a “do-nothing” approach towards energy consumption.

Basic indications of the types of benefits that an energy management program could provide — especially regarding profitability.

Phase 2 – Walk-through screening survey

Objectives

To identify major energy-consuming plants / systems / equipment, and processes.

Confirm obvious energy waste and inefficiencies.

Prioritize areas and systems for further detailed investigation.

Phase 2 – Basic Management Audit

Existing Structure of Responsibilities for Energy Management

- a. Organizational Structure
 - i) Energy Management Team: Identify if there is a dedicated team or individual responsible for energy management. This could be an energy manager, sustainability officer, or facilities manager.
 - ii) Roles and Responsibilities: Review the roles and responsibilities assigned to the energy management team. Determine how responsibilities are distributed, such as who is in charge of monitoring energy consumption, implementing energy-saving measures, and reporting on energy performance
 - iii) Reporting Lines: Examine the reporting structure. Understand to whom the energy management team reports (e.g., senior management, board of directors) and how energy management initiatives are communicated throughout the organization.

Phase 2 – Basic Management Audit

Existing Structure of Responsibilities for Energy Management

- b. Policies and Procedures
 - i) Energy Management Policy: Check if there is a formal energy management policy in place. This policy should outline the organization's commitment to energy efficiency, key goals, and strategic approaches.
 - ii) Procedures and Protocols: Review the procedures for energy management, including how energy audits are conducted, how energy-saving projects are implemented, and how performance is monitored.

Phase 2 – Basic Management Audit

Existing Structure of Responsibilities for Energy Management

c. Resource Allocation

- i) **Budget:** Analyze the budget allocated for energy management. Ensure that adequate resources are provided for energy efficiency projects, training, and technology upgrades.
- ii) **Tools and Equipment:** Evaluate the tools and technology used for monitoring and managing energy consumption. This might include energy management systems (EMS), metering equipment, and software.

Phase 2 – Basic Management Audit

Staff Awareness and Commitment to Energy Efficiency (EE)

- a. Training and Education
 - i) Training Programs: Assess whether staff members receive training related to energy efficiency. This can include workshops, seminars, or online courses that focus on energy-saving practices and the importance of energy management.
 - ii) Knowledge Levels: Determine the level of knowledge staff have regarding energy efficiency. This might involve surveys or interviews to gauge their understanding of energy-saving measures and their role in achieving energy

Phase 2 – Basic Management Audit

Staff Awareness and Commitment to Energy Efficiency (EE)

b. Engagement and Communication

- i) **Communication Channels:** Review how energy management information is communicated to staff. This includes internal newsletters, emails, posters, or meetings that promote energy efficiency initiatives.
- ii) **Employee Involvement:** Evaluate the extent to which employees are involved in energy management efforts. Look for programs that encourage staff to contribute ideas or participate in energy-saving initiatives.

Phase 2 – Basic Management Audit

Audit Steps

- a) Document Review: Start by reviewing all relevant documents, including the energy management policy, organizational charts, job descriptions, and training materials.
- b) Interviews: Conduct interviews with key personnel, such as the energy manager, department heads, and staff members, to understand their roles, responsibilities, and awareness levels.
- c) Surveys: Distribute surveys to employees to gather insights on their knowledge of energy efficiency and their level of engagement with energy management practices.

Phase 2 – Basic Management Audit

Audit Steps

- d) Observation: Observe daily operations to see how energy management responsibilities are carried out and how staff apply energy-saving practices in their work.
- e) Analysis: Analyze the collected data to identify gaps in the current structure and areas where staff awareness and commitment can be improved.

Phase 2 – Basic Management Audit

Report Findings and Recommendations

- a) Findings: Summarize the key findings regarding the structure of energy management responsibilities and staff awareness and commitment.
- b) Recommendations: Provide actionable recommendations to enhance the structure of energy management responsibilities, such as defining clearer roles, improving resource allocation, or enhancing staff training programs. Also, suggest ways to increase staff awareness and commitment, like implementing better communication strategies or creating incentive programs.

Phase 2 –Data requirements

Essential Data and Information

Design and Energy Services:

- i) Overview of design and associated energy services.
- ii) Available equipment and control systems.
- iii) Performance assessment of these services compared to the designed specifications



Phase 2 –Data requirements

Additional Data and Information Required

Operational Details:

Operating hours and functions of the site.

Energy System Documentation:

Line diagrams of energy systems, including utility meters and sub-metering.

Energy-Using Equipment:

Inventory of energy-using equipment, including rated power, quantity, operational status, and usage hours.

Architectural and Construction Information:

Architectural drawings and building construction details.

Phase 2 –Data requirements

Additional Data and Information Required

Mechanical and Energy Systems:
As-built details of mechanical services and other energy-using systems.

Lighting Systems:
Information on interior and exterior lighting systems.

Operation and Maintenance Manuals:
Manuals for operation and maintenance.

Energy Data Records:
Existing energy-related data and records of key operating parameters to verify site data measurement needs.

Common Energy Audit Equipment

CHEMICAL MEASUREMENT

Flue Gas Analysis
Flue Gas Analyzer

- CO₂ & O₂,
- CO
- Temp
- Efficiency

THERMAL MEASUREMENT

- Thermometer
- Thermocouple & Indicator
- Thermograph
- Data-logger
- Hygrometer

ELECTRICAL MEASUREMENT

- 3-Phase/
1-Phase Power Analyzer
- Voltage, Current.
 - kVA, kW, kVAr
 - Power factor
- Harmonics
Lighting - Lux meter

MECHANICAL MEASUREMENTS

Flow

- Vane Anemometer
- Ultra Sonic Flow Meter
- Flow/Velocity
- Temperature
- Relative Humidity

Pressure

- Pressure Recorder
- Leaks
- Ultra Sonic Leak Checker

Speed - Contact Tachometer
Multifunction kit

- Flow/Velocity, Pressure.
- Temperature, Relative Humidity
- Sound
- dB Meter
- Time

Stop watch

Measuring tape



Phase 2 – Discussion with site personnel

To have insight on

- Recent alteration to the size, operating hours or functions of the site –to confirm the reliability of historical energy consumption data
- Specific services & systems that are not functioning properly –to be the target in the walk-through survey
- EE measures implemented before the audit & its progress and results

Phase 2 - Factors to be considered by the energy auditor

CONDITION

- Age, physical condition & remaining service life

SPECIFICATION

- Name plate kW rating, loading & operating hours

DESIGN

- Deficiencies that will contribute to inefficient operation

OPERATION

- Is it functioning according to the design intention?

EFFICIENCY

- Obvious maintenance problems & energy wastes

Phase 2 –Data analysis

- Ideal facilities –equipped with sub-metering : total annual energy consumption to be divided into main services & systems to obtain the breakdown
- Not ideal facilities-to use simple mathematical analysis using the data collected

**(kWh/year = rated kW x % loading
x operating hours/year)**

Phase 2 – Outputs from data analysis

Identifying and Developing Recommendations to Improve Energy Efficiency at the Site:

No-Cost Measures:

Implement operational and maintenance changes, such as turning off unused equipment during identified periods.

Potential Upgrades and Retrofits:

Assess opportunities for retrofitting, replacing, or upgrading inefficient equipment, which will require a detailed study or audit, potentially extending to an IGA.

Phase 2 – Plan of action / Report to Management

The breakdown of energy use & associated cost : in visual form -e.g. Pie charts

A brief update & discussion on installed systems & major equipment & their conditions

Obvious design, operation & maintenance deficiencies that are contributing to energy inefficiencies

A list of energy saving measures identified according to no-cost measures & capital required measures

Order or magnitude energy & cost saving associated with measure & preliminary estimated cost for implementation where possible.

Phase 2 – Type of recommendations at this stage

Should be clearly discuss :-

Energy end uses / Significant Energy Use (SEUs) –priority for energy management programme

EE measure that can be implemented immediately

Workplans for measures requiring further investigation – detailed / investment grade energy audit

Methods & strategies to assign responsibilities for energy management – adopt EnMS requirements!

