RMK-12 ENERGY AUDIT CONDITIONAL GRANT (EACG)

ENERGY AUDIT GUIDE

(FOR INDUSTRIAL BUILDINGS)

BY

SUSTAINABLE ENERGY DEVELOPMENT AUTHORITY

(SEDA MALAYSIA)

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1.0 ENERGY AUDIT

Energy audit is an important tool in establishing the energy supply and consumption pattern and the measures that need to be taken to optimize energy usage in buildings. Energy audit is an important effort to facilitate the building owners / ESCO to identify the energy saving potentials and to promote efficient use of energy.

The reference in this document stipulate the objectives, scope of work, deliverables, and other requirements of energy audit to be conducted at selected commercial buildings that consume high electrical energy.

Thus, the building owners and ESCOs shall comply with the terms of reference provided in order to conduct and produce a good, systematic and quality audit exercise, as well as uniform and comprehensive reports.

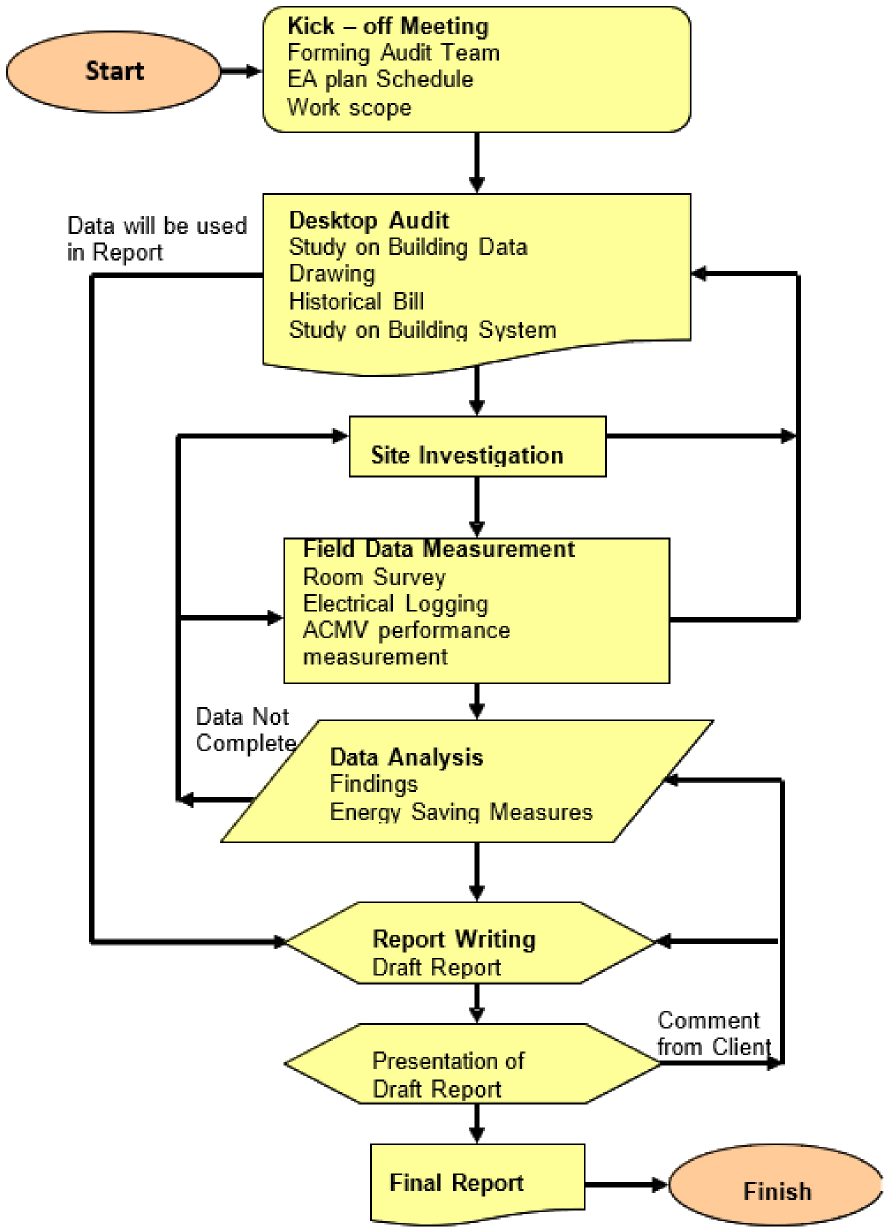
The objectives of the Energy Audits are;

- **To identify the energy supply information and status;**
- **To identify the current energy management program, setup, policy, implementation, and effectiveness.**
- **To identify present and historical energy usage pattern;**
- **To identify where the wastage occurs and measures to be taken to optimize consumption and reduce wastage; and**
- **The findings of this audit will be used to assist the building owner to formulate energy management plan and implement the relevant energy saving measures (ESMs) recommended in the energy audit report.**
- **Providing detail technical solutions and estimated cost in the energy audit report.**

2.0 METHODOLOGY OF ENERGY AUDIT

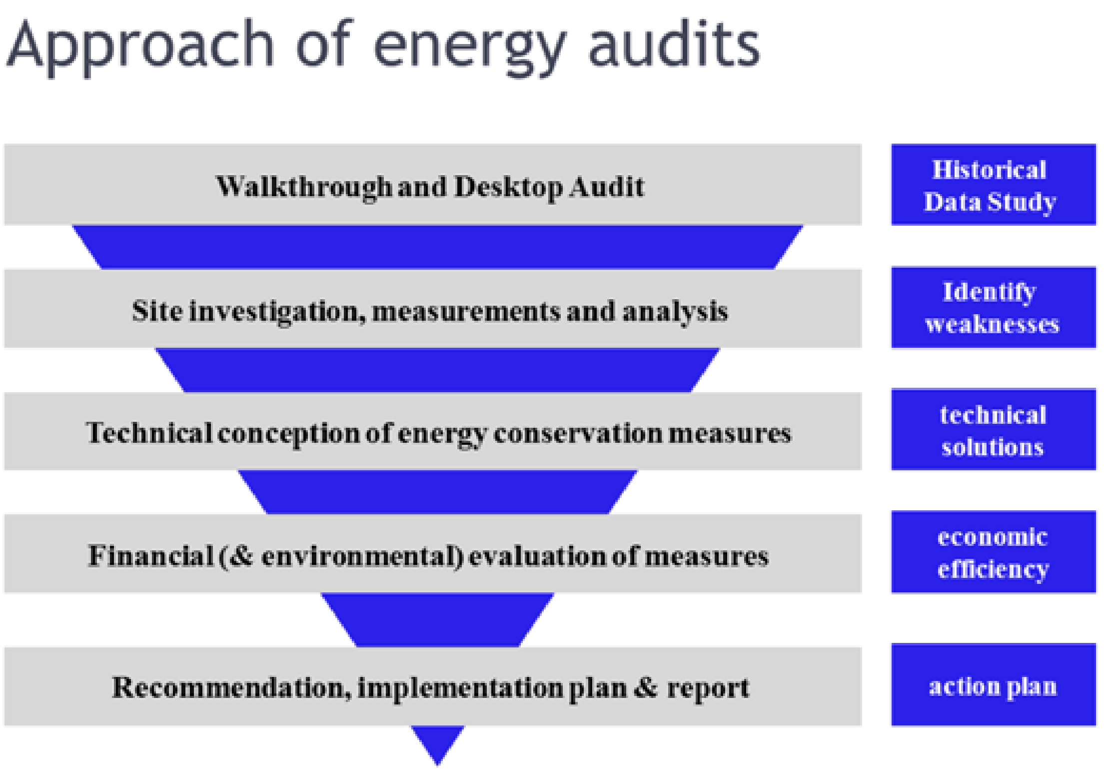
The energy audit consists of several main activities such as the following:

- √ Kick-off meeting
- √ Walk through
- √ Site investigation and measurement
- √ Data analysis
- √ Data verification
- √ Report Writing
- √ Presentation of result
- √ Feedback from all parties
- √ Submission of final report



The energy audit approach and process normally involve;

i. Obtain and study the historical data of the building in order to establish baseline;
ii. Identify the current weakness or energy wastages;
iii. Propose the technical solutions to minimise the wastages;
iv. Evaluate and perform economic efficiency or life cycle costing analysis; and
v. Develop recommendation and action plan



3.0 SCOPE OF WORK ENERGY AUDIT

The main component of the audit shall cover the following:

3.1. Energy Management Of The Building;

- To review Operation and Maintenance Contract including budget required;
- To review existing Energy Efficiency Policy/Energy Management System;
- To review documents and data pertaining to energy usage;
- To review Organizational Structure and Resource Allocation for Energy Management; and
- To obtain installation information and Energy Management Matrix.

3.2. Energy Supply Information;

- Tariff structure;
- Maximum demand value and charges;
- Voltage level;
- Historical supply information (preferably 5 years-subject to age of building); and
- Power factor.

3.3. Energy Usage Information;

- To conduct power distribution profile monitoring and analysis for overall electrical supply (compulsory) and main electrical powered equipment (if available) **at least for a period of 14 days**;
- To conduct electrical energy load loss survey and site evaluation for the audited system (refer to energy audit proposal and scope submitted and approved by the government / Energy Audit Conditional Grant Committee);
- To study on the energy usage for all equipment and systems.
- To establish electricity consumption distribution based on equipment/systems e.g. air-conditioning, lighting, office equipment etc. in kWh, GJ and percentage;
- To identify and study operating schedule or parameters that affecting the energy consumption; and
- To establish Specific Energy Consumption (SEC) for each installation
- To identify control system being used (automatic/manual);
- To conduct power measurement and analysis;
- To carry out necessary measurement for relevant parameters;
- To conduct pump system efficiency (depend to site condition);
- To calculate overall System Coefficient of Performance;
- Fans and Blowers (if relevant)
  - To describe the system(s) briefly;
  - To study the system schedule and operation hours; and
  - To describe observations and findings.

- Lighting System (if relevant)
  - To prepare a list of types of lamps used and its rated power at internal and external areas (fluorescent, CFL, LED etc);
  - To study lighting operating schedule;
  - To conduct measurement and analysis of lighting fitting layout and lux level;
  - To conduct power measurement and analysis; and
  - To conduct lighting control systems and zoning analysis.

- Air Compressor System (if relevant)
  - To provide air compressor system diagram;
  - To identify the number of air compressor used in the system;
  - To study the air compressor operating schedule; and
  - To provide and explain load profile for each compressor.

- Electrical Motor, Pumps and Production Machine (if relevant)
  - To show the list of machine/equipment types and quantity;
  - To describe the system and operations for each type of machine/equipment;
  - To provide and explain load profile for each machine/equipment; and
  - To describe observations and findings for each machine/equipment.

- Ventilation System / Indoor Air Quality & Infiltration (if relevant)
  - To identify control system being used (automatic/manual);
  - To study ventilation system operating schedule;
  - To conduct air flow measurement and analysis;
  - To conduct energy and power measurement for selected fan;
  - To conduct CO and CO_2 level measurement and analysis; and
  - Analysis on zoning and air change measurement.

- Building Automation System (BAS) (if relevant)
  - To confirm the function of the BAS facilities and parameters being controlled;
  - To perform measurement variation study between actual and the reading in the system; and
  - To study the characteristic of BAS in term of monitoring, control and reporting.
- Process Equipment (if relevant)
  - To survey and identify the types of process equipment in each room and area with its power consumption (rated capacity, performance rating etc).

- Steam Generation by Biogas/Diesel/others and Distribution System (if relevant)
  - To explain the generation and distribution system; and
  - To explain the energy consumption and load profile for each generator and distributor system.
- Any processes that proposed to be audited

3.4. Energy Saving Potential And Measures (ESMs)

ESMs (action plan and estimated time required to implement the measure recommended, amount of saving and cost of implementation). The ESMs shall address the energy management and energy efficiency. Renewable energy can be included but it is not part of the Energy Audit Conditional Grant scope.

- Energy Saving Measures and Recommendations
  - Text
    - Describe the proposed energy savings measures
    - A list of equipment potential credible suppliers
  - Chart
    - Graphical illustration
    - Existing and proposed system (*if applicable*)
  - Photo
    - Existing situation
    - Proposed equipment sketches or sample photo from manufacturer catalogue

- To list opportunities for electrical energy saving measures identified (saving to systems / equipment / control / monitoring / management) in tables
  - Each measure should have tables consisting:
    - The assumptions used in estimating the energy savings
    - The methods used in estimating the savings
    - Technical calculation
    - The conditions to achieve the savings

- To identify detailed methods to achieve savings/electrical energy reduction according to;
  - No cost/ min cost – changes of time and operation methods, minor repair / improvements
  - Low and high cost or Medium cost - based on percentage
  - High cost measure

- To estimate total potential electrical energy saving in kWh & GJ;
- To propose an action plan and the estimated time required to implement each saving measure if the management decides to implement it; and
- To propose methods of measurement and calculation to quantify energy savings based on identified saving potentials.

3.5. Financial analysis

Normally involved basic life cost cycle analysis for the proposed energy saving measures (SPP, ROI)

- Measures and costs
- Each measure and potential saving
- Expected return of investments from financial evaluation tools (e.g. SPP, ROI etc.) in years or months.

3.6. Financial and Energy Saving Measures Implementation Planning for the Owner to Implement (3 Years)

Brief budget and implementation planning for building owner to implement within the 3 years.

- 1st Year, estimated implementation cost and savings.
- 2nd Year, estimated implementation cost and savings.
- 3rd Year, estimated implementation cost and savings.

* The ESMs implementation planning shall address the energy management and energy efficiency. Renewable energy can be included but it is not part of the Energy Audit Conditional Grant scope. The total cost and savings from renewable energy are not counted as implementation and savings achieved under this EACG scheme.

4.0 MANDATORY REQUIREMENT

Energy audit report shall be according to the Energy Audit Report Template as in **Appendix A; *EACG Energy Audit Report Template***

Prepared and updated by,
SEDA Malaysia

Mobile : +603 8870 5849 / +603 8870 5814 / 019-2829102 for any enquiry

ENERGY AUDIT CONDITIONAL GRANT REPORT

FOR

BUILDING NAME

Prepared by

Company logo	Client logo
Company Name and Address	Client Name and Address

Under

SUSTAINABLE ENERGY DEVELOPMENT AUTHORITY MALAYSIA

CONFIDENTIALITY

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DISCLAIMER

Auditor Name located in *Auditor address* has no personal or financial interest in supplying or installing equipment for this document.

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GLOSSARY

In this report, the following words and abbreviations shall be defined as follows:

Words/Abbreviations	Definition
Audit	Energy Audit
TRH	Ton Refrigerant Hour
TNB	Tenaga Nasional Berhad
kWh	kilowatt hour
MD	Maximum Demand
PF	Power Factor
ESM	Energy Saving Measures
BCS	Building Control System
DDC	Direct Digital Control
BEI	Building Energy Index
LEI	Lighting Energy Index
ACEI	Air Conditioning Energy Index
PEI	Plug Load Energy Index
OTTV	Overall Thermal Transfer Value
RTTV	Roof Thermal Transfer Value
WWR	Window to Wall Ratio
CCTV	Closed Circuit Television
ACMV	Air Conditioning Mechanical Ventilation
COP	Coefficient of Performance
CHWP	Chilled Water Pump
CWP	Condenser Water Pump
CT	Cooling Tower
HEX	Heat Exchanger
AHU	Air Handling Unit
FCU	Fan Coil Unit
VAV	Variable Air Volume
VRV	Variable Refrigerant Volume
VSD	Variable Speed Drive
EnMS	Energy Management System
DPM	Digital Power Meter
BCiS	Building Consumption Input System

DECLARATION BY REGISTERED ENERGY AUDITOR

I, [Name of REA], hereby declare that –

(a) I have conducted the energy audit;

(b) I have ensured the accuracy and completeness of the energy audit report to the best of my knowledge and expertise;

(c) I have prepared the energy audit report in accordance with the Guidelines on Energy Audit Report issued by the Commission; and

(d) I shall be responsible for the preservation of confidentiality, integrity and availability of the information obtained when conducting the energy audit and when preparing the energy audit report.

Signature: ____________________ Date: ____________________

[Name of REA]
[Certificate of Registration number]

ACKNOWLEDGEMENT BY FACILITY REPRESENTATIVE

I, [*Name of Facility Representative], hereby acknowledges receipt of the energy audit report prepared by the REA, [Name of REA], confirms that I have reviewed the contents of the energy audit report and accepts responsibility to take appropriate actions and measures based on the energy audit findings and recommendations in the energy audit report.

Signature: ____________________ Date: ____________________

[Name of Facility Representative]
[Position/Title]

Note:
**Facility Representative refers to the energy consumer or the person in charge of a building who is responsible for overseeing the implementation of energy-saving initiatives of the facility.*

1 EXECUTIVE SUMMARY

***SHALL** include but not limited to objectives of the audit, scope of the audit, summary on the systems / equipment audited, summary information on baseline, load apportioning and brief description of energy saving measures.*

Energy Audit Conditional Grant (EACG) is an energy efficiency programme under the 12th Malaysia plan (RMk-12) for the implementation year of 2021-2025. This programme is supported by grants which were allocated for the year 2021 until 2025 to commercial and industrial sectors to collaborate with local energy service companies (ESCOs) registered with the energy commission (ST) to conduct energy audit in their buildings.