Training & awareness program & technique to raise awareness on the importance of energy management

Phase 3–Detailed Studies / Assessment / Energy Audit

For measures that require large capital investment with longer pay back period

Data requirements

Energy consumption of system/equipment being assessed further

Detailed capital costs needed for the proposal

Project cost

Projected annual energy & cost savings from the measure

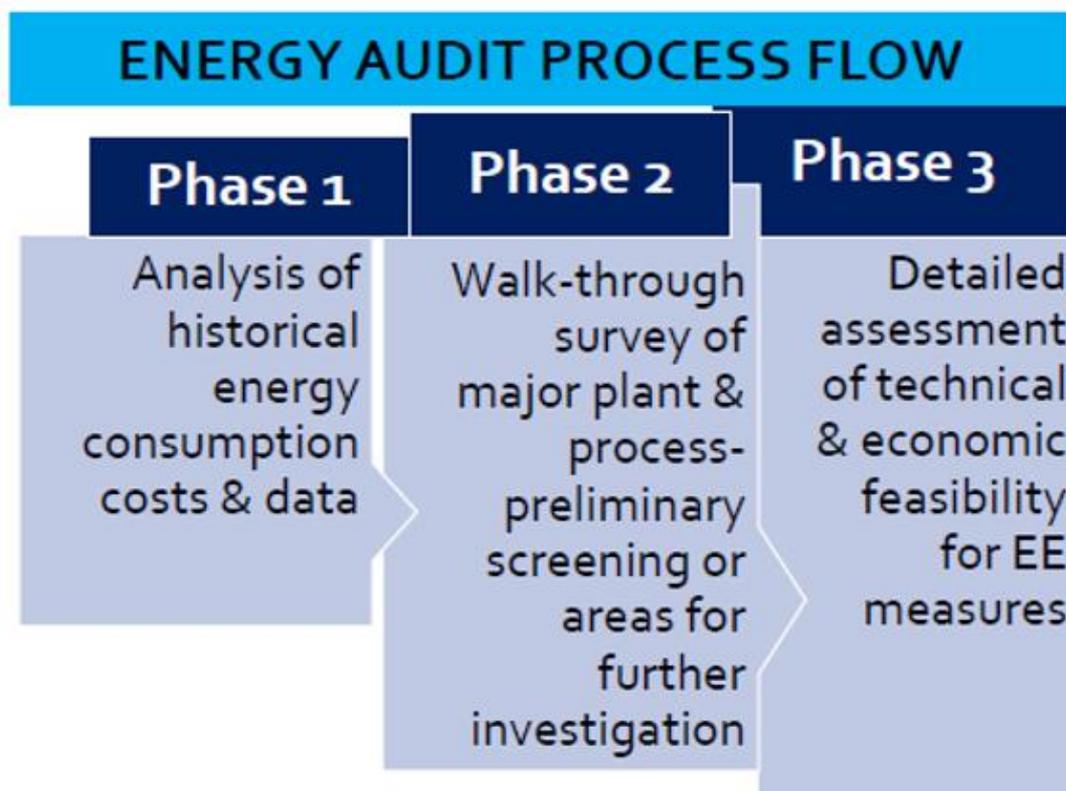
Projected non-energy cost savings resulted from the implementation (maintenance, spare parts, labour & etc)

Exercise

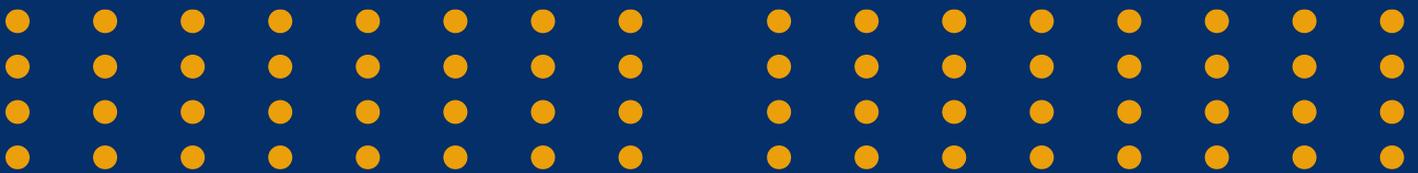
Question

By using suitable diagram, show the audit process flow for energy audit.

Answer



ENERGY AUDIT TOOLS



ENERGY AUDIT EQUIPMENT

Type of Equipment : Electrical Measurement

Equipment	Parameter Measurement	Function	Application
Power logger Meter.	V, I, PF, kW & kWh	- to measure main electrical parameters such as KVA, kW, PF, Hertz, KVAr, Amps and Volts.	Applied on-line to measure various electrical parameters of motors, transformers, and electrical heaters. There is no need to stop the equipment while taking the measurements.
Harmonic Power Meter	V, I, PF & THD	- to measure main electrical parameters including harmonics	There is no need to stop the equipment while taking the measurements.
Data Logger	V, I, PF, kW & kWh, kVar, kVA	- to measure main electrical parameters such as KVA, kW, PF, Hertz, KVAr, Amps and Volts.	Applied on-line to measure various electrical parameters of main supply.
Illuminance Meter	lux	To measure illumination (light) levels.	To measure illumination levels in offices, factories etc.

ENERGY AUDIT EQUIPMENT

Type of Equipment : Electrical Measurement

Power Quality Meter (V, I, PF, kW, KVA, KVA_r, kWh, KVAh, KVA_rh)



Harmonics



Data Logger



Lighting Lux meter: illumination



ENERGY AUDIT EQUIPMENT

Specification of Energy Audit Equipment

Equipment Used	:	Portable multi power meter Measure V, A, W, VA, VAR, Hz, Wh, Cos θ
Brand	:	Elcontrol
Model	:	VIP System 3
Range	:	V = 300mV to 600V A = 0.05 to 1000A
Accessories	:	Memory pack (512K/2643 data) Harmonic pack, Internal printer



Equipment Used	:	Power Meter Measure V, A, W, VAR, VA, Cos θ , Hz
Brand	:	Kyoritsu
Model	:	6300
Range	:	Max. voltage 600V Max. current 500A
Accessory	:	Internal memory Compact Flash Memory USB interface software



ENERGY AUDIT EQUIPMENT

Specification of Energy Audit Equipment

Equipment : Portable illuminance meter
Used : Measure Lux of the lamp
Brand : Testo
Model : 545
Range : 0 to 100,000 Lux
Sensor : Silicon Photodiode



Equipment : AC Power Meter
Used : Measure KW, V, I & PF
Brand : El-control
Model : NanoVIP
Range : Max 600V
Max 200A



ENERGY AUDIT EQUIPMENT

Basic Equipment for Measurement and Monitoring

Equipment	How it look	Function	Application
Electrical Measuring Instruments		<p>to measure main electrical parameters.</p> <p>Parameters such as KVA, kW, PF, Hertz, KVAr , Amps and Volts.</p>	<p>Applied on line to measure various electrical parameters of motors, transformers, and electrical heaters. There is no need to stop the equipment while taking the measurements.</p>
Combustion Analyzers		<p>To measure the composition of the flue gases after combustion has taken place.</p> <p>Parameter O₂, CO, CO₂</p>	<p>To determine the composition of the flue gases in the duct in order to assess the combustion conditions and efficiency and leakages of atmospheric air into the system.</p>

ENERGY AUDIT EQUIPMENT

Basic Equipment for Measurement and Monitoring

Equipment	How it look	Function	Application
Leak Detector		Detect the ultrasonic sound of a leak	To detect leaks of compressed air and other gases which are normally not possible to detect with the human ear.
Lux Meters		To measure illumination (light) levels.	To measure illumination levels in offices, factories etc.

ENERGY AUDIT EQUIPMENT

Type of Equipment : Thermal Measurement

Equipment	Parameter Measurement	Function	Application
Infrared Camera	°C		
Combustion Analyzer	°C, O ² , CO, SOX	To measure the composition of the flue gases after combustion has taken place. Parameter O ₂ , CO, CO ₂	To determine the composition of the flue gases in the duct in order to assess the combustion conditions and efficiency and leakages of atmospheric air into the system.
Multi-channel Data Logger	V, I, °C		
Pressure Meter	Barg, psi		
Strabo-Tacho Meter	rpm	Speed measurement instruments	Used to measure the speed of rotation of motors, fans, pulleys etc.
Hygro Meter	°C & %		
Infrared Pyrometer	°C		
Leak Detector		Detect the ultrasonic sound of a leak	To detect leaks of compressed air and other gases which are normally not possible to detect with the human ear.