The grant will serve as a financial facility (assistance) to building/installation owner to do energy audit to implement energy saving at their premises. This programme also to promote energy audit exercise to establish the current energy consumption baseline and identify potential energy saving in their premises which will foster awareness on the importance of energy management among commercial and industrial premises owner in Malaysia to reduce energy consumption (save energy and save operational cost).

With the current act, Energy Efficiency and Conservation Act (EECA) 2024, an energy consumer to whom this Act applies shall from time-to-time cause to be conducted an energy audit in respect of his activity, business or trade so as to comply with the requirements relating to the submission of energy audit report under subsection 9(2).

Building name has an estimated total gross building area of [**987m^2**], net floor area of [**869m^2**] and an air-conditioned area of [**733m^2**]. The annual electricity consumption obtained from the historical TNB billing data for the baseline year [2019] is [**232,050kWh]** with a cost of **[RM66,831.00]**. Building name is [describe the building composition, e.g. one unit of single-story building]. The building name is used as a Packaging factory which also emplaced 200 staffs at the moment.

Energy Audit had been conducted by [Auditor name] for [Client name and Building Name], between [date]. An energy audit is defined as a systematic and objective assessment of energy needs, consumption and efficiency. This report represents the findings of the Energy Audit for the audited equipment which includes [e.g. chiller plant, centralised air conditioning system and lighting system]. The audit for the general equipment was done using a general survey.

1.1 OBJECTIVE

The objective of this detailed energy audit study is to determine the energy performance of the building through detailed measurement and analysis, and identify potential savings that can optimize energy consumption, reduce wastage and reduce the operating costs of the building.

The compiled data and findings from this audit are to be used to assist Client name to monitor and operate the plant more efficiently and at the same time identify potential energy saving measures for improved performance and optimization of equipment operation.

1.2 SCOPE OF ENERGY AUDIT

Example

The scope of works covered in the energy audit are as per SEDA's guideline listed below.

Energy Management of the installation:

- Review of operation and maintenance contract including budget required
- Review of existing energy efficiency policies or if an energy management system was in place
- Review all documents pertaining to energy usage
- Review organizational structure and resource allocation for energy management
- Obtain all installation information
- Energy management matrix

Energy supply information:

- Tariff structure, energy consumption and costs
- Maximum demand and costs
- Voltage supply level from TNB and Consumer
- Historical supply information for the past 3 years
- Power factor information

Energy usage information:

- Conduct overall power distribution profile of the premise including the main electrical powered equipment, monitoring and analysis for audited system at least for a period of 14 days
- Conduct electrical energy load loss survey and site evaluation for the audited system (refer to energy audit proposal and scope submitted and approved by the government / Energy Audit Conditional Grant Committee)
- Study on the energy usage for all/selected equipment and systems
- Establish electricity consumption distribution based on equipment/systems e.g. heating and cooling system, lighting, chiller, boiler, compressor and etc. in kWh or equivalent, and percentage
- Identify and study operating schedule or parameters that affecting the energy consumption
- Establish Specific Energy Consumption (SEC) for each installation
- Identify control system being used (automatic/manual)
- Conduct power measurement and analysis
- Carry out necessary measurement for relevant parameters
- Conduct pump system efficiency (depend to site condition)
- Calculate overall System Coefficient of Performance

- Fans and Blowers
  - Describe the system(s) briefly
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  - Prepare a list of types of lamps used and its rated power at internal and external areas (fluorescent, CFL, LED etc)
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  - Provide and explain load profile for each compressor

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  - Show the list of machine/equipment types and quantity
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- Plant/Building Automation System (BAS)
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  - Survey and identify the types of process equipment in each room and area with its power consumption (rated capacity, performance rating etc)

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  - Explain the generation and distribution system
  - Explain the energy consumption and load profile for each generator and distributor system

Energy saving potential and measures (ESM)

ESMs (action plan and estimated time required to implement the measure recommended, amount of saving and cost of implementation). The ESMs addresses energy management and energy efficiency. Renewable energy can be included but is not part of the Energy Audit Conditional Grant scope.

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- Identify detailed methods to achieve savings/electrical energy reduction according to:
  - No cost/ min cost – changes of time and operation methods, minor repair / improvements
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  - High cost measure

- Estimate total potential electrical energy saving in kWh
- Propose an action plan and the estimated time required to implement each saving measure if the management decides to implement it.
- Propose methods of measurement and calculation to quantify energy savings based on identified saving potentials.

Financial analysis

The basic life cost cycle analysis for the proposed energy saving measures (SPP, ROI)

- Measures and costs
- Each measure and potential saving
- Expected return of investments from financial evaluation tools (e.g. SPP, ROI etc.) in years or months.

Financial and Energy Saving Measures Implementation Plan for Owner to Implement (3 years)

- 1st Year, estimated implementation cost and savings.
- 2nd Year, estimated implementation cost and savings.
- 3rd Year, estimated implementation cost and savings.

The ESMs implementation planning addresses energy management and energy efficiency. Renewable energy can be included but is not part of the Energy Audit Conditional Grant scope. The total cost and savings from renewable energy are not counted as implementation and savings achieved under this EACG scheme.

1.3 INFORMATION ON THE SYSTEMS / EQUIPMENT

At the building, there are several systems available and functional. One of the biggest systems is the Air Conditioning and Mechanical Ventilation (ACMV) where a total capacity of 900 RT was installed at the facility. A number of the systems are audited to find out the relevant information on their performance. The audited systems are as follows;

System	Quantity	Capacity	Total Capacity	Performance
Water Cooled Chiller	3	300 RT	900 RT	0.6 kW/RT
Water Cooled Chiller	1	450 RT	450 RT	0.6 kW/RT
Cooling Tower	4	500 RT	2,000 RT	80% effectiveness
Air Cooled Chiller	1	75 RT	75 RT	1.1 kW/RT
Air Handling Unit	45	** Btu/h @ kW	** Btu/h @ kW	
Fan Coil Unit	15	** Btu/h @ kW	** Btu/h @ kW	
Air-Conditioning Split Unit	20	** Btu/h @ kW	** Btu/h @ kW	** kW/RT
Vertical Transport	10	kW	kW	
Lighting	500	12 W – 36 W	94 kW	
Pumps	3	15 kW	45 kW	

Table 1.1: Information on Audited Systems

1.4 INFORMATION ON BASELINE PERIOD

For [building name], the baseline was set up for the period of [baseline period]. A sum of ***** kWh @ *** GJ had been consumed for that period which is equivalent to Rm ***. At the moment, only one type of energy being used which is electrical energy, supplied by Tenaga Nasional Berhad (TNB). With a net floor area of *** m^2, the energy intensity performance is *** GJ/m^2. The summary information for the baseline consumption is as follows;

Information			***Baseline period (Annual) (mm/yyyy – mm/yyyy)**
Energy or Energy Resources	*Energy or Energy Resources name (example "Electricity", if more than one, add new row below)*	*Unit of measurement (example kWh)*	
		**GJ	
	Natural Gas	*MMBtu*	
		**GJ	
	Total Energy or Energy Resources (GJ)		
Production data	*Products name (example "Cement", if more than one, add new row below)*	*Unit of measurement (example MT)*	
Specific Energy Consumption		*Unit of measurement for specific energy consumption (example GJ/MT, if more than*	

	one, add new row below)	

Table 1.2: Summary information for [baseline period] at [building name]

Note:
* baseline period shall be in month and year as specified in the tables above.
** for conversion to GJ, please refer to the Appendix F: Conversion Coefficients and Equivalence
*** examples of variable data such as operating hours, production volume, weather, occupancy, etc which affects the energy consumption of facility or SEU, as referred to the Guidelines on Energy Management System issued by the Commission.

1.5 LOAD APPORTIONING

At the building, the biggest consumption during the logging period was Air Conditioning and Mechanical Ventilation (ACMV) which is 74% followed by Lighting system and Plug load. Chiller consumed 49% of the total power while lighting system and plug load are 11% and 9% respectively.

System	Power, kW	Percentage
Chiller	150	[illegible]
Cooling Tower	35	[illegible]
Lighting	[illegible]	11%
Plug load	[illegible]	9%
AHU	[illegible]	7%
ACSU	19	6%
Others	18.5	6%
Total	**306.3**	**100%**

Table 1.3: End Load Apportioning

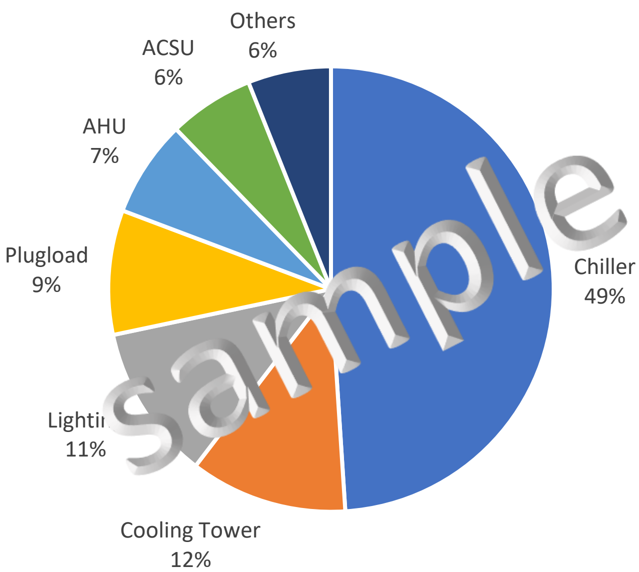


Figure 1.1: End Load Apportioning

1.6 ENERGY SAVING MEASURES

Brief summary of energy savings recommendations.

Six (6) Energy Saving Measures (ESMs) have been identified in the Energy Audit conducted. The baseline energy consumption was found to be ******* GJ/year**. By implementing all recommended Energy Saving Measures, the energy consumption for Building name can be reduced by about **23%**, or **52,416kWh @ 188.69 GJ** per year representing **RM15,096.00** in monetary value. The estimated budget cost of implementing the Energy Saving Measures is **RM27,042.00** with a payback period of about **1.79 years**. The estimated savings, investment costs and Simple Payback Period of all recommended Energy Saving Measures, are listed in the table below.

No	Category *Operation/ System/Equipment*	Type *Air conditioner/Chiller/AHU, compressor, fan, lighting, motor, pump, boiler, thermal oil heater, furnace, etc..*	Description	System Baseline (GJ/year)	Estimated Yearly Saving		Estimated Investment (RM)	Estimated Simple Payback Period (Years)	Estimated Carbon Reduction (Ton/year)	System Saving (%)	Overall Percentage Saving (%)
					Energy (GJ)	Cost (RM)					
No-Cost											
1											
2											
				Total							
Low/Medium-Cost											
3											
4											
				Total							
High-Cost											
5											
6											
				Total							
				Overall							

Note:
**for "Category" and "Type", reference shall be made to the Guidelines on Energy Efficiency and Conservation Report issued by the Commission.*

Table 1.4: ESM Summary Table

Using the estimated current annual energy consumption **232,050kWh @ *** GJ** and [amount of production], the current Specific Energy Consumption (SEC) is **224 kWh/pcs/year @ *** GJ/pcs/year** costing **RM67.68 /pcs/year** and after implementing all recommended Energy Saving Measures to **173 kWh/pcs/year @ *** GJ/pcs/year**. The percentage reduction is **11%.**

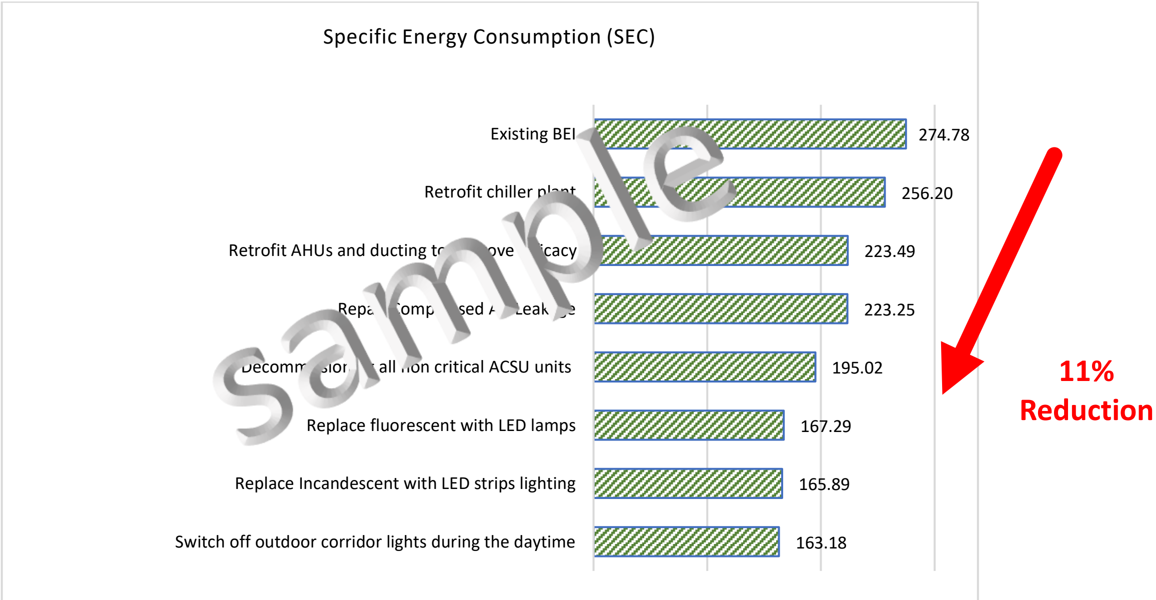


Figure 1.2: SEC Reduction Chart

2 INTRODUCTION

*The introduction **SHALL** include the details on audited facility, brief description of all energy resources consumed at the facility, constraints faced while conducting energy audit, and justification on scope of energy audit.*

The Industrial sector is the largest energy consumer in Malaysia amounting to **50%** of the total energy consumed in the country. The energy audit is a major component of an Energy Management System (EnMS) and has to be carried out continuously to ensure continuous of monitoring, control and management of energy use as well as reduction in energy consumption.

With the current act, Energy Efficiency and Conservation Act (EECA) 2024, an energy consumer to whom this Act applies shall from time-to-time cause to be conducted an energy audit in respect of his activity, business or trade so as to comply with the requirements relating to the submission of energy audit report under subsection 9(2). The energy consumer shall appoint a Registered Energy Auditor (REA) to conduct the energy audit and the energy audit shall be conducted in such manner as the Registered Energy Auditor may determine.

The energy audit is a major component of an Energy Management System (EnMS) and has to be carried out continuously to ensure continuous of monitoring, control and management of energy use as well as reduction in energy consumption. Client name, intends to conduct a detailed energy audit exercise for the plant in location. Client name has appointed Auditor name, the energy service company to conduct the energy audit.

Building name was built in 1998 and has been in full operation for the last 25 years. It comprises of a 12m high factory lot with a 250m^2 mezzanine floor for the administration office. The plant is used solely for the production of plastic injection moulded speaker boxes. A 10,285m^2 warehouse is located in an adjacent building. With a capacity of 200 factory workers, the plant operates on a 24 hour shift, with 3 working shifts daily.

Building Description

Building Name	**: Client name**
Address	**: Client address**
Business Activities	:
Number of employees	:
Sector	:
Sub-sector	:
In operation since:	:
Gross Floor Area, m^2 (GFA)	:
Net Floor Area, m^2 (NFA)	:
Air-Conditioned Area, m^2 (relative to GFA)	:
Data Centre Area, m^2	
Enclosed Parking Area, m^2	:
External corridor area, m^2	:
Historical variables for baseline period	**: e.g CDD, Operating Hour, etc.**

Table 2.1: Building Description

The selection of "Sector" and "Subsector" can be referred to Appendix B of the Guidelines on Energy Efficiency and Conservation Report issued by the Commission

2.1 INDUSTRIAL PLANT DESCRIPTION

Brief description of the building orientation

The plant is located in location. It comprises of a 12m high factory lot with a 250m^2 mezzanine floor for the administration office. The plant is used solely for the production of plastic injection moulded speaker boxes. A 10,285m^2 warehouse is located in an adjacent building. The plant comprises of the compressed air, boiler and process equipment. The electrical substation is located just at the back of the factory block. The administration office holds the Production, Engineering and Logistics office. An adjacent building holds the warehouse where the raw materials and finished goods are stored. With a capacity of 200 factory workers, the plant operates on a 24 hour shift, with 3 working shifts daily.

The factory and warehouse blocks materials are mainly aluminium and partially concrete. The aluminium roof has a skylight to allow daylight into the plant. The Gross Floor Area (GFA), Net Floor Area (NFA) and Air Conditioned Area of the building is given below in the Table.

Picture/s of building – side, front, top views

Description	Gross Floor Area	Net Floor Area	Air-Conditioned Area	Height (m)
Client name	32,375	31,611	25,321	12 (1 floor) and 1 mezzanine floor

2.2 ENERGY MANAGEMENT MATRIX REVIEW

An assessment was carried out to determine whether an Energy management system (EnMS) is in place in the building. Currently there is no official system but there have been a few energy saving exercises carried out in the past few years. One such exercise is replacing the car park lighting of 36W bare channel fluorescent lamps with 18W LED lamps. A digital power meter (DPM) is also installed to measure the energy consumption so that savings can be accounted for.

An energy management matrix was used to determine the scope of energy practices being implemented in the building.

	Policy and Systems	Organization	Motivation	Information System.	Training and awareness	Investment
4	Formal energy /environmental policy and management system, action plan and regular review with commitment of senior management or part of corporate strategy	Energy / environmental management fully integrated into management structure. Clear delegation of responsibility for energy use	Formal and informal channels of communication regularly exploited by energy / environmental manager and staff at all levels	Comprehensive system sets targets, monitors materials and energy consumption and wastes and emissions, identifies faults, quantifies costs and savings and provides budget tracking	Marketing the value of material and energy efficiency and the performance of energy / environmental management both within the organization and outside it	Positive discrimination in favour of energy / environmental saving schemes with detailed investment appraisal of all new build and plant improvement opportunities
3	Formal energy / environmental policy but no formal management system and with no active commitment from top management	Energy / environmental manager accountable to energy committee, chaired by a member of the management board	Energy / environmental committee used as main channel together with direct contact with major users	Monitoring and targeting reports for individual premises based on sub-metering, but savings not reported effectively to users	Programme of staff training, awareness and regular publicity campaigns	Same pay back criteria as for all other investments. Cursory appraisal of new build and plant improvement opportunities
2	Unadopted / informal energy / environmental policy set by energy / environmental manager or senior departmental manager	Energy / environmental manager in post, reporting to ad-hoc committee but line management and authority unclear	Contact with major users through ad-hoc committee chaired by senior departmental manager	Monitoring and targeting reports based on supply meter / measurement data and invoice. Env / energy staff have ad-hoc involvement in budget setting	Some ad-hoc staff awareness and training	Investment using short term pay back criteria mostly
1	An unwritten set of guidelines	Energy or environmental management the part-time responsibility of someone with only limited influence or authority	Informal contacts between engineer and a few users	Cost reporting based on invoice data. Engineer compiles reports for internal use within technical department	Informal contacts used to promote energy efficiency and resource conservation	Only low cost measures taken
0	No explicit policy	No energy environmental manager or any formal delegation of responsibility for env/energy use	No contact with users	No information system. No accounting for materials and energy consumption and waste	No awareness raising of energy efficiency and resource conservation	No investments in increasing environmental performance or energy efficiency in premises

Table 2.2: Energy Management Matrix

Current Target

2.3 THE SUMMARY FROM PREVIOUS ENERGY AUDIT REPORT (if Any)

As of now, there was no Energy Audit had been done before and this will be the first audit to be done. Thus, it is important for the building owner to find out the performance of the building in order to find opportunity for energy savings. At the same time, there was no Energy Saving Measures had been done and this is reflected in the Energy Management Matrix.

2.4 THE STATUS OF IMPLEMENTATION OF ESM FROM PREVIOUS ENERGY AUDIT REPORT (if Any)

As there is no energy audit done before, no ESM had been proposed ever.

2.5 ENERGY RESOURCES CONSUMED AT THE FACILITY

As a packaging plant, this facility currently consumed only one type of energy resource which is electrical energy, supplied by Tenaga Nasional Berhad (TNB). The account number is 7681304 with a tariff of C2.

2.6 THE CONSTRAINTS FACED WHILE CONDUCTING THE ENERGY AUDIT

such as difficulty in getting information, limitation and disclaimer, if applicable. State and justify any possible constraints involved in conducting the audit, such as availability of sub-metering, assumptions used in analysis, basis of estimation approach used and the limit of the responsibility or legal liability.

During the audit activities, a few constraints were faced by the auditor where the MSB itself is hard to be accessed due to small space. The auditor also had to face with the difficulties to set up the data logger due to restriction from the building owner's side. However, the issues were handled as professional as we can with the help from the on-site chargeman.

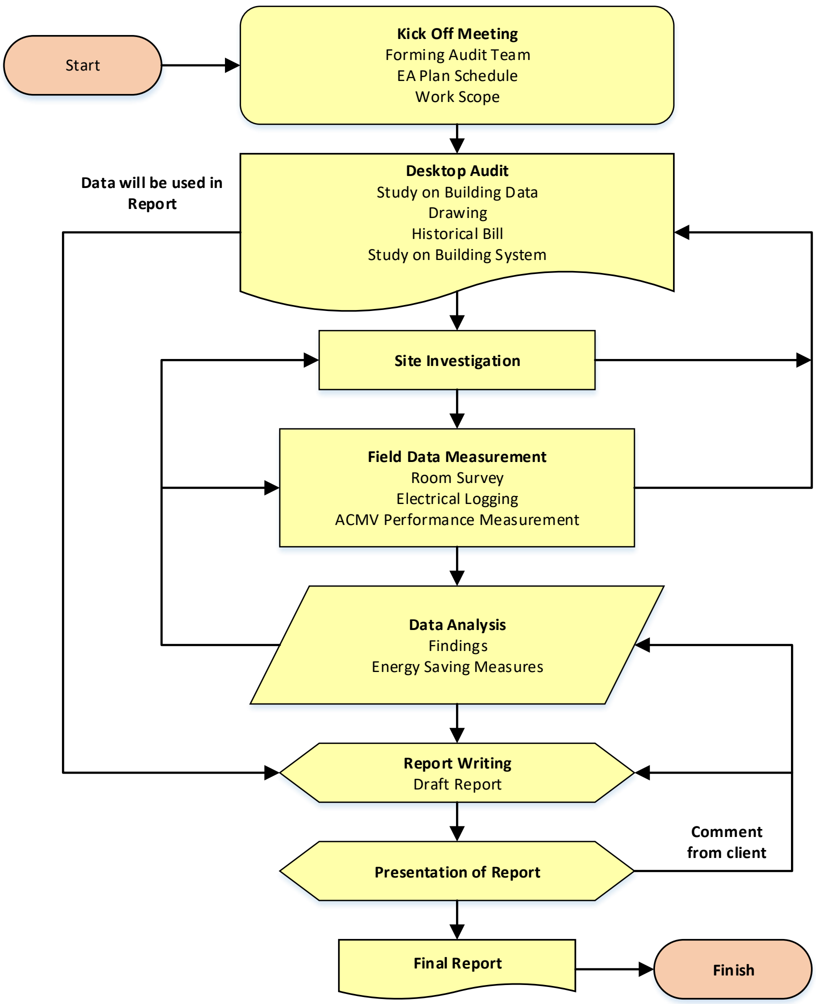
2.7 THE JUSTIFICATION ON THE SCOPE OF THE ENERGY AUDIT CONDUCTED BY THE REA

As a packaging plant, the scope conducted is relative to the daily operation of the building usage. The production equipment utilizes the biggest amount of electrical energy where majority of the equipment in the building are used for production. Energy consumption had been recorded for the analysis to find out opportunity for improvement. For the lighting system, the current usage is the second largest among other system in the building where a sum of 5,907 units of lightings had been detected. As such, it is necessary to find out any possible saving measures to be taken to further reduce the consumption.

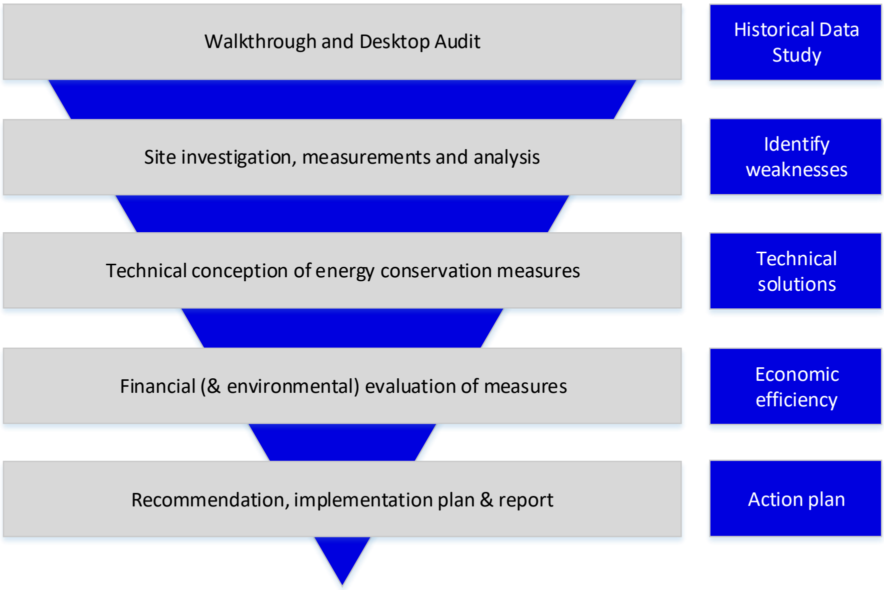
3 ENERGY AUDIT METHODOLOGY

<u>SHALL</u> include but not limited to chronology and description of the methods, timeframe, list of tools

The methodology used for the energy audit is based on SEDA's guideline shown below. The kick off meeting was held on date/time. All desktop data was made available to the energy audit team prior to the on-site audit works. The on-site audit works was held between date and date. There were some delays due to unforeseen circumstances, but the energy auditor managed to complete all works within the stipulated timeframe.



The data collection and analysis of all data was completed within the timeframe given. The energy baseline was determined from the past year TNB bills analysis and was cross referenced with the 2 week data logging that took place at the beginning of the audit. During the on-site survey and investigation, several weaknesses on energy wastage were identified. These are listed in the energy supply and consumption analysis sections. Recommendations for energy saving opportunities, financial evaluation and projected implementation was completed in the last week before submission of the draft report and are highlighted in the energy saving and financial evaluation, and implementation sections of the report. Refer figure below.



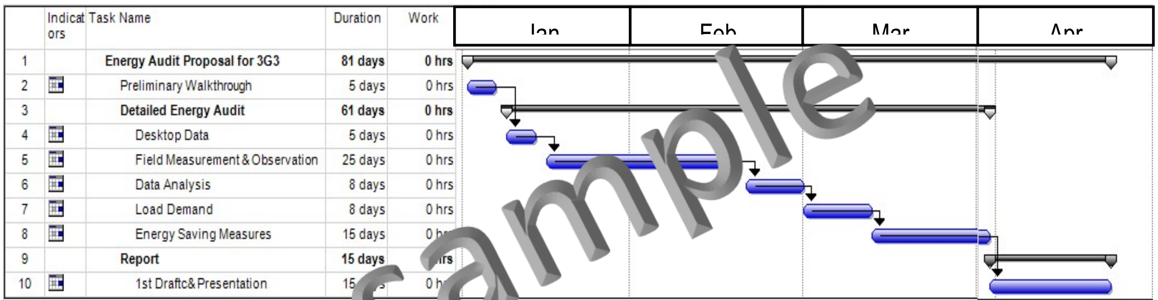
3.1 TYPE OF ENERGY AUDIT AND PROCESS

The energy audit conducted was a Detailed Energy Audit or also known as **ASHRAE Level II** which included a detailed survey of the premises. Detailed data collection was obtained through on-site measurements such as power data logging and on-the-spot measurements. The energy audit focussed on significant energy use including the chilled water plant, air handling units and lighting.

The detailed analysis was done based on the data collected with estimated energy use values and costs to develop a proposal for implementation of energy saving projects.

3.2 ENERGY AUDIT TIMEFRAME

The time schedule for carrying out the audit is a per table below. The audit started on 2 Mar 2022 and was completed on 20 May 2022. There was a 2 week delay due to shutdown of some of the processes in the plant for maintenance works.



	Indicators	Task Name	Duration	Work
1		Energy Audit Proposal for 3G3	81 days	0 hrs
2		Preliminary Walkthrough	5 days	0 hrs
3		Detailed Energy Audit	61 days	0 hrs
4		Desktop Data	5 days	0 hrs
5		Field Measurement & Observation	25 days	0 hrs
6		Data Analysis	8 days	0 hrs
7		Load Demand	8 days	0 hrs
8		Energy Saving Measures	15 days	[illegible]
9		Report	15 days	[illegible]
10		1st Draftc& Presentation	[illegible]	[illegible]

Table 3.1: Energy Audit Timeline

3.3 ENERGY AUDIT EQUIPMENT

The type of audit equipment is as per table below:

Equipment	Function
	**Data Loggers / Power Monitoring Meter (Single/3phase)** Measures electrical power parameters such as kWh, kVArh, kVAh and power factor (pf) Other parameters measured include Frequency, Maximum Demand, Voltage, Current and Power Quality It is normally used to check for electrical faults and if the phases are balanced.
	**Thermohygrometer (Temperature/ Relative Humidity Meter)** Measures the temperature as well as the relative humidity of an area. It is normally used for air-conditioning design or investigations. Usually measured in °Celsius/°Fahrenheit and %Relative Humidity
	**Anemometer** Measures the air velocity flowing through a channel. It is normally used for measuring air flow in an air handling unit, at duct intakes and opening such as doorways. Usually measured in m/s.
	**Tachometer** Measures motor speed on shafts. It is also used to calculate motor efficiency.
	**Ultrasonic Flowmeter** Measures the velocity of fluid over a known area. It is normally used for measuring chilled water flow in pipes. Usually measured in l/s.

Table 3.2: List of Audit Equipment

3.4 POLICY AND TARGETS

Policy declaration and brief description of targets and timeframe

Client name has an Energy Management Policy in place. The Client is committed to ensuring that all activities in the company are carried out sustainably. Some of the commitments are listed below:

1. Provide adequate training for employees
2. Employ energy conservation and saving practices to all levels of the company
3. Committed to make information on energy conservation and resource available to all levels of the company
4. Committed to comply with local legal requirements where necessary
5. Continuously monitor and control energy consumption
6. Identify energy wastages and take corrective measures to eliminate them
7. Procure energy efficient products
8. Periodically review and improve goals for a successful sustainability program

Targets for the energy management program for Client name are:

1. Real live tracking of energy consumption and maximum demand control
2. Reduce energy cost by 20% within the next 3 years
    - Through implementing energy saving measures
    - Procuring energy efficient equipment
    - Upgrading lighting system and control
    - Training to continuously optimize energy consumption

3.5 ENERGY DATA, DOCUMENTATION AND MONITORING

Describe the level of documentation available in the organization, policies, records, regulations, guides, training in relation to energy management

Describe monitoring of energy use procedures, energy performance indicators, effectiveness of action plans in achieving objectives and targets, evaluation of actual vs expected energy consumption – results from monitoring and measurement should be recorded

The energy consumption documents as well as information pertaining to energy consumption such as policy, regulations, procurement documents, design and installation drawings, testing and commissioning reports and financial evaluation reports are kept in the administration office under the purview of the Registered Energy Manager (REM), name and is accessible to the top management and energy management team. For every quarter, a monthly assembly will be done and the performance of the energy consumption will be presented to the staffs.

The REM sees to monitoring the energy consumption of the company. Two (2) energy audits have been conducted in the past 8 years and some minor energy saving implementation projects have been carried out, i.e. replacing LED in certain areas and purchasing 5-star appliances for the office.

The REM also reports the energy consumption to Suruhanjaya Tenaga, Malaysia yearly as per requirement.