ENERGY AUDIT EQUIPMENT

Instruments

Chemical

Dräger: CO₂ level from flue gas



Fyrite kit: percentage of CO₂ and O₂ from flue gas



ENERGY AUDIT EQUIPMENT

Instruments

Mechanical

Flow	
Anemometer : Air Velocity	 A green handheld anemometer with a circular fan at the top and a digital display showing '28.9' and '74.8'.
Ultrasonic Flowmeter	 A person's hands holding a white ultrasonic flowmeter device with a digital display showing '0.000' and several buttons.
Pilot tube : gas flow rate	 A blue pilot tube with a long, thin metal probe and a digital display at the end.
Smoke pellet : Small air velocity room	 A collection of red and white smoke pellets, including a large container labeled 'ROTHENBERGER' and several individual pellets.

ENERGY AUDIT EQUIPMENT

Instruments

Mechanical

Pressure

Manometer : absolute pressure



Barometer : atmosphere pressure



Gauge : pressure differential



Transducers : for remote application



ENERGY AUDIT EQUIPMENT

Instruments

Mechanical

Speed: tachometer



Steam trap testing :
stethoscope, electronic tester



Leaks: ultrasonic leak checker



ENERGY AUDIT EQUIPMENT

Instruments

Humidity

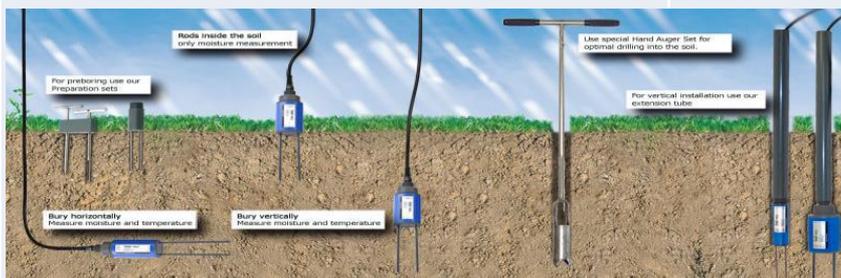
Psychrometer (Dry Bulb & Wet Bulb thermometer)



Dew point hygrometer



Electrical conductivity humidity meter



ENERGY AUDIT EQUIPMENT

Instruments

Temperature

Digital Temperature & Humidity Meter



T & H Data logger



Glass steam thermometer (mercury or alcohol): 20 500 C

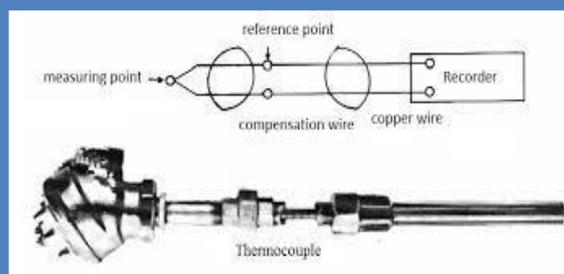


ENERGY AUDIT EQUIPMENT

Instruments

Temperature

Thermocouple transducer:
surface, material, air and gas:
270 to
1820 C



Resistance thermometer
(platinum, nickel,
thermistor): 150 to
1000 C



Optical pyrometer: > 750 C



ENERGY AUDIT EQUIPMENT

SPECIFICATION OF ENERGY AUDIT EQUIPMENT

Equipment	: Portable Infrared camera
Used	: Measure temperature in long distance
Brand	: FLIR SYSTEM
Model	: ThermaCAM PM 675
Temp range	: Up to 1000°C (+1832°F), optional
Focus distance	: 24° x 18°/0.5m
Thermal Sensitivity	: <0.1°C @ 30°C (0.18°F @ 86°)
Accuracy	: ± 2% of reading or ± 2°C (± 3.6°F)



Equipment	: Portable electronic combustion analyzer
Used	: Measure CO, CO ₂ , O ₂ , NO, NO ₂ , SO ₂ & OC
Brand	: Testo
Model	: 350
Measurement Range:	
Temperature	: -40 to +1200°C
Pressure	: ± 50 hPa
O ₂	: 0 to 21 vol%
CO ₂ (calculation):	: 0 to CO ₂ max
CO with H ₂	: 0 to 10000 ppm
CO w/o H ₂	: 0 to 20000 ppm
NO	: 0 to 3000 ppm
NO ₂	: 0 to 500 ppm
SO ₂	: 0 to 5000 ppm



ENERGY AUDIT EQUIPMENT

SPECIFICATION OF ENERGY AUDIT EQUIPMENT

Equipment Used	:	Portable ultrasonic steam trap tester
	:	Accurate leak detection and mechanical inspection through advanced ultrasonic technology.
Brand	:	U.E
Model	:	UP 100KT
Frequency Response	:	20-100Kz (Centered at 28-42kHz)



Equipment Used	:	Portable infrared pyrometer
	:	Measure temperature in °C and °F
Brand	:	Testo
Model	:	860 T2
Temp Range	:	-30 to 900°C (-25to1600°F)
Accuracy	:	+ 2K or + 0.75%
Storage Temp	:	-20 to 50°C (-25 to 122°F)
Optional Resolution	:	60:1



ENERGY AUDIT EQUIPMENT

SPECIFICATION OF ENERGY AUDIT EQUIPMENT

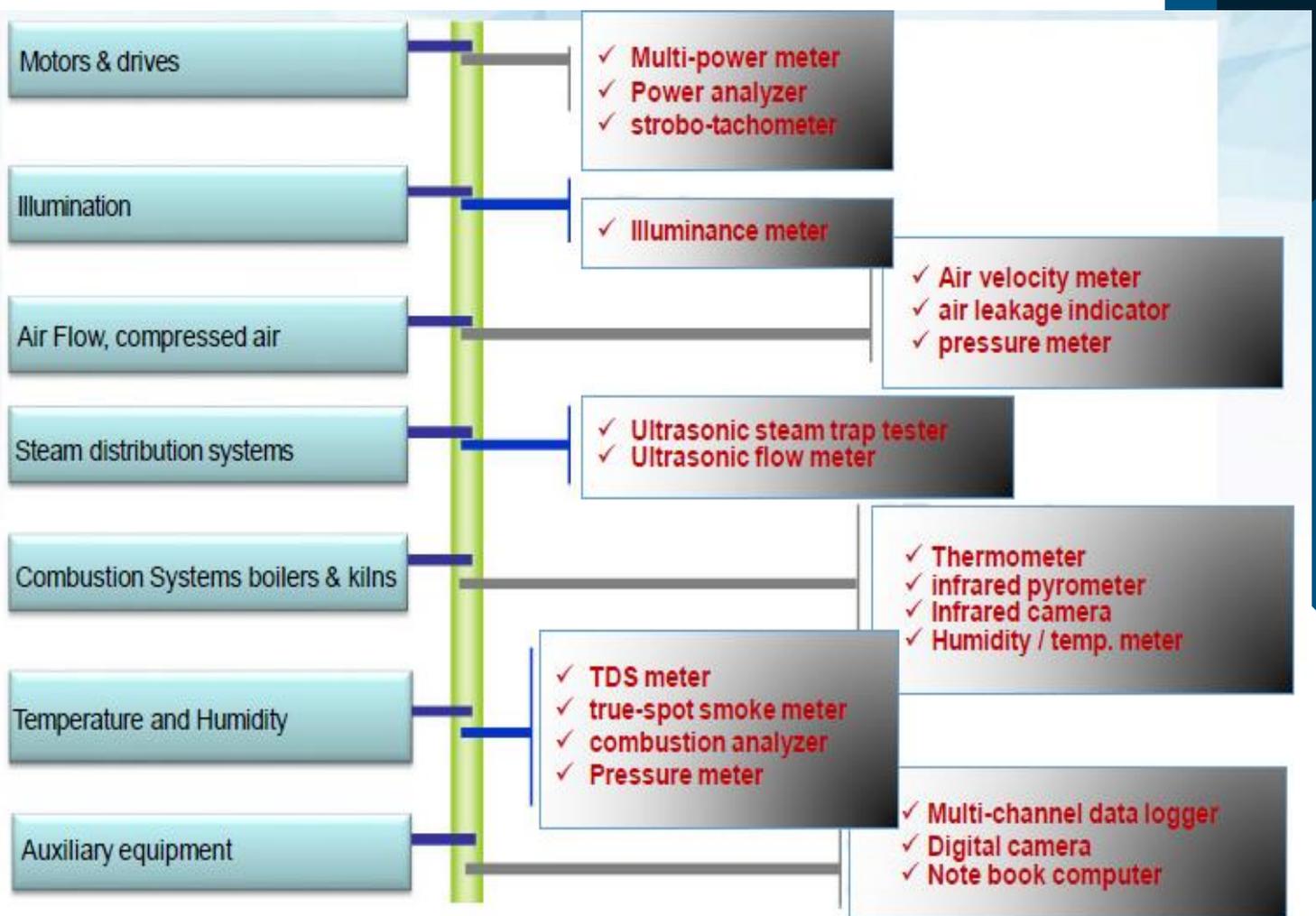
Equipment	:	Portable air velocity meter
Used	:	Measure temperature and velocity.
Brand	:	Testo
Model	:	435
Range Air	:	0 to 20m/s
Velocity	:	
Range Air	:	- 20 to + 70 ⁰ C
Temperature	:	



Equipment	:	Portable temperature meter
Used	:	Measure temperature, & fine K factor
Brand	:	Testo
Model	:	950
Max measured	:	-200...+1100 ⁰ C
value	:	-2...+600 ⁰ C
(Surface)	:	
Probe	:	Thermocouple K
	:	Surface thermometer



SUMMARY OF ENERGY AUDIT EQUIPMENT



Exercise

Question

State the function of Data Logger, Lux Meter and Harmonic Power Meter.