3.6 COMPLIANCE TOWARDS REGULATIONS

Describe evaluation procedures in complying with legal requirements in relation to energy use and consumption, records

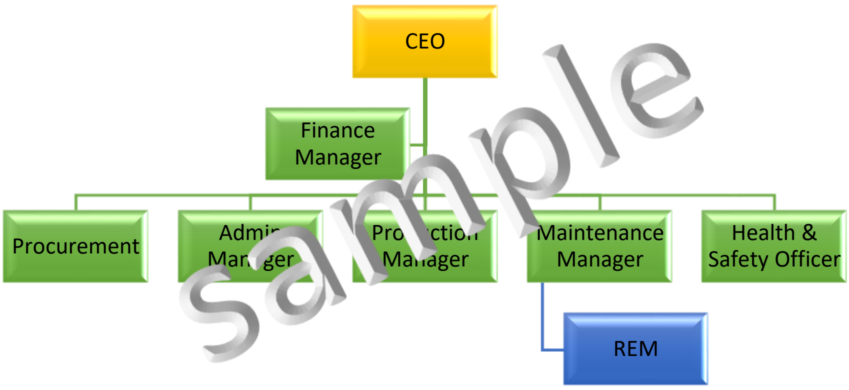
The company is subject to Energy Efficiency and Conservation Act (EECA) 2024:

1. Is applicable to large energy users, i.e. 21,600 GJ consumption for one year
2. Appointment of Registered Energy Manager
3. Energy Management System (EnMS)
4. Energy Efficiency and Conservation report
5. Energy Audit
6. Energy Audit Report

3.7 ENERGY MANAGEMENT TEAM

List names, position and role

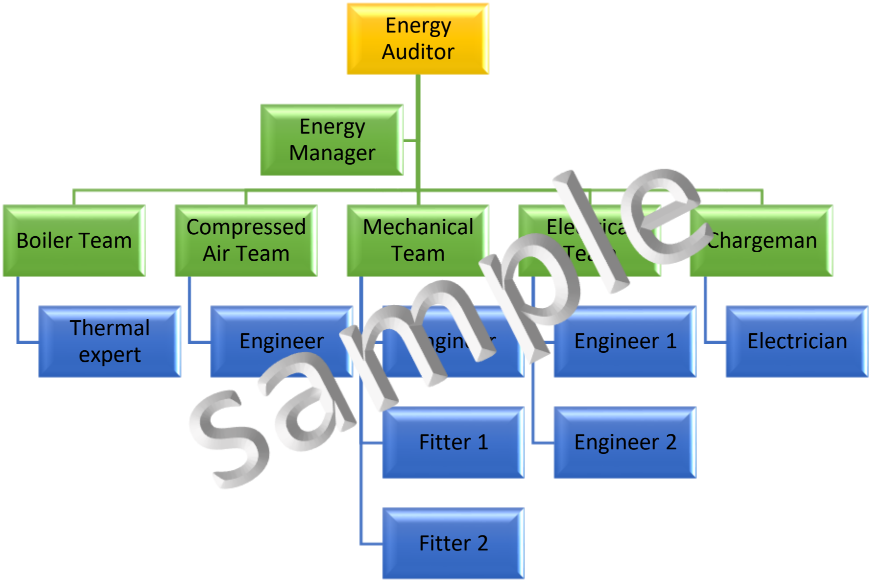
The energy management team is headed by Manager name and assisted by his team members as shown in the Chart. The CEO overlooks the whole energy management activities carried out by the company. The team meets once a week to discuss issues pertaining to energy consumption and production output. The activities are mainly carried out by the Maintenance Team and reported back to the energy management team.



3.8 ENERGY AUDIT TEAM

List names, position and role

The energy audit team is headed by auditor lead and assisted by his team members as shown in the Chart. The Energy Auditor is assisted by a team of experts from various fields of expertise to carry out the various types of energy audit measurements. The data is compiled by the Energy Manager who analysed the data and prepared the energy audit report.



3.9 OPERATIONS AND MAINTENANCE SYSTEM REVIEW

List scope of works involved for energy management

The Operation & Maintenance Contract for the building covers the following:

- Monitoring and managing energy usage and conservation
- Steps taken and opportunities identified to reduce energy consumption
- Operate a continuous improvement process on energy usage
- Review annually the building performance against current best practice and institute an energy conservation program for the following year
- Demonstrate innovation in the efficient use of energy and materials to provide a sustainable environment
- Conduct energy audits
- Implement energy saving opportunities in stages
- All relevant building energy parameters shall be monitored before and after the energy saving measures are implemented
- An energy saving baseline shall be established for comparison
- Conduct training for awareness to staff
- Integrate best energy practice in the daily operation and servicing of the building

4 DETAILS OF OPERATION

This section shall provide detailed description of the function and operation of the facility that may include the detail of production process, operation hours, type of machinery used, and significant energy consumption machinery or equipment.

The factory and warehouse blocks materials are mainly aluminium and partially concrete. The aluminium roof has a skylight to allow daylight into the plant. The Gross Floor Area (GFA), Net Floor Area (NFA) and Air Conditioned Area of the building is given below in the Table.

Picture/s of building – side, front, top views

Building Description

Business Activities	**: Packaging**
Number of employees	**: 200**
Sector	**: Industrial**
Sub-sector	**:**
Products	**: Food packaging**
In operation since:	**: [illegible]004**
Operation hour	**: 8:00 am to 5:00 pm**
Significant Energy Usage	**: Process Equipment and Lighting**

Table 4.1: Building Description

4.1 PRODUCTION TYPE

Explain briefly the products manufactured by the plant including sample pictures of the products starting from the first year of production until now

4.2 PROCESS/S FLOW DESCRIPTION

Briefly explain the process flow of production including graphical figures to show the steps of the process

Example

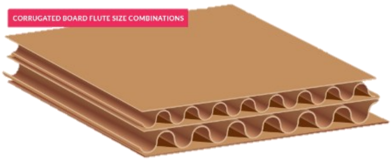
The diagram below shows the process flow for the production of corrugated carton boxes.

Paper Roll-

Paper rolls are brought in from paper roll manufacturers. The paper is made from recycled paper, bleached and pressed into paper sheets.

Corrugator-

The corrugating machine will heat up the glue using steam from the boiler to glue the corrugated sheets together. Depending on production requirements, there are 3 types of corrugated board based on number of layers and flute sizes.



Sheet Boards-

The sheet boards are cut according to size to be sent to the printer and die cutter or slotter machines for the final touches.

Stitching/Gluing-

The finished sheet boards are then sent for stitching or gluing before being packed for delivery.

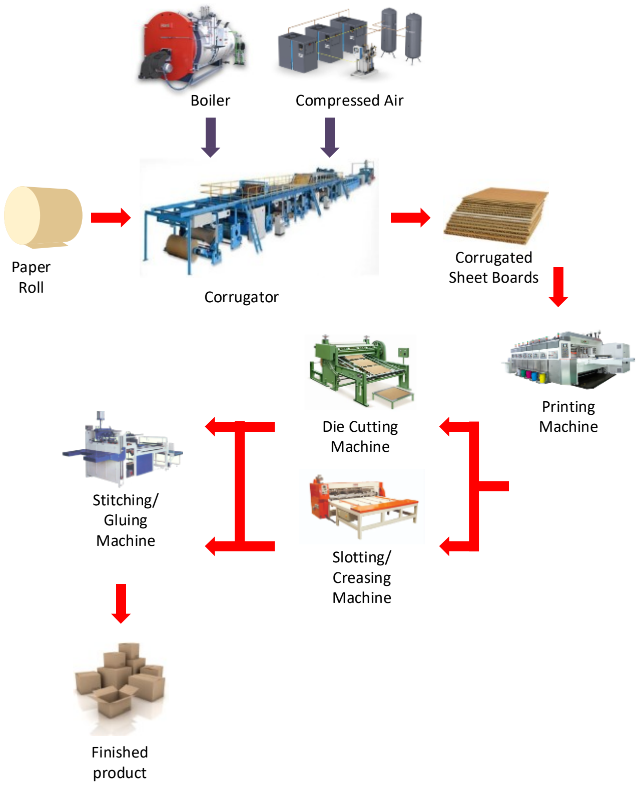


Figure 4.1: Process Flow Diagram

5 AUDITED EQUIPMENT/SYTEM

5.1 ELECTRICITY SUPPLY

5.1.1 SYSTEM DESCRIPTION

Describe the incoming supply which includes but not limited to voltage level, rating and number of transformers installed and tariff used.

The building has two 11kV/415V TNB Incomers supplying power to the building. The building electrical supply and distribution system then feeds into two transformers Tx1 and Tx2. Both transformers are rated at 2500kVA/3500kVA. The transformers feed 2 MSBs labelled MSB1 and MSB2 respectively. The Annex building also obtains its power supply from the main building MSBs.

Two (2) 1250kVA Gensets are used for back-up supply in case of power failure. The two gensets are on standby during power failure. The tariff used for this facility currently is Tariff C1, Medium Voltage with the energy consumption charge at 36.5 cent per kWh and maximum demand charge at RM30.30 per kW. The average cost is RM0.43/kWh.

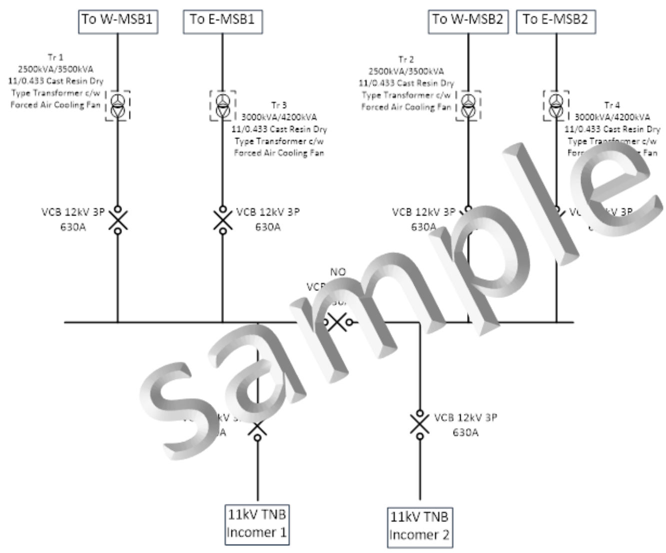


Figure 5.1: Simple Single Line Diagram

	Tariff Usage	C1: Medium Voltage
	Incoming Voltage	**11 kV / 415 V**
Year	Energy Rate (RM/kWh)	Maximum Demand Rate (RM/kW)
Jan 2014- present	RM0.365	RM30.30

Table 5.1: Electrical Supply Information

5.1.2 BUILDING LOAD PROFILE ANALYSIS

For systems with more than 1 MSB, please provide the total MSB loads for the total building load profile and the individual MSB. The period shall be a minimum of 14 days.

Data Loggers to measure power in an hourly profile were installed in both MSBs. The loggers recorded the voltages, average frequency and power factor for the 3 phases. The electrical load profiles were recorded on a daily and weekly basis. Both weekday and weekend profiles were captured and monitored. The total load profile is shown in the following graph. Appendix 2 shows the graphs for the 2 weeks measured weekday and weekend profiles.

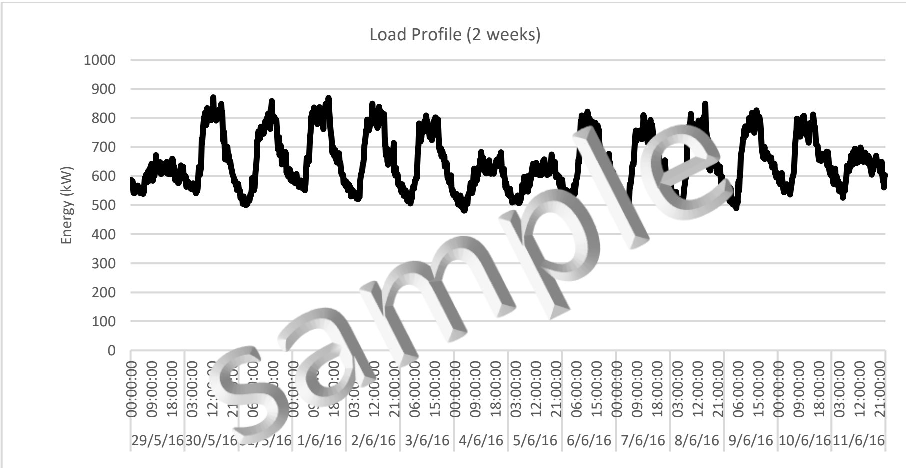


Figure 5.2: Total Building Load

5.1.3 IDENTIFICATION OF SIGNIFICANT ENERGY USAGE (SEU)

To provide the active system SLD and do analysis on the building load and identify the SEU.

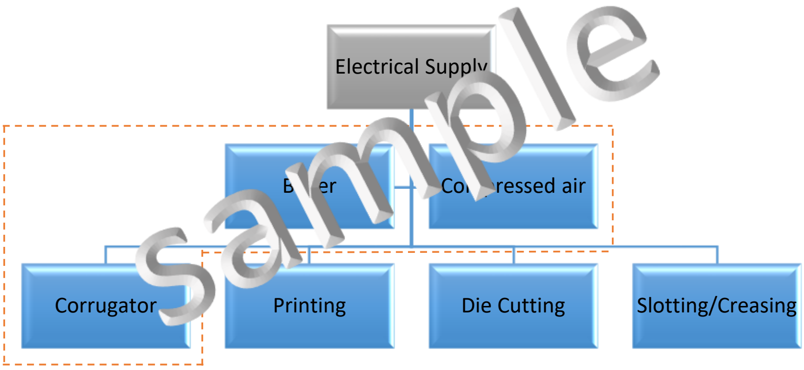


Figure 5.3: Active System Single Line Diagram

An asset list had been provided by the client where we separate the assets by category as in Figure 5.3. From it, we then look into each system power capacity to determine the Significant Energy Usage (SEU) for this building. Three main significant users were selected as SEU as such these three systems are contributing to the big amount of power demand which affect the building load. Thus, they shall be considered for opportunity for improvements. Through the asset list, the SEU selected were Chiller, Cooling tower and Lighting system.

5.1.4 TECHNICAL DESCRIPTION OF THE IDENTIFIED SEU

The description for the identified SEU are as follows:

System	Quantity	Capacity	Total Capacity	Performance
Water Cooled Chiller	3	300 RT	900 RT	0.6 kW/RT
Water Cooled Chiller	1	450 RT	450 RT	0.6 kW/RT
Cooling Tower	4	500 RT	2,000 RT	80% effectiveness
Air Cooled Chiller	1	75 RT	75 RT	1.1 kW/RT
Lighting	500	[illegible]2 W – 36 W	94 kW	

Table 5.2: Technical Description of the SEU

5.2 THERMAL ENERGY

5.2.1 SYSTEM DESCRIPTION

The report shall provide information about the thermal energy supply collection, distribution or storages systems and a thermal energy flow diagram.

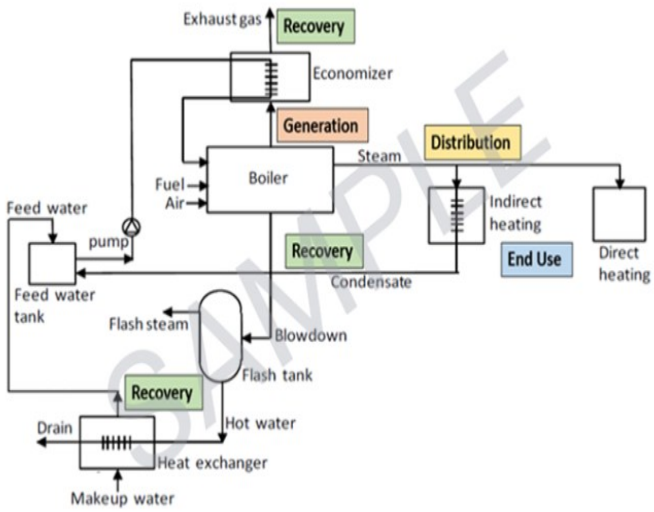


Figure 5.4: Sample of thermal energy flow diagram

5.2.2 TECHNICAL DESCRIPTION

Briefly describe the technical description on the thermal energy of the facility which includes but not limited to –

(i) heat generation and distribution;

(ii) heat-use processes;

(iii) waste heat utilization; or

(iv) co-generation.

5.2.3 IDENTIFICATION OF SEU

Description and identification of SEU for thermal energy which shall include the following

(i) the methodology used to identify the SEU;

(ii) the technical description and plot of the thermal load profile of the identified SEU which includes but not limited to –

A. reactor;

B. boiler system;

C. dryer system;

D. industrial furnace system such as kiln or oven;

E. heat exchanger;

F. preheater;

G. chiller;

H. absorption chiller system;

I. co-generation system;

J. steam system;

K. thermal oil heater system; or

L. heat pump system.

6 BASELINE ANALYSIS

6.1 MAXIMUM DEMAND REVIEW

Describe maximum demand status and means to control monthly maximum demand levels

For the baseline period, it was found the maximum demand is ranging from 1,450 kW to 2,588 kW with the highest recorded is 3,150 kW. However, there is currently no maximum demand control in place.

6.2 HISTORICAL ENERGY CONSUMPTION

Describe energy consumption and cost for all energy type with at least 12 months period.

The historical energy consumption of the building can be found in the monthly electricity bills for the past 2 years, i.e. 2013 to 2014. Chart below shows the Energy Consumption and Energy Costs for the building from 2013 to 2014.

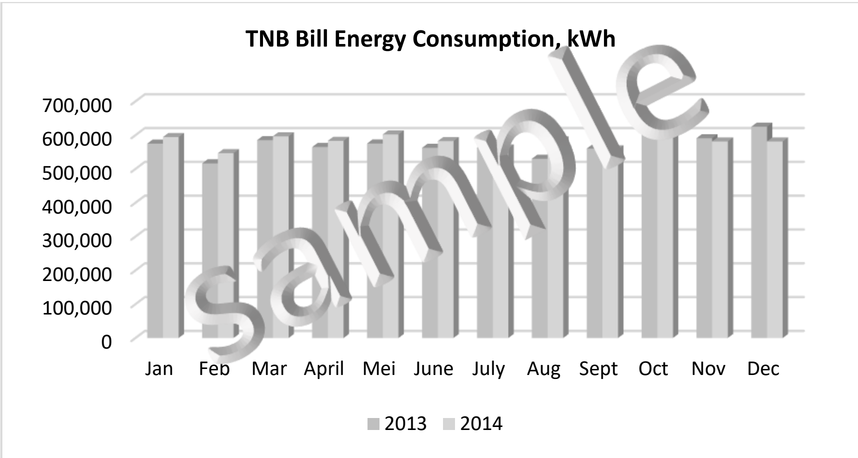


Figure 6.1: Energy Consumption, kWh

The energy consumption is seen at the lowest in the month of July as there were many holidays during that month. The trend is showing a higher consumption in year 2014 compared to 2013, but the consumption had been decreasing at the end of the year starting on September 2014.

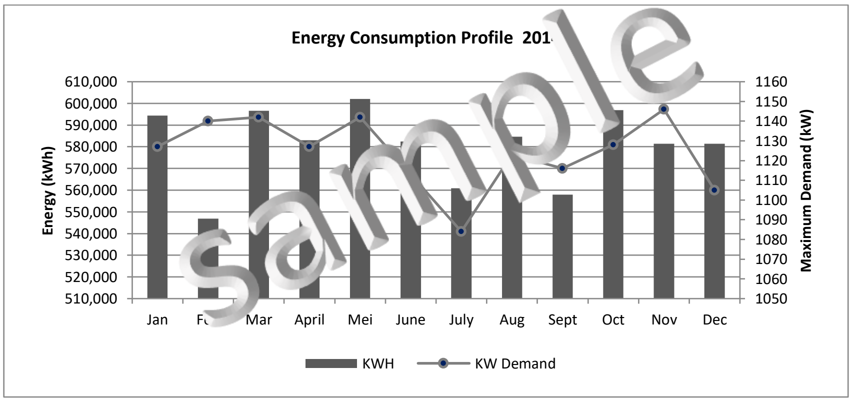


Figure 6.2: Energy Consumption, kWh versus Maximum Demand, kW

The maximum demand reading is fluctuating which shows it does not directly proportionate with the monthly energy consumption. The data on February show maximum demand value is high however the monthly energy consumption is showing the lowest reading for 2014. This mean the energy consumption is not directly affected by the maximum demand.

6.3 REGRESSION ANALYSIS

*To do regression analysis for the relationship between energy or energy resources consumption and relevant variables such as the operating hours, production output, etc. To do analysis for **both single and multiple regression***

There are there (4) major factors related to Building Energy Index (BEI) determined for building name which are as follows:

1. Independent variable such as (No of working days, no of operations and etc)

Table below shows the data for the independent variable and the dependent variable is operating throughout the month and year in 2023.

Month 2021	Independent variable	Independent variable	Independent variable	Energy Consumptions (kWh)
Jan				
Feb				
Mar				
Apr				
May				
Jun				
Jul				
Aug				
Sep				
Oct				
Nov				
Dec				

Table 6.1: Variables used for Regression Analysis

Multiple Analysis using Three (3) Variable Factors

Multiple Regression Analysis was performed using Microsoft Excel for number of patients, number of working days as the multiple independent variables. Table below shows the summary of output of the Regression Analysis. From Table, the y-intercept, the coefficient of each independent variable as in Equation 1, R-square (coefficient of determination) and standard error of the mathematical modelling can be obtained.

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.913109046
R Square	0.83376813
Adjusted R Square	0.771431179
Standard Error	17490.6745
Observations	12

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	12275356212	[illegible]	[illegible]	0.001749518
Residual	8	2447389555	[illegible]		
Total	11	14722745766			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	4938.496614	[illegible]	0.024623144	0.980958673	-457561.0765	467438.0697	-457561.0765	467438.0697
No of Patients	47.56917116	15.15889545	3.13803676	0.013846208	12.61269557	82.52564675	12.61269557	82.52564675
No of Working Days	18439.21638	7182.802472	2.567133992	0.033275587	1875.64418	35002.78858	1875.64418	35002.78858
CDD- Accuwheather	209.8566564	379.5745498	0.552873359	0.595456861	-665.443825	1085.157138	-665.443825	1085.157138

Table 6.2: Regression with Three Independent Variables

Y = 47.57x1 + 18439.21x2 +209.85x3 + 4938.49

Where,

Y	= Electricity consumption (kWh)
X1	= independent Variable
X2	= independent Variable
X3	= independent Variable
4938.49	= Base load

The R^2 = 0.833 is more than 0.75. All these 3 factors will be considered in monitoring the energy consumption

6.4 ENERGY INTENSITY PERFORMANCE

Based on the baseline performance, the energy intensity performance used for this building is Specific Energy Consumption (SEC) where the value of SEC is the products of annual consumption divided by production amount, which is 8,000 pieces. It was found the baseline SEC is currently at **222 GJ/pcs/year**.

Month	Consumption, GJ	Energy Intensity (GJ/pcs)
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		
Total	**** GJ**	**222.0 GJ/pcs/year**

Table 6.3: Specific Energy Consumption

7 OBSERVATION AND FINDINGS

7.1 ELECTRICAL SYSTEM / EQUIPMENT

7.1.1 LOAD APPORTIONING

Describe load apportioning breakdown

At the building, the biggest consumption during the logging period was Air Conditioning and Mechanical Ventilation (ACMV) which is 74% followed by Lighting system and Plug load. Chiller consumed 49% of the total power while lighting system and plug load are 11% and 9% respectively.

System	Power, kW	Percentage
Chiller	150	4[illegible]%
Cooling Tower	35	11[illegible]
Lighting	3[illegible]5	11%
Plug load	[illegible]7.[illegible]	9%
AHU	[illegible]1.5	7%
ACSU	19	6%
Others	18.5	6%
Total	**306.3**	**100%**

Table 7.1: End Load Apportioning

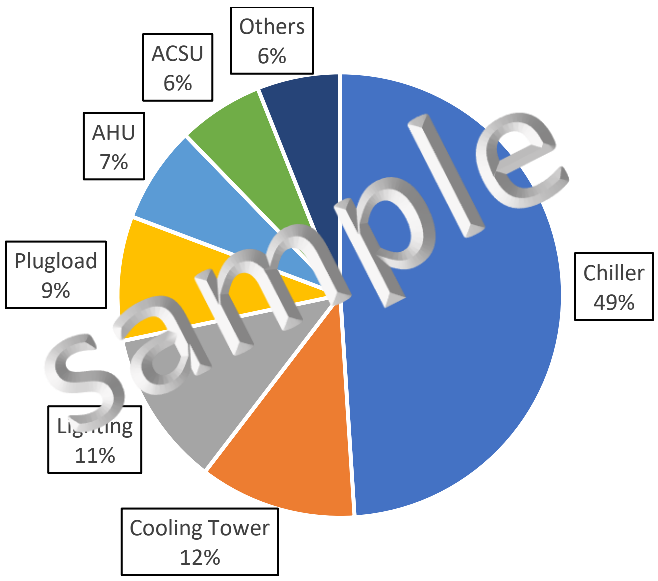


Figure 7.1: End Load Apportioning

7.1.2 ENERGY INDICES

The following are the energy and power indices obtained from the energy audit.

Energy Intensity Index		
Building Energy Intensity Index (BEII)		kWh/m2
Lighting Energy Intensity Index (LEII)		kWh/m2
Air Conditioning Energy Intensity Index (ACEII)		kWh/m2
Building Power Baseload		kW

Power Density Index		
Lighting Power Density		W/m2
Air Conditioning Power Density		W/m2
Equipment Power Density		W/m2
Baseload Power Index		W/m2

Table 7.2: Energy Indices

7.1.3 ENERGY SUPPLY

Describe the energy supply and consumption analysis which includes but not limited to load factor, maximum demand, type of tariff and power factor value from the logging activities

The logging data shows an average voltage of 405 V during the logging period. This value is still in the good range where TNB supply is 400 V with a variation of -6% and +10%. The measured voltage shows the incoming supply is not over-voltage where over-voltage issues shall not be a problem for this facility.

At the same time, the power factor also can be measured. From the logging activities, it was found that the building had recorded a **power factor of 0.90** which is in the recommended range by TNB, thus there is no power factor penalty subjected to the installation. This also shows the capacitor bank installed are still functioning well.

Using the measured maximum demand (230.8 kW) during the logging period, we then compared with the current month TNB bill which record a maximum demand of 243 kW. As such, a percentage of difference is calculated to measure the discrepancy of the logged data with the TNB bills. A 5% discrepancy is detected between the logged data with the TNB bill which is used as the main method for data monitoring and record. With the 5% difference, this logged data is deemed reliable and can be used as a reference for the building energy consumption.

	Measured (Logging)	TNB Bill
Maximum Demand, kW	230.8	243
Percentage of difference	-5.02%	

Table 7.3: Percentage of discrepancy

7.1.4 CHILLED WATER SYSTEM AND DISTRIBUTION

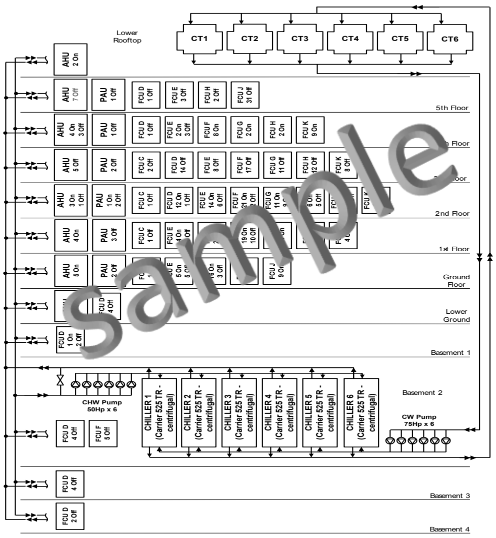
7.1.4.1 SYSTEM DESCRIPTION *(List of the system can be put in the Attachment section)*

Describe system

The air conditioning system in the building is supplied by a number of air handling units in several plantrooms around the building, which serve manufacturing area, offices, canteen and certain parts of general area of the building. The air conditioning system components include:

- Six (6) water-cooled chillers, cooling towers, chilled water pumps and condenser water pumps located at the air conditioning plant, outside the manufacturing block.
- Forty (40) air handling units (AHUs) located in the building AHU plant rooms on each floor
- Three Hundred and Eighty-Six (386) fan coil units (FCUs)
- Twelve (12) package air conditioners (PAUs).

The air conditioning for the plant is run for 24 hours a day.



System	Quantity	Capacity	Total Capacity	Performance
Water Cooled Chiller	3	300 RT	[illegible]00 [illegible]	0.6 kW/RT
Water Cooled Chiller	1	450 RT	4[illegible]	0.6 kW/RT
Cooling Tower	4	500 RT	[illegible] RT	80% effectiveness
Air Cooled Chiller	1	75 [illegible]	75 RT	1.1 kW/RT
Air Handling Unit	45	* [illegible]Btu, [illegible] @ [illegible]W	** Btu/h @ kW	
Fan Coil Unit	15[illegible]	** [illegible]u/h @ kW	** Btu/h @ kW	
Air-Conditioning Split Unit	2[illegible]	[illegible]* Btu/h @ kW	** Btu/h @ kW	** kW/RT

Table 7.4: ACMV Specifications

7.1.4.2 LOAD PROFILE ANALYSIS

Describe load profile

The chilled water is on a continuous 24-hour supply to the building. This chilled water is metered with a Calorimeter, which is sited in the Chilled Water Pump room.

Ultrasonic Flow Rate Meters were used to measure:

- 24 hours supply and return chilled water temperature
- 24 hours chilled water flow rate

These measurements were for a 1-week time period.

- Electricity power to the pumps
- Electricity frequency to the pumps

These measurements were taken with the instruments listed below.

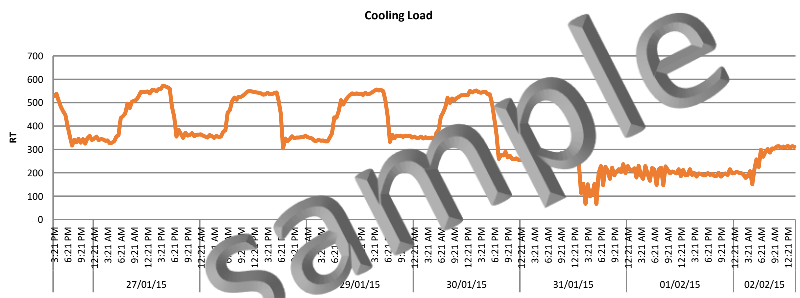
Equipment	**Purpose**
Temperature Logger and Probe	To measure temperature and time
Ultrasonic Flow Rate Meter	To measure flow rate
Multimeter	To measure amperes

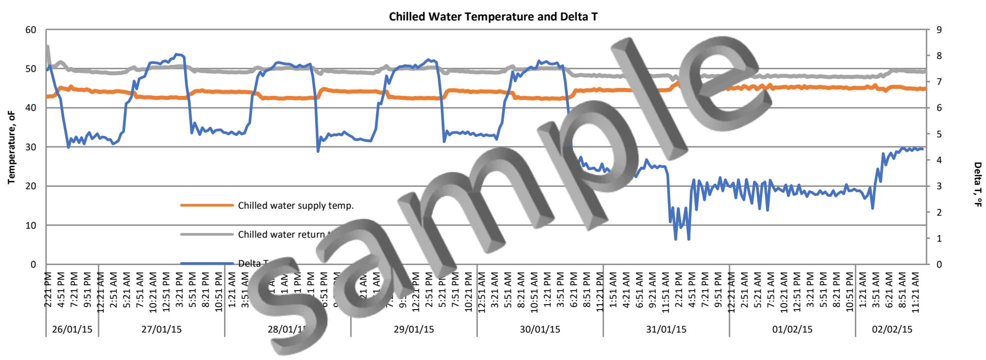
Using the above temperature logger and probe together with the ultrasonic flow meter, the 24 hours chilled water supply was measured for its supply and return temperatures and its flow rates.

The daily 24hour temperature and flow rate data is used to confirm the:

- Average supply and return chilled water temperature
- Average temperature differential (ΔT)

Profiling the flow rate of the supply and return chilled water





7.1.4.3 OBSERVATION AND FINDINGS

Evaluate Chiller COP and System COP. CALCULATION can be put in the attachment

Example

From the chiller plant energy audit works, it can be concluded as the following;

A week data measurement of chiller plant shows that COP of chiller No 1 is 4.7 and COP of chiller No 2 is 4.5. Based on the System COP chart below, the chillers are considered to still be within 'Good' range.

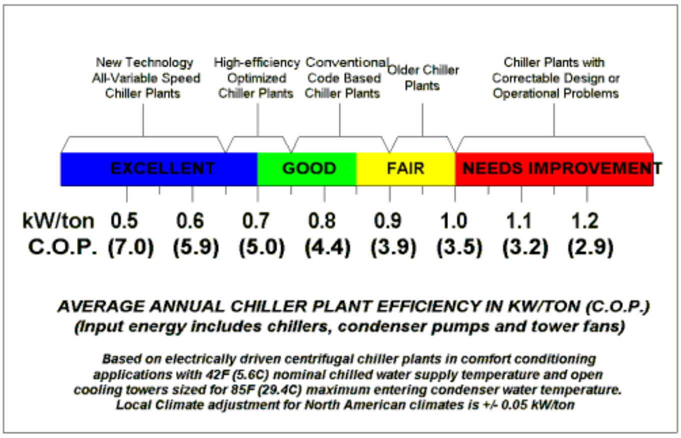
Average chiller COP

Chiller No 1: 4.7

Chiller No 2: 4.5

Chiller No 3: 4.2

Average leaving chilled water temperature for all chillers are also high (9.6°C & 9.5°C respectively for chiller 1 & 2). This indicates inability of both chillers to produce chilled water temperature at set point (7.0°C). Leaving condenser water temperatures are also at the high side, 37°C against chiller rated condenser leaving temperature of 35°C.



7.1.5 AIR HANDLING UNIT

7.1.5.1 SYSTEM DESCRIPTION

Describe system. List of the AHU can be insert at the attachment

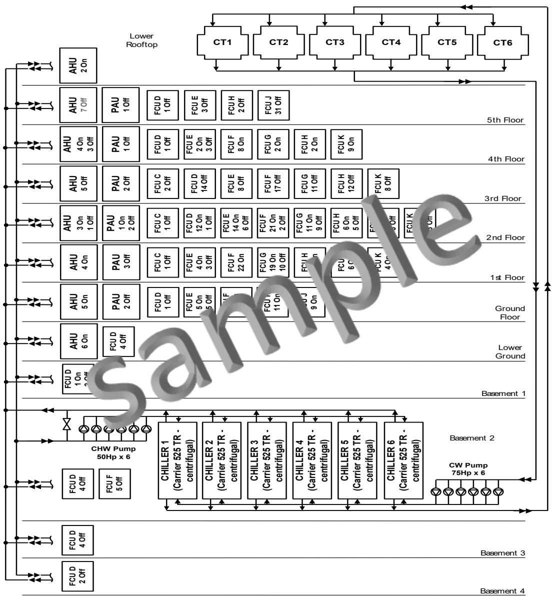
Example

The air conditioning system in the building is supplied by a number of air handling units in several plantrooms around the building, which serve manufacturing area, offices, canteen and certain parts of general area of the building. The air conditioning system components include:

- Six (6) water-cooled chillers, cooling towers, chilled water pumps and condenser water pumps located at the air conditioning plant, outside the manufacturing block.
- Forty (40) air handling units (AHUs) located in the building AHU plant rooms on each floor
- Three Hundred and Eighty-Six (386) fan coil units (FCUs)

- Twelve (12) package air conditioners (PAUs).