Answer

Data Logger

To measure main electrical parameter such as KVA, kW, PF, Hertz, KVAR, Amps and Volts.

Lux Meter

To measure illumination (light) levels.

Harmonic Power Meter

To measure main electrical parameters including harmonic

DETAILED ENERGY AUDIT PROCESS



Steps In Detailed Energy Audit Process

1. Define Audit Scope

- a) Type of audit
- b) Boundary
- c) Task involved
- d) Timeframe
- e) Expected Output



Steps In Detailed Energy Audit Process

2. Understand processes and requirement

- a) Obtain Site Drawings: Acquire available site drawings, including building layout, steam distribution, compressed air distribution, electricity distribution, and other relevant diagrams.
- b) Assess Processes: Evaluate the processes and requirements necessary to maintain production output and services.
- c) Discuss with Senior Management: Engage with senior management to define the objectives of the energy audit and establish financial guidelines for implementing the audit's recommendations.

Steps In Detailed Energy Audit Process

2. Understand processes and requirement

- d) Analyze Energy Consumption Data: Collaborate with relevant personnel to analyze major energy consumption data.
- e) Conduct Site Investigation: Perform a site investigation in conjunction with facilities, engineering, and production personnel.



Steps In Detailed Energy Audit Process

3. Obtain data on energy input and output

- a) Desktop Data Collection: Gather available documentation such as process flow diagrams, historical energy bills, lighting layouts, air conditioning system drawings, design manuals, load control systems (including timers), and any automation systems.
- b) Field Data Collection:
Complete Missing Data: Address any gaps in information not obtained during the desktop data collection.

Verify Accuracy: Confirm the accuracy of the data collected through desktop research.

Steps In Detailed Energy Audit Process

3. Obtain data on energy input and output

b) Field Data Collection:

Observe Building Operations: Examine building operations to identify energy waste and assess the maintenance status.

Conduct Load Profiling: Perform load profiling and apportioning.

Take Field Measurements: Execute necessary field measurements as required.

c) Cross-Checking Load Demand Data:

Verify Load Estimates: Compare the end-use loads estimated from equipment data surveys (first method) with those estimated through logging (second method) to ensure the accuracy of the assumptions.

Steps In Detailed Energy Audit Process

4. Identify energy balance data and information

Energy Supply and Consumption Data: Gather data on energy supply and consumption.

Apportion Energy Consumption: Allocate energy consumption by categories similar to SEUs (Significant Energy Uses) identification.

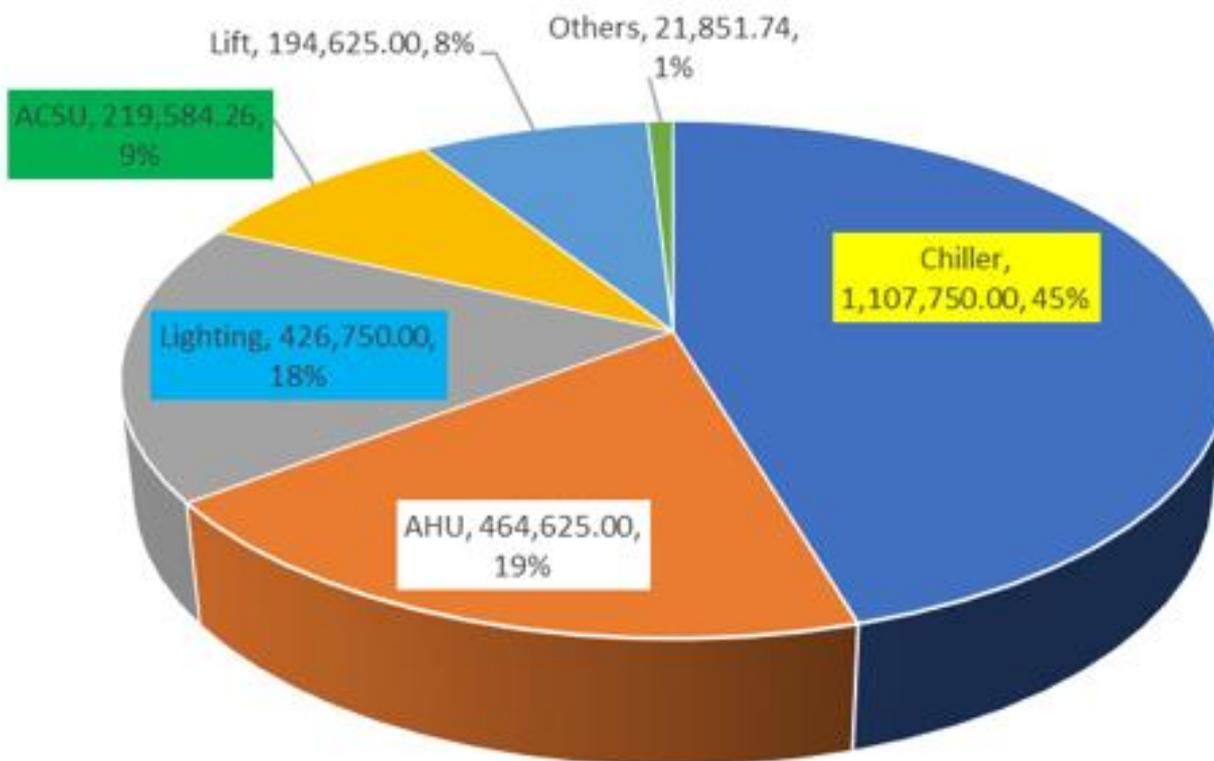
Type of Energy: Include various types of energy such as fuel and electricity.

Equipment/System: Consider different equipment and systems, including production machinery, motors, air conditioning units, lighting, and others.

Applications: Break down energy use by applications such as production facilities, office spaces, and tenant areas.

Steps In Detailed Energy Audit Process

5. Establish loads distribution from measurements

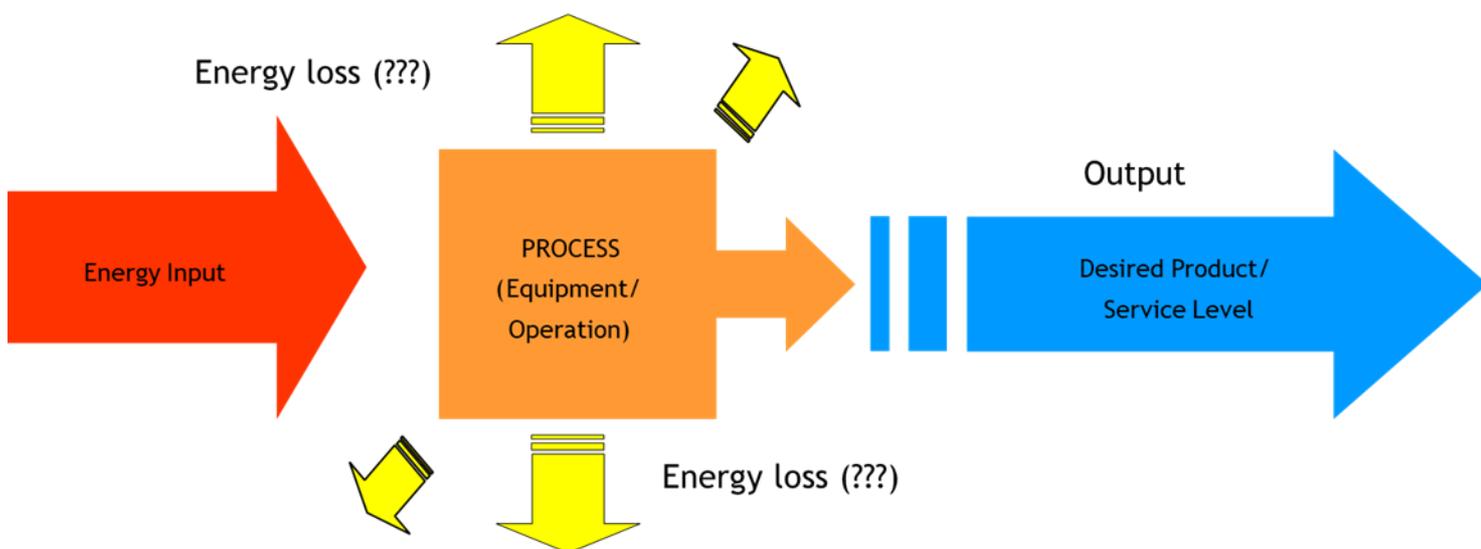


Steps In Detailed Energy Audit Process

6. Analyse Energy Balance and Energy Performance Data

Energy and Material Balance: Evaluate the balance of energy and materials, and conduct an analysis of energy loss and waste.