The air conditioning for the plant is run for 24 hours a day.



7.1.5.2 BLOWER FAN SPECIFIC POWER

Describe findings

The fan specific power is a measure of the air distribution system efficacy in W/m^3.hr. It is the ratio of power consumed in Watt to the delivered air flow in cubic meter per hour. MS1525:2019 standard recommends that the power required by the entire fan system at design condition (for air flow >17,000 m^3/hr) should not exceed 0.42 W/m^3.h for AHU with operation time exceeding 750 hours a year.

The air flow data of twelve (12) AHUs have been obtained and compared with the MS 1525:2019. None of the AHUs with more than 17,000 m^3/hr (10,000 cfm) air flowrate were found to be operating below the recommendation design value of 0.42 W/m^3.hr. Table below shows the AHU air flow statistics data.

7.1.5.3 AIR CHANGE RATE AND AHU CAPACITY ANALYSIS

Describe findings

The air change analysis was carried out to determine the actual air change rate for all zones. The air change rate is based on how many times the air within a defined space is replaced in an hour.

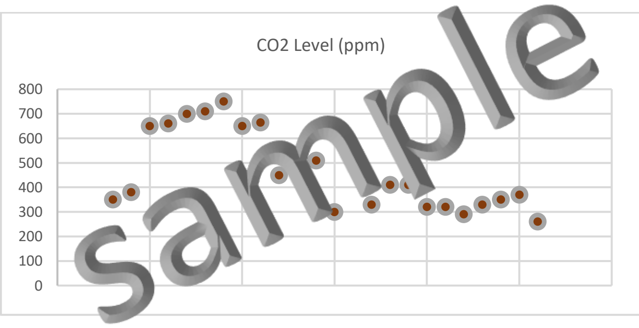
Table below provides the calculated values of Air Change per Hour (ACR). Majority of the AHU has low ACH except for AHU PR 1/6 which serves OT room (designed minimum ACR of 20). Minimum ACR is generally 6.0 ACH to prevent fungus growth. No major energy saving potential can be realized from ACR reduction.

7.1.5.4 INDOOR AIR QUALITY

Describe findings

Example

The measurement for indoor air quality is done using a CO_2 sensor. In most buildings CO_2 sensors are installed in the return duct of the air conditioning system. The indoor air quality measured in the building is within the range of 158 and 381ppm. The maximum allowable reading in a room is 1000ppm after which the air in the room will become stale and will make the occupants feel sleepy due to lack of oxygen and fresh air.



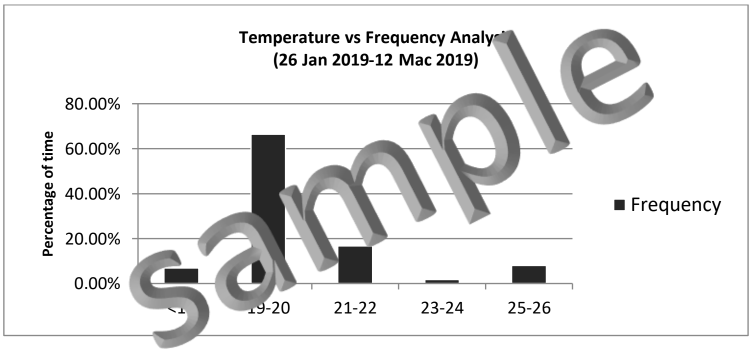
7.1.5.5 TEMPERATURE AND RELATIVE HUMIDITY

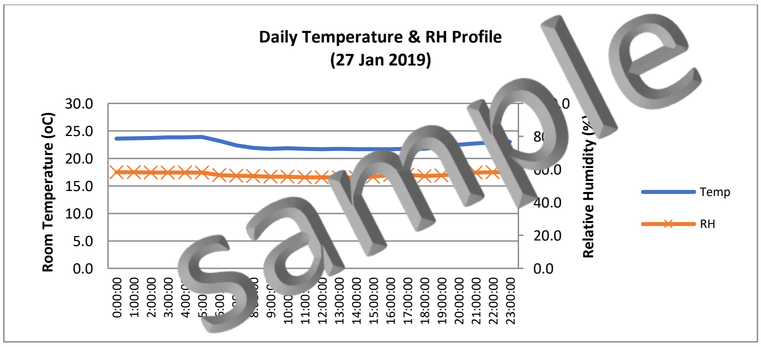
Describe findings

Example

The temperature and relative humidity levels for each space were measured using temperature logger at selected area to represent the level of cooling and moisture content of the workspace. The minimum temperature is 19.3°C and relative humidity levels are 50% and 85% respectively. Some areas are too cold and the temperature setting in these areas need to be increased. This could be due to failed control functionality of the VAV boxes or faulty temperature/RH sensors.

The measured RH of more than 70%, i.e. high moisture content in the air can lead to mould growth between cold and warm spaces such as door/window openings.





7.1.5.6 OBSERVATION AND FINDINGS

From the air conditioning and ventilation energy audit works, it can be concluded as the following:

a. The condition of the AHU plantroom needs to be improved as some plantroom 4 was found to be very dusty. This may cause the filters to get dirty very fast and load the AHU blower fan. Maintenance is done periodically.
b. It was noted that condensation was seen in a few parts along the ducting. Source of the leakage or problem should be rectified immediately in order to reduce energy losses through loss of cooling.
c. The need to compensate the centralized cooling with ACSU, shows that there is insufficient cooling provided by the centralized cooling system and the system needs to be reviewed.
d. All air conditioning areas have automatic door closers and doors are always kept closed.
e. The room temperatures are sufficient at time of audit but there have been complaints that it gets too warm when there are many people in the waiting area.

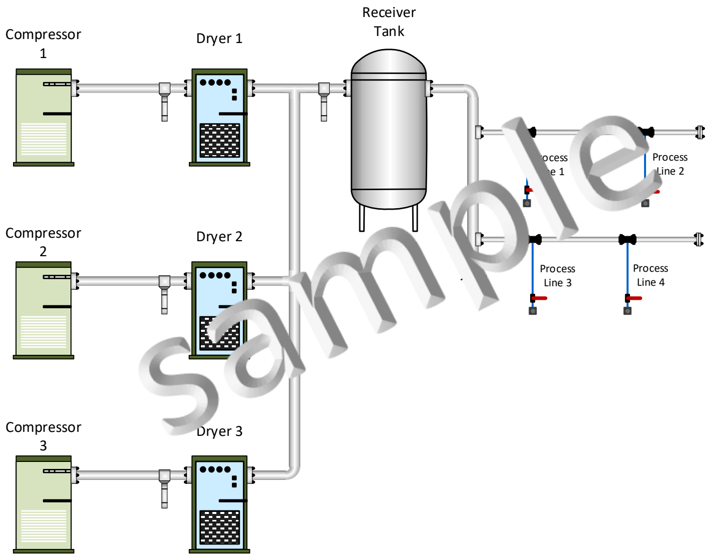
7.1.6 COMPRESSED AIR SYSTEM AND DISTRIBUTION

7.1.6.1 SYSTEM DESCRIPTION

Example

The compressed air system used in Building name building comprises three (3) 21.2 kW Ingersoll Rand compressors. All three compressors are continuously running under different operation modes. One of the compressors is fully loaded and the second is operated in loaded and unloaded mode in accordance to the compressed air demand and the third compressor is run as a hot reserve in case if one of the loaded compressors fails. In addition, there is one diesel driven compressor used as a standby unit during the shutdown.

Air compressors supply compressed air at 125 psi (8.6 bar) and the pressure of the compressed air at the manufacturing equipment is 105 psi (7.2 bar). According to the operator of the compressed air system, a low pressure alarm will operate at 89 psi (6.14 bar) and manufacturing equipment will shut down when the pressure drops to 85 psi (5.86 bar).



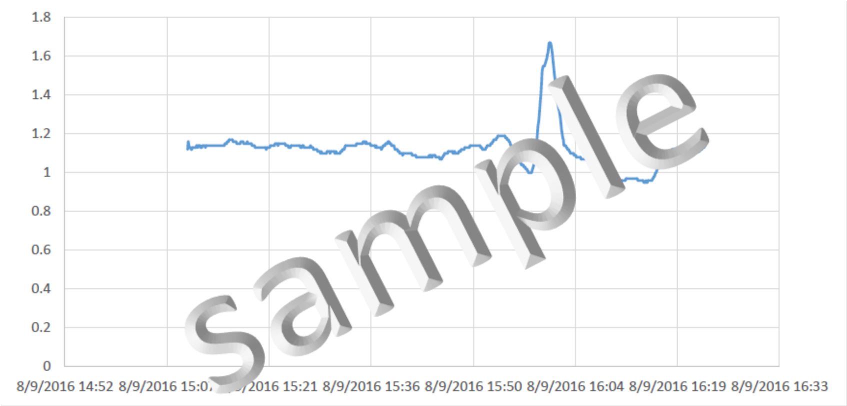
Compressed Air System Schematic

A brief site assessment of the existing compressed air equipment was conducted and some preliminary data logging of the facility's air pressure, compressor amps and power usage. Note that the estimates are based on data taken over a 7-day measurement period and projected forward to create an annual profile. The readings and observations during the measurement period show the compressed air system was operating at estimate about 1.12 m^3/min. with the 21.2 kW compressors in full load.

The air pressure was highly variable due to the high differential pressure drop across the compressed air system clean up equipment (dryers, pre- & after-filters etc). and plant operation. The plant possibly has air quality problems (water in the pipes) due to high dryer inlet air temperatures which causes overloading.

The flow rates measured exceed the minimum requirements of a typical plant mgps. The minimum required flowrate for process lines 1 to 5 is 350L/min at 7 barg (101.5 psi). The minimum requirement flowrate for the process lines 6 to 9 is 80L/min at 4 barg (58 psi).

Some significant air loads may be inappropriate, causing the compressor to be loaded near its full capacity. Significant improvements are possible. Refer Figure below for discharge flow rates.



Discharge flow rates

7.1.6.2 OBSERVATION AND FINDINGS

Compressor:-

1. The 3 units of 21.2kW compressors was logged during the audit.
2. The 21.2kW compressor controller auto sequencer configurations have setting of the auto restart time period that is short, dependent on the minimum tank pressure of 9.0 barg (130.5psi), of approximately 10 minutes, duration. This causes frequent start/stop. About 5-6 start/stop sequences per hour was detected during the assessment period. It is a good energy efficiency strategy for small-capacity systems.
3. Slow blow down, high unload kW, of approximately 5kW, causes inefficiency in compressed air systems. Both compressors showed poor turn down. The consumption was about 50 - 75% power during unload. Further investigation and servicing on the compressor is recommended.

Storage tank:-

1. The installed tank is an appropriate size in this plant.
2. At the nominal compression pressure of 10 barg (145 psi), there is 15,000 litres of air.

Compressed Air Distribution

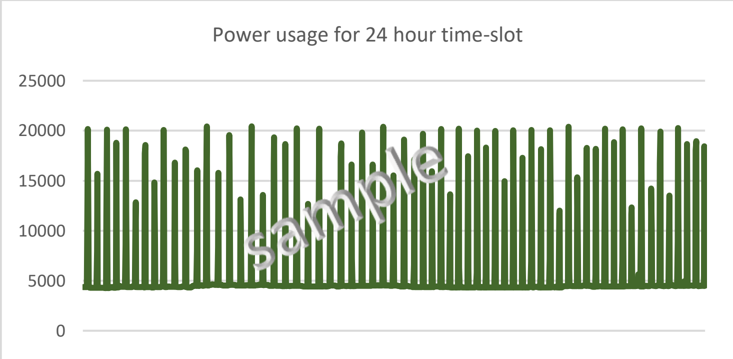
The pressure drop to the process lines is about 5-7 barg (72.5 – 101.5 psig). This indicates pressure drop over many bends and valves in the piping network.

Artificial demand

The compressed air system pressure can be reduced to achieved compressed air energy optimization as the plant can reduce and remove un-necessary bends and valves in the existing piping network. These un-necessary bends and valves will reduce the air pressure at the existing delivered pressure setting. Stable pressure and consistent flow is needed.

Compressed Air System Cost Estimate

The electrical input to the compressed air system, the airflow output and system pressures were monitored using data loggers. From this, an approximate annual electrical operating consumption was calculated. The baseline power usage of approximately 5kW can be seen. Refer Figure below.



Energy usage for 24-hour period on 5 May

The data recorded by the instrumentations show that the total annual energy consumption for compressed air is about 41,600 kWh at a weekly use of 800kWh. Average facility air loading appears to be about 1.12 m^3/min produced at an average of 9.5 barg (after the dryer and inline filter).

Using a utility rate of RM0.53 taken from the most recent power utility electrical billing, the cost of operating the compressed air system calculates to about RM 22,000 per year not including typical maintenance costs. This will be used as the base case for savings calculation purposes.

Compressor Operating Mode

The compressors were on managed by a sequencer controller to rotate compressor change over to equalize hours of operation of the compressors. Unloaded power consumption, about 5 kW, is much higher than it should be, possibly due to problems with the internal blow down circuit.

During assessment period, the 21.2 kW compressor was recorded running unload about 50 - 75% of time, consuming power but not producing compressed air.

Compressor Control

The data logger showed plant compressed air usage varied for 0.91 m^3/min to 1.67 m^3/min during the assessment period.

A VSD compressor is recommended because it would be more energy efficient in partial load. Saving can be achieved because VSD compressor does not have waste unload run time, the turn down almost proportional to flow reduction.

Compressor Standby Capacity

The estimate average utility capacity is about 1.12 m^3/min and the dynamic demand flow recorded or logged during the assessment period was 1.67 m^3/min.

Compressor Condition

The two 21W compressors are about 20 years. The compressors flow capacity might have dropped due to machine age. The compressors may show some reliability and stability issue.

Compressor Discharge Pressure

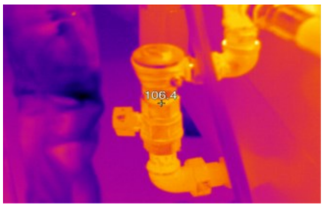
The average compressed air system pressure at the process line was 5 - 7barg (72.5 – 101.5 psig). If pressure could be lowered by 10 psi, that energy consumption saving about 5 % would be gained. For a relatively small compressor configuration here in HS, it is not recommended for the installation of a pressure/flow controller. The greater pressure stability and pressure reduction it provided is not vital in a plant.

Leaks, Condensate drain and Abandoned Uses

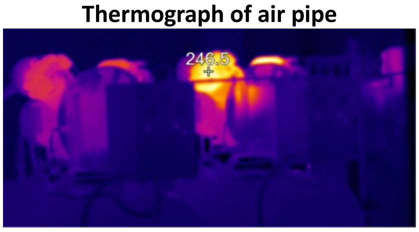
Air leakage and flow from the air consuming equipment in a facility is usually significant unless there is a regular system monitoring, leak detection and repair. Studies in the USA show that average leakage rated are 10 to 30 % of average compressor air consumption.

Air Dryer and Filter

The plant dew point was considered at the high side range from 42 - 45 °C. The inlet temperature to the dryer was detected at about 55°C during the assessment. Figures below shows thermographs of the compressor systems.



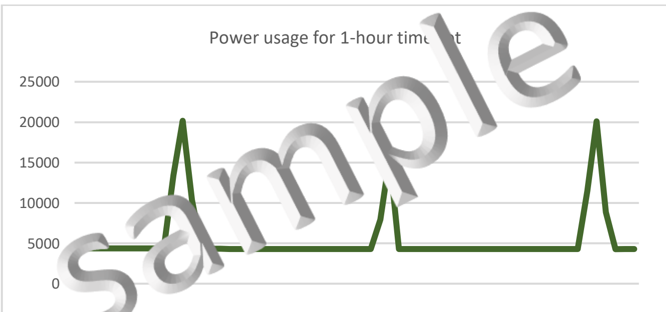
Thermograph of air pipe



Thermograph of compressor system

Efficiency

As seen in Figure, the power usage of the compressor system for a typical 1-hour period shows a baseline use of approximately 5kW and a peak usage of 21kW. The efficiency is relatively poor as the baseline is a significant portion of the power used.



Power usage for 1-hour time slot

The compressed air total installed capacity system of 20.0m^3/min. The estimated average utility capacity flow demand capacities during the audit period was about 1.12 m^3/min. The estimated highest and lowest flow demand capacities recorded were 1.67 m^3/min and 0.91 m^3/min respectively.

The average discharge pressure recorded at the plant main header after the dryer during the assessment period was 9.5 barg (137.8 psig). The highest and lowest pressures were 10.0 barg (145 psig) and 9.0 barg (130.5 psig) respectively.