Identify Energy Waste: Determine areas where energy is being wasted or has the potential to be wasted.



Steps In Detailed Energy Audit Process

7. Identify Energy Saving Measures (ESMs)

Energy Saving Measures (ESMs) were identified through evaluation of site survey data and analysis of monitoring data. A description of each ESM is included in the "Rationale" section before its energy savings calculations. The ESM description is intended as a general description only. It is not to be assumed that the ESM description includes all details of work necessary for implementation. The ESMs should be evaluated to determine if a complete mechanical/electrical design should be prepared prior to their implementation.

Conceptual ideas, develop and refine measures

Review existing/previous ideas – brainstorming and value analysis

Communication with manufacturers/technology experts for more efficient technologies solutions

Steps In Detailed Energy Audit Process

7. Identify Energy Saving Measures (ESMs)

ESMs:

- a) Must be quantified.
- b) Should be measurable using proposed M&V methods.
- c) Essential for prioritizing measures for implementation.
- d) Can inform energy consumption and operational cost forecasts.

Prepare A List of ESMs

- a) Develop a list of all potential ideas.
- b) Select and prioritize items for implementation.
- c) Plan and manage their implementation.



Steps In Detailed Energy Audit Process

7. Identify Energy Saving Measures (ESMs)

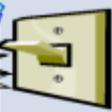
ESMs from System Optimization :

- a) Evaluate the entire system, not just individual components.
- b) Establish user requirements and specifications.
- c) Explore opportunities in usage.
- d) Explore opportunities in distribution.
- e) Explore opportunities in generation (consider last).



Steps In Detailed Energy Audit Process

7. Identify Energy Saving Measures (ESMs)

Measures	Example
 <ul style="list-style-type: none"> • No cost 	<ul style="list-style-type: none"> • Fine-tuning of building services • User awareness • Repair leaks • Reschedule load/usage • Saving potential 3~10%
 <ul style="list-style-type: none"> • Low cost 	<ul style="list-style-type: none"> • Cooling system improvement • Lighting system and technology improvement • Building envelope • Insulation • Monitoring & Targeting • Housekeeping • Saving potential 6~10%
 <ul style="list-style-type: none"> • High cost 	<ul style="list-style-type: none"> • Equipment technology change • System change • Cogeneration • Fuel conversion • Saving potential 10~15%

Saving Ideas

Internal initiatives (SEM)

Internal or with ESCO



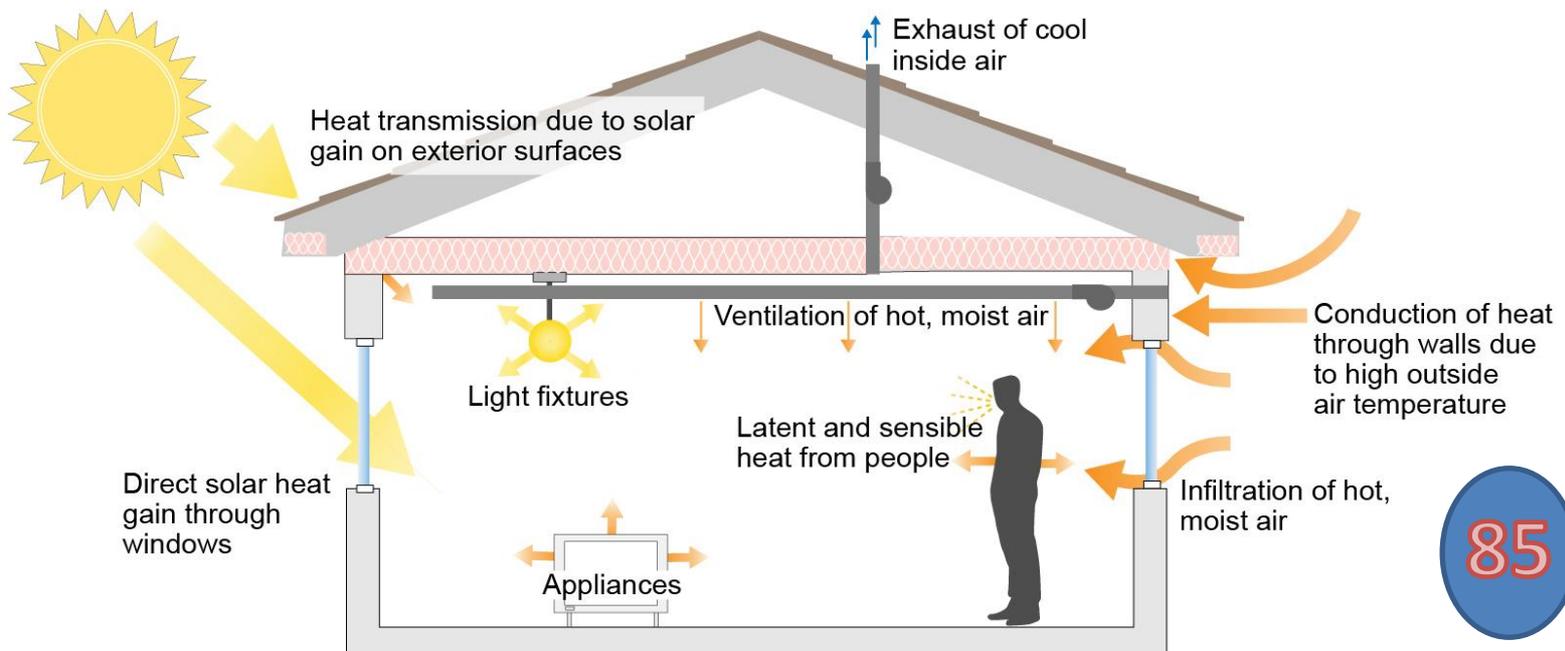
Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential ESM from Efficient Cooling:

Reducing Heat Gains:

- Conduct periodic inspections of air conditioning systems.
- What are the control set point temperatures?
- Where are the sensors located?
- What is the control strategy?
- Are there manual overrides?
- Are windows open?
- Is the heating on simultaneously?
- How are the occupants dressed?



Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential ESM from Efficient Cooling:

Operation of Centralized Chiller System/Air Conditioning Unit

- a) Is the system running when not needed?
- b) Is the system operating excessively?
- c) Is the system frequently cycling on and off?
- d) Is there a mismatch between cooling requirements and the cooling system's performance?



Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential ESM from Efficient Cooling:

Maintenance Review Checklist

- a) Blocked Pipes/Ducts
Inspect and clear any obstructions in pipes and ducts to ensure proper flow and prevent potential issues.
- b) Insulation
Check the condition of insulation throughout the system or building. Ensure it is intact and effectively maintaining energy efficiency.



Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential ESM from Motors

Motor and Drive System Efficiency



- a) **Oversized Motors:**
Large motors can be inefficient and may consume more energy than necessary. Ensure motors are appropriately sized for their applications.
- b) **Belt-Driven Motors:**
For motors connected to fans or pumps via belt drives, regularly inspect the belts for signs of wear or inadequate tension.
- c) **Drive Component Misalignment:**
Check for misalignment between drive components, as misalignment can lead to increased wear and inefficiency.

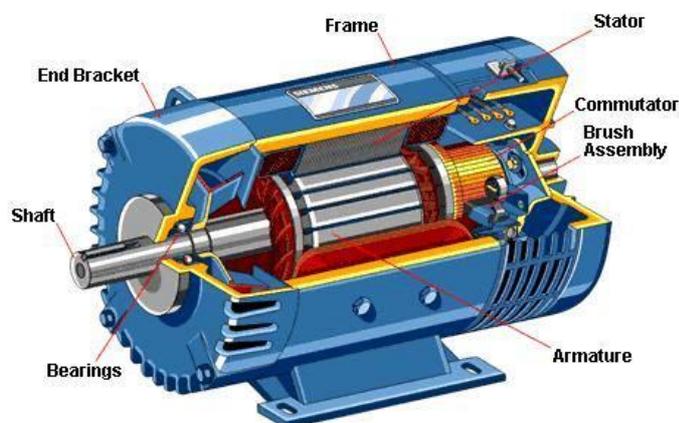
Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential ESM from Motors

Overloaded Motor – Overheating

- a) Thermal imaging can detect:
 - Overheating
 - Electrical problems, such as poor cable connections
- b) Alternating current (AC) motors can be:
 - Retrofitted with Variable Speed Drives (VSDs)
 - Replaced with high-efficiency motor models



Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential ESM from Motors

Options for High-Efficiency Motors

- a) Efficiency Classification:
 - IE1 (Standard Efficiency)
 - IE2 (High Efficiency)
 - IE3 (Premium Efficiency)
 - IE4 (Super Premium Efficiency)
- b) Operational Controllers:
 - Variable Speed Drives (VSDs): Adjust motor speed and torque to match the load requirements, improving energy efficiency and performance.
 - Soft Starters: Reduce the inrush current during motor start-up, which can minimize wear and improve overall efficiency.
 - Programmable Logic Controllers (PLCs): Automate and optimize motor operation by integrating with system controls for better efficiency.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Energy Saving Measures (ESMs) from Variable Speed Drives (VSDs) Applications

a) Variable Speed Drives for Pumps and Fans:

Control the Speed of AC Motors: Adjust the motor speed to match the actual demand, improving efficiency.

Control the Motor Shaft Load for Variable Loads: Optimize performance by matching motor output to varying load requirements.

Allow Variable Flow Control: Avoid energy losses associated with traditional control valves and dampers by regulating flow more precisely.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Energy Saving Measures (ESMs) from Variable Speed Drives (VSDs) Applications

b) Soft Start of AC Motors:

Reduce Start-Up Costs: Minimize inrush current and mechanical stress during motor start-up, which can extend equipment life and reduce energy consumption.

b) Running Cost Reduction:

Efficient Operation for Pumps and Fans: VSDs can significantly lower running costs when the required flow is less than the design capacity, optimizing energy use.



Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from Ventilation Systems



Things to Look For:

a) Cleanliness:

Ensure that the system components (filters, ducts, etc.) are clean and well-maintained to deliver the same quantity of air efficiently.

b) Heat Recovery Potential:

Assess whether the system can be retrofitted or upgraded with heat recovery components to reclaim and reuse energy from exhaust air.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from Ventilation Systems

Things to Look For:

- c) Night Purging and Free Cooling:
Explore the potential for using the ventilation system for night purging or free cooling to reduce the need for mechanical cooling during cooler periods.
- d) Natural vs. Mechanical Ventilation:
Determine if natural ventilation is utilized and evaluate whether it operates simultaneously with mechanical ventilation. This can help optimize energy use and reduce redundant operation.



Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from Energy-Efficient Lighting

Items to Consider to Achieve Cost Reduction:



a) Types of Lamps:

T5 Fluorescent Lamps: Utilize advanced technology to offer higher efficiency and longer life compared to older fluorescent types.

LED Technologies: Provide significant energy savings, longer lifespan, and lower maintenance costs compared to traditional incandescent and fluorescent lamps.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from Energy-Efficient Lighting

Items to Consider to Achieve Cost Reduction:



- b) Ballasts:
Low Loss Types: Install high-efficiency ballasts that minimize energy losses and improve the overall performance of fluorescent lighting systems.
- c) Luminaires:
Energy-Efficient Design: Choose luminaires that are designed for optimal light distribution and efficiency. Look for fixtures that maximize light output while minimizing energy consumption.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from the Use of Sensors

Common Types:

- a) Temperature Sensors:
Monitor and control heating, ventilation, and air conditioning (HVAC) systems to maintain optimal temperature and reduce energy consumption.
- b) Humidity Sensors:
Regulate moisture levels to enhance comfort and energy efficiency in HVAC systems, preventing overuse of dehumidifiers or humidifiers.
- c) Carbon Dioxide (CO₂) Sensors:
Manage ventilation rates based on occupancy levels, ensuring adequate air quality while avoiding excessive energy use.



Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from the Use of Sensors

Common Types:



- d) **Movement Sensors:**
Control lighting and HVAC systems based on occupancy, turning off or adjusting systems when spaces are unoccupied to save energy.



- e) **Daylight Sensors:**
Adjust artificial lighting levels based on the amount of natural light available, reducing the need for electric lighting and saving energy.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from the Use of Sensors

Considerations for Effective Use:



- a) Location:
Position sensors to provide accurate and representative readings for the space or area, ensuring they effectively monitor the intended conditions.



- b) Periodic Checks and Calibration:
Regularly inspect and calibrate sensors to ensure they provide reliable data and maintain accurate performance over time.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from Adopting a Computerized Energy Management System (CEMS)

Capabilities Beyond Basic Control:

a) Data Logging:



Sensor Data: Continuously log data from various sensors (temperature, humidity, CO₂, etc.) for in-depth analysis.

Control Outputs: Track the performance and settings of controlled systems to ensure they operate efficiently.

Alarms and Energy Usage: Record alarms and metered energy usage to identify inefficiencies and areas for improvement.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from Adopting a Computerized Energy Management System (CEMS)

Capabilities Beyond Basic Control:

- b) Automated Data Collection:
Web-Based Interfaces: Utilize increasingly common web-based interfaces for real-time access to data, remote monitoring, and control.
- c) Control and Configuration:
Parameter Adjustment: Allow operators to easily alter control parameters to optimize system performance.
Log Setup and Data Retrieval: Facilitate the setup of data logs and retrieval of historical data for analysis and reporting.

Steps In Detailed Energy Audit Process

8. Identify Energy Saving Potentials

Potential Energy Saving Measures (ESMs) from Adopting a Computerized Energy Management System (CEMS)

Capabilities Beyond Basic Control:

- d) Monitoring and Efficient Operations & Maintenance (O&M): Enhanced Monitoring: Provide comprehensive monitoring capabilities to track system performance and energy consumption.
- e) Ongoing Efficiency: Use data insights to continuously improve operational practices and maintenance strategies, leading to sustained energy savings.

Steps In Detailed Energy Audit Process

Examples of Energy Saving Measures (ESMs)

1. Establish an Energy Management System (EMS): Implement an EMS to systematically monitor, control, and reduce energy consumption across facilities. This includes data logging, performance analysis, and optimizing energy use.
2. Reduce Air Conditioning Operating Hours:
Decrease the daily operating hours of the air conditioning system by 1 hour during lunchtime to save energy while maintaining comfort.

Steps In Detailed Energy Audit Process

Examples of Energy Saving Measures (ESMs)

3. De-lamping of Fluorescent Lights:
Remove one tube from triple-tube fluorescent lamps to reduce lighting energy consumption without significantly impacting illumination levels.
4. Replacement of Modulating Valve for Air Handling Unit (AHU):
Upgrade to a new, more efficient modulating valve for the AHU to improve system performance and reduce energy usage.
5. Upgrade Lighting to LED:
Replace 4" T5 fluorescent light tubes with T8 LED 18W tubes to lower energy consumption and extend the lifespan of lighting fixtures.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Financial analysis is the process of evaluating the financial health and performance of a business, project, or investment by analyzing financial data and metrics. It involves the examination of financial statements, cash flow, profitability, and other key financial indicators to make informed decisions, assess risks, and determine the overall value or viability of an investment or operational decision.

Item for Investment	Operating Cost/year	Saving/year (in energy or other unit)	Saving/year (RM)
Equipment Instrumentation Civil works & others	Purchasing cost Maintenance & repairs Labour Energy Depreciation	Electrical energy Thermal energy Others (disposal, labour and etc.)	