The following is a list of recommendation for the improvement:

1. Replace the online filter elements which is one of the factors causing pressure drop.
2. Investigate the high ambient temperature.
3. Start a leakage detection and repair program.

7.1.7 LIGHTING SYSTEM

7.1.7.1 SYSTEM DESCRIPTION

The different types of lighting equipment and quantity is listed in the table below.

Picture	Lamp Type	Lamp (W)	Ballast (W)	Qty	Area Used
	2 x 4 recessed with full reflectors	36	8	350	Office, Laboratory
	1 x 4 recessed with prismatic diffuser	36	8	3350	Staircase, Corridors
	1 x 4 bare channel	36	8	300	Car park
	CFL	18	-	60	Lobby, Lifts
	PAR	60	-	15	Rooftop
	Incandescent	100		80	Decorative lighting for Foyer, Building Façade
	PAR	60		80	Tasklight

Table 7.5: Summary Lighting System

The lighting operating schedule of the building is listed below in the table.

No	**Description**	**Operation Hours** **Start**	**Stop**
Main Building			
1	Office	7:30am	17:30pm
2	Lobby, Walkway	7:00pm	18:30pm
3	Car park	7:00pm	7:00am

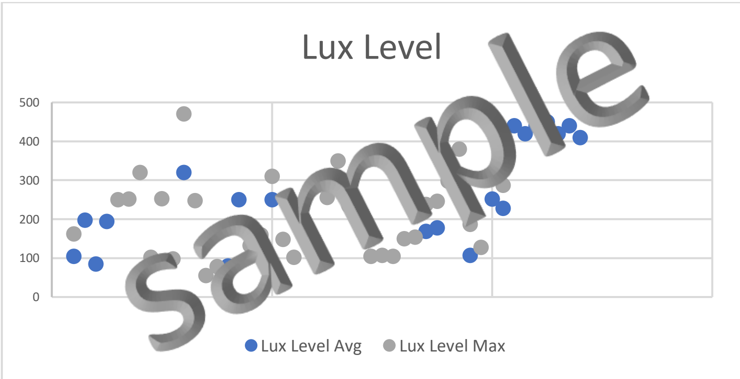
7.1.7.2 LUX LEVEL

Describe findings

Example

The lux levels for each space was measured using a lux meter to indicate the level of lighting the occupants receive in the workspace. The average lighting levels in the office space is 240 lux. The maximum lighting level recorded is 1052 lux in one of the offices which is more than sufficient than the recommended values stipulated in the MS1525:2019, standard. The average lux levels in the common walkways and lobby is 175. See Appendix 5 for the room lux level readings.

The car park lighting was upgraded from 36W fluorescent tubes to 18W LED tubes. There is a separate report on the installation with the Facility Manager. The car park lighting is switched on 24 hours. There is sufficient lighting in the car park for some areas that are compensated with daylight due to openings within the car park area. See Figure 11.



7.1.7.3 OBSERVATION AND FINDINGS

From the lighting energy audit works, it can be concluded as the following:

a. The number of lights can be reduced for the over lit areas.
b. Car park lighting can be switched off during the day when there is sufficient daylight in the areas closest to the sides of the building openings.

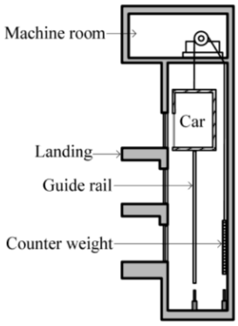
7.1.8 VERTICAL TRANSPORT SYSTEM

7.1.8.1 SYSTEM DESCRIPTION

Briefly describe lift system

Example

The lift system used is a conventional traction system that use ropes that pass over a wheel connected to an electric motor. The motor is controlled using an electronic drive.



7.1.8.2 LIFT/ESCALATOR USAGE ANALYSIS

Describe system and operation

Example

The list of lifts is shown in the table below. All lifts operate from 6:30 am to 7:00pm daily, except the OKT and service lift which operates 24 hours daily.

Room No./ Description	**Equipment Description**	**Rated Power [kW]**	**Quantity**
North Lift	Lift No. 2	22	1
South Lift	Lift No. 4	22	1
Main Lobby	Lift No. 6	22	1
Main Lobby	Lift No. [illegible]	22	1
OKT Lift	Lift No. 8	11	1
Service Lift	Lift No. 12	22	1

7.1.8.3 OBSERVATION AND FINDINGS

Lift operating hours can be reduced. The lift motors are standard motors.

7.1.9 PLUG LOADS

7.1.9.1 PLUG LOADS USAGE ANALYSIS

Describe findings

Example

The equipment used in the building includes general office equipment comprising, PCs, mainframe computers, printers, binders, cutters, audio-video equipment, projectors and other low power equipment.

7.1.9.2 OBSERVATION AND FINDINGS

Example

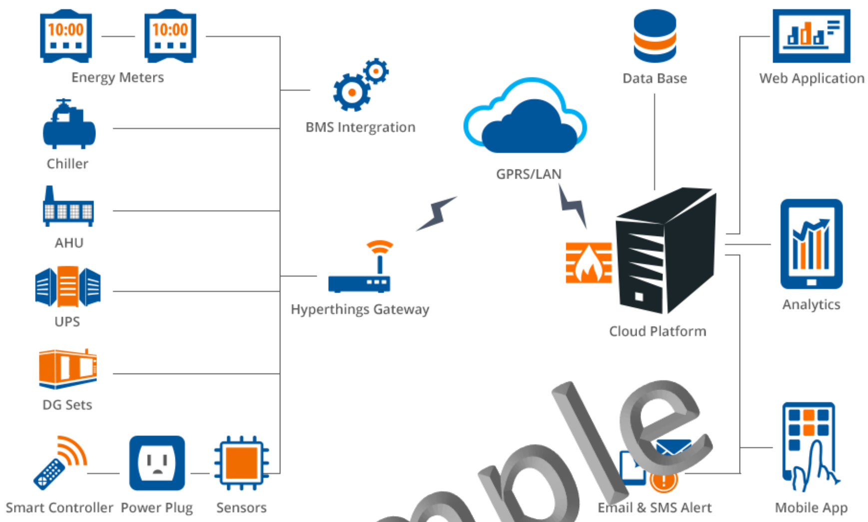
During the energy audit, it was noticed that some computers were left running during the lunch break. There have been instances where computers are left running overnight according to the security guards.

7.1.10 BUILDING MANAGEMENT SYSTEM

7.1.10.1 SYSTEM DESCRIPTION

Describe findings

Figure below shows a typical schematic of the building control system. Control of the equipment can be done via the BCS such as start/stop functions of Pumps, AHU, FCU, VRV, Fans and Lights. Further control can be done to set VSDs and VAV dampers to open/close to the required setpoint. Feedback from sensors such as temperature, humidity and CO_2 can also influence the VSDs and VAVs to operate to the required setting.



System	Equipment	Control strategy
ACMV	AHU	• Fan speed is controlled by variable speed drive. Controlled variable is supply duct static pressure which is set at certain value. • Control valve position is controlled by valve actuator. Controlled variable is supply air temperature. • AHU operation is controlled by schedule program from BCS.
	VAV	• VAV damper position is controlled by VAV actuator. Controlled variable is zone temperature. • VAV position and zone temperature are monitored by BCS.
	VRV	• VRV damper position is controlled by VAV actuator. Controlled variable is zone temperature. • VRV position and zone temperature are monitored by BCS.
	Ventilation/Fresh Air Fan	• Fresh air fan operation hours are controlled by schedule program from BCS. • Speed regulation of fresh air fan is controlled by Variable speed drive. Controlled variable is static pressure which varies according to fresh air damper position to each AHU.
	Chilled water pump	Chilled water pump is controlled by variable speed drive. Controlled variable is chilled water pressure differential between supply and return main.
Lighting	Indoor General Areas	Lighting operation is controlled by schedule program from BCS

7.1.10.2 OBSERVATION AND FINDINGS

Example

The facility manager/maintenance team/BCS operator are currently implementing upgrade works on the various equipment, communication links via sensors and controls and rescheduling of operation times for individual equipment. Testing and commissioning works are also being carried out to test the response of each equipment.

7.2 THERMAL SYSTEM / EQUIPMENT

Stream Description	Temperature (°C)	Flow Rate (kg/h)
Hot Water Inlet	80	500
Hot Water Outlet	40	500
Steam Inlet	150	200
Condensate Outlet	90	200
Cooling Water Inlet	25	[illegible]00
Cooling Water Outlet	35	[illegible]00

Table 7.6: Stream [illegible] Details

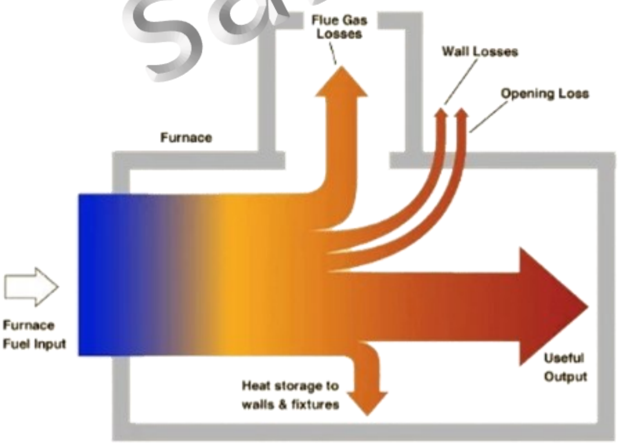


Figure 7.2: Sankey Diagram for [Building Name]

Where applicable, the data and specific findings on identified SEU, emphasizing on details that includes but not limited to as follows:

for boiler –

A. the pressure;
B. the temperature;
C. the steam capacity;
D. the flow rate;
E. the blowdown;

F.	flue gas analysis; and
G.	efficiency of the boiler.

for thermal oil heater –
*A.	the pressure;*
*B.	the inlet and outline temperatures;*
*C.	the production capacity;*
*D.	the ambient air condition;*
*E.	the flue gas analysis; and*
*F.	efficiency of the thermal oil heater.*

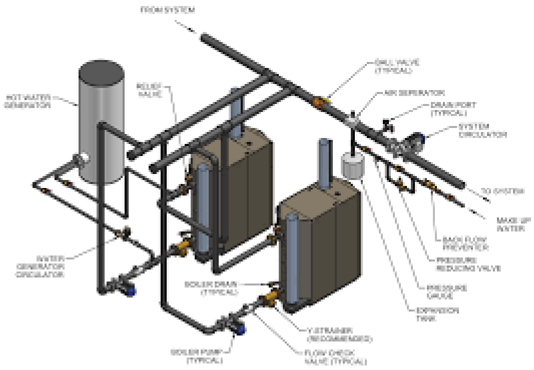
for furnace –
*A.	operating temperature;*
*B.	production capacity;*
*C.	flue gas analysis; and*
*D.	efficiency of the furnace*

Any related output parameter data for other thermal equipment or system -
The related information or basic measurable data that is related to energy consumption and conservation as well as the efficiency of the equipment or system

7.2.1 BOILER/HOT WATER SYSTEM AND DISTRIBUTION

7.2.1.1 SYSTEM DESCRIPTION

In order to provide a comprehensive analysis, we have analysed the quantity, quality, reliability and repeatability of the existing boiler and hot water system. The Heated Water System consists of 2 units of 1.8t fire-tube boilers and 2 units of Hot Water Heater units. Refer Figure below.



A brief site assessment of the existing boiler and hot water equipment was conducted and some preliminary data logging of the facility's temperature. From these measurements and observations, an annual operating consumption estimate has been developed based on the observed operating profile and logged data on the assessment period.

These annual estimates will represent true annual costs only if conditions during the measurement period were typical of the entire annual period. Diesel fuel for the boiler and Hot Water Heater systems are delivered to the plant approximately every 6 weeks. The fuel is stored in a 5000ltr skid tank on site.

The fuel is then pumped to the boiler and hot-water equipment. The readings and observations during the measurement period show the diesel-powered boiler and Hot Water Heater system used an average total of 2,100ltr between each fuel delivery.

7.2.1.2 OBSERVATION AND FINDINGS

Boiler and Hot Water Heater site observation

Flue Gas loss

Boiler: The flue gas temperature was measured at a maximum 281.4°C. See Fig.

Hot Water Heater System: The flue gas temperature was measured at a maximum 84°C.

Both these systems release high temperature flue gas into the stack. Combined, the stack temperature would be in excess of 300°C. This makes the flue gas a recommended option for heat recovery. This economiser can then be used either for pre-heating the utility water input into the Hot Water Heater equipment or pre-heating the water supplied to the Hot Water Heater or warming the water in the hot water holding tanks.

An economiser pre-heating the utility water input into the Hot Water Heater can possibly perform the hot water heating task without requiring the Hot Water Heater operation. Further investigation is recommended.

Radiation and convection loss

The major energy losses in a boiler are from two sources. These are flue gas losses (which are covered above) and radiation and convection losses. Figures below shows the boiler main valve temperature.

Each boiler generates 1.8 t/hr steam. Referring to the ABMA chart, we can see that the loss of energy through radiation and convection is approximately 2.6% of the input fuel, in this case, the diesel fuel.

Leakage loss

With the age (over 15 years) of the Boiler system, leakages will be expected in the piping network and the steam traps.

Blow down loss

The blow-down water is not metered. The boiler blow-down water is drained to the drain via a 1.5-inch outlet pipe. This draining process is performed approximately 3 – 6 times per shift from 7am – 6pm. The blow down is released for approximately 30 seconds. Simple maths shows that about 18-20 litres blow-down water is released during each 30-sec draining.

Condensate loss

Condensate loss is the loss of the sensible heat in the liquid condensate returned to the boiler. Condensate can have as much as 16% of the total energy in the steam vapour. As such, condensate is an important energy conservation measure for boilers.

Un-insulated return pipes and valves lead to condensate loss. Visible cracks in the insulation were seen in the boiler and hot water piping network.

Following a list of recommendation for the improvement:

1. Meter the amount of fuel fed to the Boiler and Hot Water Heater system
2. Meter the amount of water fed to the Boiler and Hot Water Heater system
3. Meter the amount of blow-down water from the Boiler
4. Locate and repair steam and water leaks in the system

8 ANALYSIS AND IDENTIFICATION OF ENERGY SAVING MEASURES

ESM No.1

It was found that…

Describe the problem

It is recommended that…

Describe the solution

Show the method of calculation and assumptions made:

Shall Include but not limited to:

- Energy consumption before
- Energy consumption after
- Cost savings in RM
- Estimated Investment costs in RM
- Simple Payback Period/Return on Investment
- Percentage saving compared with overall energy consumption baseline
- the methods used in estimating the savings;
- assumptions made;
- equivalent carbon emission reduction

Describe the step to implement ESM and which option will be used for Measurement & Verification.

Example

ESM 1: Use Room/Return Air Humidity Input to Automatically Control the Glycol Chiller

As explained in the previous Energy Saving Measure, the glycol cooling coil in the MAHUs is used to control the humidity of the makeup outside air by further cooling the air after the chilled water coil. The dehumidification process in the MAH's is taken to an extreme, with the air being cooled by the glycol coil to about 5.5 oC. The room humidity measured during the site inspection on 17 April 2018 was 44%, which is near the lower limit of humidity. Therefore, there is some leeway to allow a higher humidity in the building.

If the glycol cooling step in the MAH units is eliminated, the air is still cooled to around 11 oC by the remaining chilled water coils. Because of the properties of saturated air at low temperatures, the difference in moisture content of air differs only marginally between these two temperatures, and will only result in an increase of approximately 5% in room RH, to about 49%, which is within allowed limits in the manufacturing areas. The effect of increased humidity within the conditioned space will be to reduce the likelihood of static electricity build-up, which may be considered an advantage in the manufacturing areas.

Under favorable conditions, the glycol chillers may be run at part load or not at all. To eliminate the possibility of the room Relative Humidity increasing above 50%, it is recommended that a humidity sensor in the room be used to control the glycol chillers. The existing BMS measures humidity in occupied spaces, so a control signal from the BMS could be used to control the chillers.

The estimated annual energy saving achieved through this measure is 334,512 kWh with monetary value of RM69,579. The budgeted investment required for implementing this measure is RM10,000 and the Payback period is 0.14 years (1.7 months).

DESCRIPTION	UNIT	VALUE
Overall Consumption Baseline	kWh	
System Consumption Baseline	kWh	
[A] Electricity Rate	RM/kWh	
[B] Estimated Annual Saving	kWh	
[C] Estimated Annual Cost Saving **=[B] X [A]**	RM/year	
[D]Estimated Annual Carbon Reduction **=[B] X 0.758 tCO2e/MWh (GEF 2021)**	[illegible]	
[E] Estimated Investment Cost	[illegible]	
[H] Simple Payback Period **=[E] / [C]**	Year	
[I] Estimated System Saving **= [B] / System Baseline**	%	
[J] Estimated Overall Saving **= [B] / Overall Baseline**	%	
Financing Option		
Measurement & Verification	Option	

Describe the step to implement ESM and which option will be used for Measurement & Verification.