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Key Aspects of Financial Analysis:

- a) **Objective Evaluation:**
To objectively assess the financial performance and stability of an entity or project, providing insights into its efficiency, profitability, and liquidity. Includes evaluating past performance, current financial status, and future projections.
- b) **Financial Metrics and Ratios:**
Profitability Ratios: Measures such as Return on Investment (ROI), Net Profit Margin, and Gross Profit Margin that evaluate the ability to generate profit relative to sales, assets, or equity.
Solvency Ratios: Measures such as Current Ratio and Quick Ratio that assess the ability to meet short-term obligations.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Key Aspects of Financial Analysis:

b) Financial Metrics and Ratios:

Solvency Ratios: Measures like Debt-to-Equity Ratio and Interest Coverage Ratio that analyze long-term stability and debt management.

Efficiency Ratios: Metrics such as Inventory Turnover and Accounts Receivable Turnover that evaluate operational efficiency.

c) Cost-Benefit Analysis:

Evaluation of Costs: Identifying and analyzing all costs associated with an investment or project, including initial costs, operational costs, and maintenance costs.

Evaluation of Benefits: Estimating the expected financial returns or savings resulting from the investment or project.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Key Aspects of Financial Analysis:

d) Investment Appraisal:

Simple Payback Period (**SPP**) : The duration it takes for the cumulative cash inflows or savings from an investment to equal the initial investment amount.

Net Present Value (**NPV**): The difference between the present value of cash inflows and outflows over the project's lifecycle, discounted at a specific rate.

Internal Rate of Return (**IRR**): The discount rate that makes the NPV of an investment equal to zero, indicating the expected rate of return.

Life Cycle Costing (**LCC**): Analyzing the total cost of ownership over the ESM's entire lifecycle, including initial costs, operational costs, maintenance, and disposal.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Key Aspects of Financial Analysis:

e) Risk Assessment:

Identification of Risks: Analyzing potential risks that could affect financial performance, such as market fluctuations, operational issues, or regulatory changes.

Mitigation Strategies: Developing strategies to manage or mitigate identified risks.

f) Financial Projections:

Forecasting: Predicting future financial performance based on historical data, market trends, and planned strategies.

Scenario Analysis: Evaluating different scenarios and their potential impact on financial outcomes.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Purpose of Financial Analysis:

- a) **Decision Making:** Provides insights for making informed decisions regarding investments, budgeting, and strategic planning.
- b) **Performance Measurement:** Assesses how well a business or project is performing in terms of profitability, efficiency, and financial stability.
- b) **Risk Management:** Identifies potential financial risks and helps develop strategies to mitigate them.
- c) **Value Assessment:** Determines the value or viability of investments or projects, guiding resource allocation and strategic initiatives.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Low-no cost measures

Simple Payback
Period
(SPP)

Return On
Investment
(ROI)

High cost measures
With time factor

Net Present Value
(NPV)

Internal Rate of
Return
(IRR)

Recommended with the
Life Cycle Cost Analysis

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Life Cycle Cost Analysis (LCCA)

To assess the total cost of ownership of an EE measure over its entire lifespan, including initial and ongoing costs.

Steps:

Initial Costs: Include purchase, installation, and any upfront expenses.

Operating Costs: Account for energy consumption, maintenance, and repair costs.

Disposal Costs: Consider costs associated with decommissioning or disposing of the equipment.

Discount Future Costs: Use a discount rate to calculate the present value of future costs and savings.

Formula:

$LCC = \text{Initial Costs} + \text{Present Value of Operating Costs} + \text{Present Value of Disposal Costs} - \text{Present Value of Savings}$

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Simple Payback Period (SPP) formula:

$$\text{Simple Payback Period} = \frac{\text{Initial Investment}}{\text{Annual Cash Inflows or Savings}}$$

Where:

Initial Investment: The total amount of money spent on the investment.

Annual Cash Inflows or Savings: The annual amount of money saved or earned due to the investment.

Example Calculation:

If a company invests RM 10,000 in a new piece of equipment that is expected to save RM 2,500 per year in operating costs, the Simple Payback Period would be calculated as follows:

$$\text{Simple Payback Period} = \frac{10,000}{2,500} = 4 \text{ years}$$

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Interpretation:

Shorter Payback Period: Indicates a quicker recovery of the investment, which can be advantageous for investments with high uncertainty or for businesses needing quicker returns.

Longer Payback Period: Suggests a longer time to recover the investment, which might be acceptable for investments with longer-term benefits or for projects with higher overall returns.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Net Present Value (NPV)

To assess the profitability of an EE measure by calculating the difference between the present value of cash inflows (savings) and outflows (costs).

Steps:

Estimate Cash Flows: Forecast annual savings and costs over the expected lifespan of the measure.

Discount Cash Flows: Use an appropriate discount rate to calculate the present value of future cash flows.

Calculate NPV: Subtract the initial investment from the present value of cash inflows.

Formula:

$$NPV = \sum \frac{C_t}{(1+r)^t} - \text{Initial Investment}$$

Where C_t = Cash flow at time t , r = Discount rate, t = Time period.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Internal Rate of Return (IRR)

To find the discount rate at which the NPV of the EE measure equals zero, indicating the rate of return.

Steps:

Calculate IRR: Determine the discount rate that makes the NPV of cash flows equal to zero. This is typically done using financial software or iterative methods.

Formula:

IRR is the rate r where:

$$\text{NPV} = \sum \frac{C_t}{(1+r)^t} - \text{Initial Investment} = 0$$

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Example of Simple Payback Period (SPP)
Calculation for Energy Saving Measures (ESMs)

ESM 5 Replacement of 4" T5 Fluorescent Light Tube to T8 LED 18W

Tariff Rate	0.365	RM/kWh
MD	-	RM/kW
CO2 reduction	0.00078	Ton /kWh
Estimated Savings	7.0%	
Total Energy consumption	2,435,186	kWh/y

No	Item	Amount
1	Annual Energy Consumption (kWh/year)	2,435,186
2	Annual Energy Cost (RM/year)	888,842.89
3	Annual Energy Saving (kWh/year)	170,463.02
4	Annual Energy Cost saving (RM/year)	62,219.00
5	CO2 saving (tonCO2/year)	132.96
6	Investment (RM) = RM 13 per each bulb * 3791 bulb	49,283.00
7	Payback Period (year)	0.79

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Confirm Feasibility & Viability

Technical Feasibility: When assessing the technical feasibility of an Energy Saving Measure (ESM), consider the following factors:

- a) **Technology Availability:** Ensure that the required technology is available and can be sourced within the project's timeframe and budget.
- b) **Space and Infrastructure:** Verify that there is adequate space and suitable infrastructure to accommodate the new technology or modification.
- c) **Skilled Manpower:** Confirm the availability of skilled personnel needed for the installation, operation, and maintenance of the technology.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Confirm Feasibility & Viability

Technical Feasibility: When assessing the technical feasibility of an Energy Saving Measure (ESM), consider the following factors:

- d) Reliability and Service: Evaluate the reliability of the technology and the availability of service and support to address any potential issues.
- e) Impact on Safety, Quality, and Production: Assess how the ESM will affect safety, product quality, production processes, and overall operational efficiency.
- f) Maintenance Requirements and Spare Parts: Determine the maintenance needs of the technology and ensure that spare parts and support services are readily available.

Steps In Detailed Energy Audit Process

9. Conduct Financial Analysis

Confirm Feasibility & Viability

Feasibility and Viability Analysis:

Analyze and confirm the feasibility and viability of each ESM from both technical and financial perspectives:

- a) **Technical Feasibility:** Review the factors outlined above to ensure that the ESM can be implemented successfully and will perform as expected.
- b) **Financial Viability:** Conduct a financial analysis, including calculating the Simple Payback Period (SPP), Net Present Value (NPV), Internal Rate of Return (IRR), and Life Cycle Cost (LCC), to confirm the economic benefits and ensure that the investment is sound.

Tutorial



Question

Among the Energy Savings Measures (ESMs) suggested by the energy auditor is the replacement of 4" T5 fluorescent light tubes with T8 LED 18W bulbs. If the estimated savings are 3%, the tariff rate for commercial buildings is RM 0.365 per kWh, and the total energy consumption is 2,365,859 kWh per year, calculate the Simple Payback Period (SPP) for this ESM. Consider that 3,568 bulbs need to be replaced, with each bulb costing RM 13.

Answer

$$SPP = \frac{\text{Annual Energy Cost Saving (RM/year)}}{\text{Investment (RM)}}$$

Annual Energy Saving = Total Energy Consumption x Estimated Saving

$$= 2,365,859 \times 3\%$$

$$= 70,975.77$$

Annual Energy Cost Saving = Annual Energy Saving x Tariff Rate

$$= 70,975.77 \times 0.365$$

$$= 25,906.16 \text{ (RM/year)}$$

Investment (RM) = Cost for each bulb * Total bulb need to replace

$$= 13 \times 3568$$

$$= \text{RM } 46,384.00$$

$$SPP = \frac{25,906.16 \text{ (RM/year)}}{46,384.00 \text{ (RM)}}$$

$$SPP = 1.79 \text{ year}$$

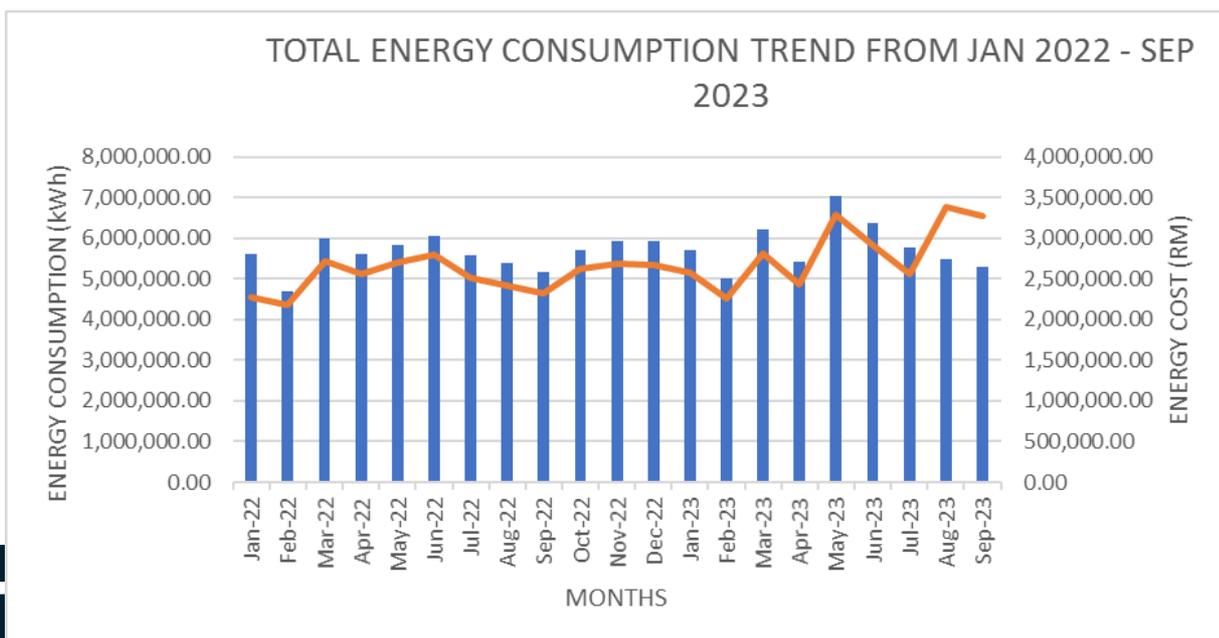
ENERGY AUDIT REPORT



Energy Audit Report



After completing the energy audit, the energy manager or auditor should present the findings to top management to ensure effective communication and implementation of recommendations. The report should be formatted in a way that is engaging and accessible for management, highlighting key insights and actionable steps clearly and concisely.



Example of Detailed Energy Audit (DEA) Report Format

Executive Summary	Objectives, scope, type or audit and summary of energy saving recommendations
Management of Energy	<p>Policy and targets</p> <p>Energy data, documentation & monitoring</p> <p>Compliance towards the regulations</p> <p>Energy management team Energy audit team</p>
Plant / Building Services Description	<p>Brief description for production process- manufacturing/services- buildings</p> <p>Process flow diagram and major components of operation</p>

Example of Detailed Energy Audit (DEA) Report Format



<p>Energy Supply Information</p>	<p>Total electricity supplied and trends</p> <p>Sources and types of energy supply</p> <p>Costs of energy supply (price, tariff).</p>
<p>Utility System Description</p>	<p>Brief description of each major energy using system & equipment</p> <p>Current energy performance/energy efficiency status (energy intensity) for plant, processes and major energy using equipment</p>

Example of Detailed Energy Audit (DEA) Report Format



Energy Consumption Information

Load profile data, charts & observations

Estimated/measures annual energy consumption in energy unit (electricity/fuel) & the percentage (%) of load distribution such HVAC, production machinery, lighting & etc;

Operating hours of the plant/building facilities & major energy using system/equipment

Example of Detailed Energy Audit (DEA) Report Format



Energy Supply and Consumption Analyses

Conclusions from supply and consumption profiles and trends from energy bills & measurements

Suitability of energy supply types & tariff/prices

Current energy performance status (energy intensity) for plant, processes and major energy using equipment

Example of Detailed Energy Audit (DEA) Report Format



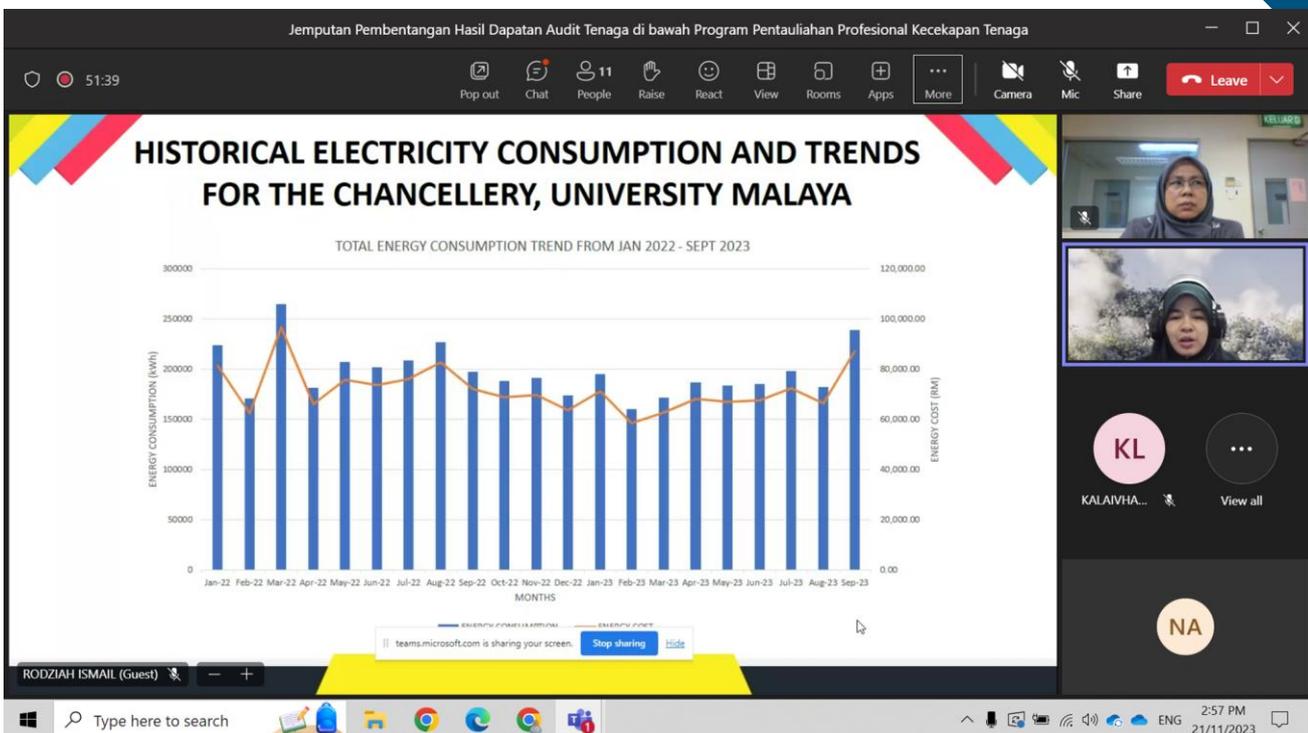
Energy Saving Measurement and Verification	Baselines data to be used to measure results Measurements & calculation methods Verification methods
Others	Appendices: Technical specifications Relevant photos on findings/observations from the site investigations References: Standards, benchmarks/guidelines/protocols referred

Present Findings

Present the findings and persuade management to implement the recommended measures.

Highlight key data that management team members need to make informed decisions.

Ensure that the findings from the energy audit are useful and actionable.



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