Method statement

ESM 1 – Replace existing lighting to LED

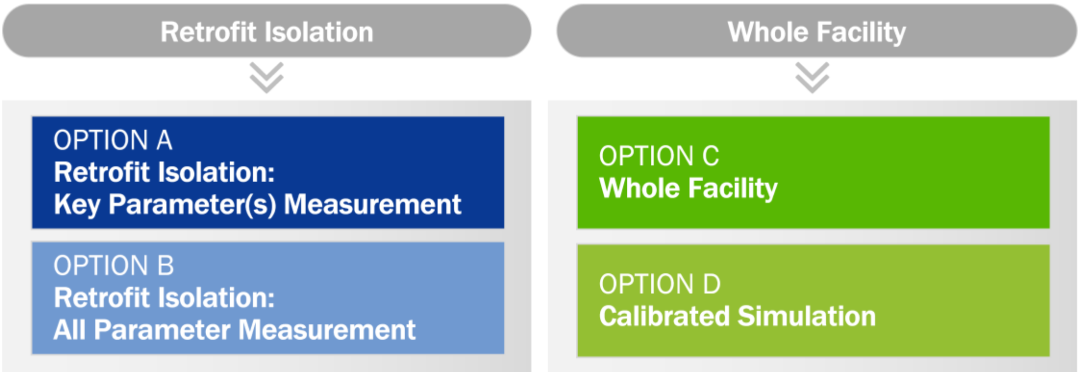
1. Conduct an energy audit to measure current consumption
2. Remove and replace existing lighting lamps/fixtures
3. Install new lighting/fixtures
4. Install energy meter for measurement and verification of new energy consumption

Measurement & Verification

Option B

Measurement & Verification

Federal Energy Management Program measurement and verification (M&V) guidelines and International Performance Measurement and Verification Protocol M&V methodologies are broken into four options. These options offer generic M&V approaches for energy- and water-saving projects.



Option A: Retrofit Isolation Approach

Option A is a retrofit isolation approach designed for projects in which the potential to generate savings must be verified, and the actual savings can be determined from limited data collection, engineering calculations, and stipulated factors. Baseline and post-installation energy uses are estimated using an engineering analysis of measured parameters or the most critical parameter of energy usage.

The intent of Option A is to verify performance through pre- and post-retrofit measurements. An individual system is measured and any potential interactions with other systems are disregarded. Use factors can be measured once (in the baseline period) or determined based upon engineering estimates, operating schedules, operator logs, typical weather data, or other documented information sources. The selection of which factors to measure should be considered relative to the contractor's responsibilities.

After post-retrofit measurements, annual inspections verify that the project has the "potential to perform." Measurements of the key parameter may or may not continue throughout the term of the contract. The level of accuracy of the calculated savings depends on the validity of the assumptions and the measurements that are made.

Option B: Retrofit Isolation or System-Level Approach

Measurements of performance and operational factors provide long-term persistence data on the energy use of the equipment or system. Measurements may be short-term, periodic, or continuous.

Option B is a retrofit isolation or system-level approach. Option B is similar to Option A but involves the measurement of all relevant parameters. This method is intended for retrofits with performance factors and operational factors that can be measured at the component or system level. Short-term periodic measurements can be used when variations in the measured factor are small, and may be sufficient to characterize the baseline. Continuous monitoring information can be used to improve or optimize the operation of the equipment over time, thereby improving the performance of the retrofit. This approach provides the greatest accuracy in the calculation of savings.

The intent of Option B is to verify performance periodically or continuously with long-term measurements.

Option C: Whole-Building Verification

Option C is a whole-building verification method. Savings are based on actual energy consumption as measured by the utility meters, usually combined with simple regression modeling to accommodate variables such as weather. Estimated savings will vary during the contract term.

Option C verification methods determine savings by studying overall energy use in a facility. The whole-building or facility-level metered data are evaluated using techniques that range from simple billing comparison to multivariate regression analysis. Generally, the overall level of savings must be more than 10% to 15% of total metered use for this method to be effective. Analyses usually consider changes in weather, occupancy, load, and operations and adjust the baseline accordingly. Option C cannot verify the performance of individual measures but will verify the total performance of all measures, including interactions between them.

Option D: Whole-Building or Component-Level Verification (Calibrated Simulation)

Option D is primarily a whole-building method but can be used at the component level. Savings are based on the results of a calibrated computer simulation model. Estimated savings may vary during the contract term if real weather data are used.

Option D uses calibrated computer simulation models of component or whole-building energy consumption to determine energy savings. Linking simulation inputs to baseline and post-installation conditions completes the calibration. Characterizing baseline and post-installation conditions may involve metering performance and operating factors before and after the retrofit. Long-term whole-building energy use data as well as periodic system level performance measurements may be used to calibrate the simulations. More elaborate models generally improve accuracy of savings calculations but increase costs.

8.1 SUMMARY OF ENERGY SAVING MEASURES

Six (6) Energy Saving Measures (ESMs) have been identified in the Energy Audit conducted. The baseline energy consumption was found to be ******* GJ/year**. By implementing all recommended Energy Saving Measures, the energy consumption for Building name can be reduced by about **23%**, or **52,416kWh @ 188.69 GJ** per year representing **RM15,096.00** in monetary value. The estimated budget cost of implementing the Energy Saving Measures is **RM27,042.00** with a payback period of about **1.79 years**. The estimated savings, investment costs and Simple Payback Period of all recommended Energy Saving Measures, are listed in the table below.

No	Category *Operation/ System/Equipment*	Type *Air conditioner/Chiller/AHU, compressor, fan, lighting, motor, pump, boiler, thermal oil heater, furnace, etc..*	Description	System Baseline (GJ/year)	Estimated Yearly Saving		Estimated Investment (RM)	Estimated Simple Payback Period (Years)	Estimated Carbon Reduction (Ton/year)	System Saving (%)	Overall Percentage Saving (%)
					Energy (GJ)	Cost (RM)					
No-Cost											
1											
2											
				Total							
Low/Medium Cost											
3											
4											
				Total							
High-Cost											
5											
6											
				Total							
				Overall							

Note:
**for "Category" and "Type", reference shall be made to the Guidelines on Energy Efficiency and Conservation Report issued by the Commission.*

Table 8.1: ESM Summary Table

9 ENERGY SAVING MEASURES IMPROVEMENT PLAN (3 YEARS)

REA may provide some recommendations of priorities and strategies on the improvement plan for the ESM

The table below lists the implementation measures to be carried out over the course of 3 years.

Year	Measures	Percentage Reduced	Cost in RM	Time to Implement
Base year				
Year 1	**No Cost**	**5%**		
ESM 1				1 month
ESM 2				3 months
Year 2	**Low/Medium Cost**	**7%**		
ESM 3				5 months
Year 3	**High Cost**	**8%**		
ESM 4				2 months

Table 9.1: ESM Improvement Plan

10 CONCLUSION

Describe BEI Chart and conclude the findings, what shall be done to the issues found from the audit

Based on the findings, several issues had been found and had been covered in the Energy Saving Measures chapter. The Chilled Water system is in a very urgent need to be replaced where the current COP measured show 1.83 kW/RT. The building owner shall do replacement as soon as possible to avoid wastage which can incur high cost to the monthly operational cost. The AHU units need to be periodically maintained and ensure the setpoints are set at 24°C.

The thermal system also need improvement to be made. The current boiler system is only at 60% efficient thus the proposed ESM will increase the efficiency up to 80%. This will reduce the amount of Natural Gas being used.

Using the estimated current annual energy consumption **232,050kWh @ **** GJ** and [amount of production], the current Specific Energy Consumption (SEC) is **224 kWh/pcs/year @ **** GJ/pcs/year** costing **RM67.68 /pcs/year** and after implementing all recommended Energy Saving Measures to **173 kWh/pcs/year @ **** GJ/pcs/year.** The percentage reduction is **11%.**

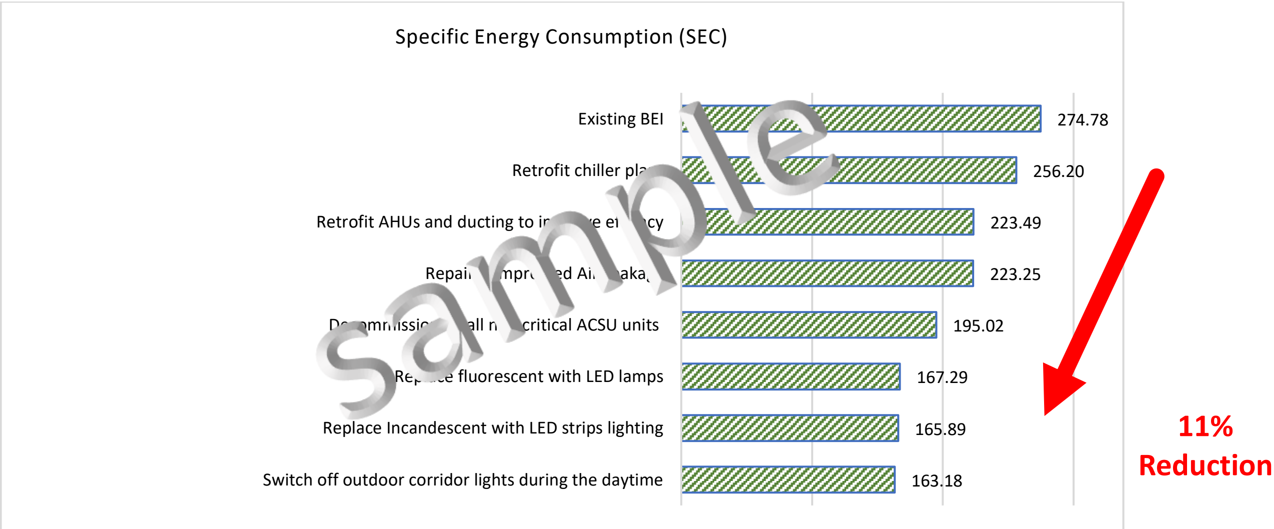


Figure 10.1: SEC Reduction Chart

11 VERIFICATION

	This Energy Audit Report is:		
prepared by:	checked by:	received by SEDA Malaysia	received by SEDA Malaysia
Name: Position: Date:	Name: Position: Date:	Name: Position: Date:	Name: Position: Date:

APPENDIX A: LIST OF EQUIPMENT

MODEL	**WCDX60**
CAPACITY	**44 TON**
VOLTS	**415**
PH	**3**
CONTROL VALVE	**115V/1PH/50HZ**
BRAND	**DUNHAM-BUSH**
SERIAL NO	**1A32100001**
HZ	**50**
REFRIGERANT	**R22**

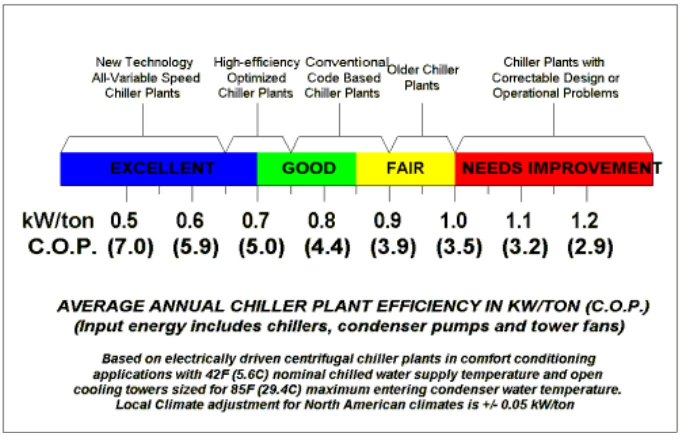
Attachment I: Chiller Specification

No.	**AHU Tag**	**Air Flow Rate, m3/hr**	**Fan Power, W**	**Fan Efficiency, W/m3 hr**	**Capacity, Btu/hr**
1	AHU ROOM 8-40	361.62	5,414.92	14.97	853,035,500.00
2	AHU ROOM 8-40	1,431.72	5,696.71	3.98	853,035,500.00
3	AHU 1	12,667.54	4,046.67	0.32	853,035,500.00
4	AHU 2	19,139.33	5,435.26	0.28	853,035,500.00
5	AHU 1	8,880.04	4,183.20	[illegible].47	682,428,400.00
6	AHU ROOM 5-01	6,708.88	3,669.02	0.55	682,428,400.00
7	AHU 1	16,887.17	18,3[illegible]	[illegible].09	853,035,500.00
8	AHU 2A	20,461.82	6,1[illegible].46	0.30	1,023,642,600.00
9	AHU 2B	16,363.30	6,[illegible]48.[illegible]6	0.42	1,023,642,600.00
10	AHU 1B	14,3[illegible].4	4,822.30	0.34	1,023,642,600.00
11	AHU 1A	[illegible],229.18	4,679.96	0.24	1,023,642,600.00
12	AHU 3A	18,058.18	5,168.00	0.29	1,023,642,600.00
13	AHU 1	10,464.99	2,992.15	0.29	682,428,400.00

Attachment II: List of AHU

APPENDIX B: EQUIPMENT ANALYSIS

Total Chiller Plant Energy Consumption (kWh/week)	2,377.87
Average Daily Energy	475.574
Average Power (kW)	52.49
Average Cooling Load (RT)	39.30
Chiller Plant Efficiency (kW/ton) (COP)	1.33



Attachment III: Chiller COP

No	AHU	Capacity, Btu/hr	Air Flow Rate, m³/hr		Served Area, m²	Air Change Per Hour (ACH)		Capacity Intensity, Btu/hr ft²
			Design	Running		Design	Running	
1	AHU-L1-M01.9	593,688	[illegible]	[illegible]	969.2	8.5	3.2	56.9
2	AHU-L1-M01.8	[illegible]	[illegible]	33,361	1,600.9	7.0	6.8	47.1
3	AHU-L1-M01.4	[illegible]	28,252	17,192	1,077.5	8.6	5.2	57.4
4	AHU-ANX-L1A.3	[illegible]	22,824	5,853	925.2	8.1	2.1	53.8

Attachment IV: AHU Capacity Analysis

APPENDIX C: ESM CALCULATION

REA must justify how they estimate the saving (By calculation/based on reference/based on their experience) Calculation each of ESM can put in appendices

To provide (*can be in Table form*):

- Energy Consumption Baseline (Each of ESM)
- Potential of energy savings in energy units and currency, CO2 Emission reduction (Each of ESM)
- Energy saving measurements and calculation methods (Each of ESM)
- Potential returns from the costs to implement energy saving measures (Simple Payback Period/Investment Rate Return) (Each of ESM)
- Overall percentage saving compared with baseline (Each of ESM)

DESCRIPTION	UNIT	VALUE
Overall Consumption Baseline	kWh	
System Consumption Baseline	kWh	
[A] Electricity Rate	RM/kWh	
[B] Estimated Annual Saving	kWh	
[C] Estimated Annual Cost Saving **=[B] X [A]**	RM/year	
[D]Estimated Annual Carbon Reduction **=[B] X 0.758 tCO2e/MWh (GEF 2021)**	tCO2e	
[E] Estimated Investment Cost	RM	
[H] Simple Payback Period **=[E] / [C]**	Year	
[I] Estimated System Saving **= [B] / System Baseline**	%	
[J] Estimated Overall Saving **= [B] / Overall Baseline**	%	
Financing Option		
Measurement & Verification	Option	

APPENDIX D: SAMPLE DATA COLLECTION FORM

FOR LIGHTING SYSTEM

Lighting Data Form

Desktop Data Collection

	Type of light: ______						
Level	Operation hours (hr/day)	Rated power (lamp + ballast) (kW)	Total unit installed (nos)	Place of use	Control system (manual/auto)	Remark	Please expand the table for other type of lighting

Field Data Collection (if any changes/absence of information during desktop data collection)

	Type of light: ______							
Level	Operation hours (hr/day)	Rated power (lamp + ballast) (kW)	Loading factor (%)	Place of use	Control system (manual/auto)	Average lux level	Remark	Please expand the table for other type of lighting

*T8/T5 fluorescent light, CFL, incandescent light, LED, etc

FOR AIR CONDITIONING SYSTEM

Air Conditioning Data Form

Desktop Data Collection

Centralized Air Conditioning System

A/C Components	Rated power (kW)	Operating hours (hr/day)	Loading factor (%)	Time usage factor (%)	Control (manual/ auto)	Year installed	Refrigerant type (R134 / R22 / HFC / etc)	Chiller type (centrifugal / screw / etc)	COP chiller design (kWr/kWe)	Setting temperature	
										Supply temp (°C)	Return temp (°C)
Chiller 1											
Chiller 2											
Chiller 3											
AHU 1											
AHU 2											
AHU 3											
Cooling tower 1											
Cooling tower 2											
Cooling tower 3											
Total chilled water pumps											
Total condenser water pumps											

Air Conditioning Data Form

Split Unit Air Conditioning System

Split Unit No.	Level	Room No / Description	Rated Power (kW)	Operating hours (hr/day)	Control (manual/ auto)	Remarks
Split Unit 1						
Split Unit 2						

Field Data Collection (if any changes/absence of information during desktop data collection)

Chiller No.	Loading factor (%)	Time usage factor (%)	Flow rate (l/s)	Operating hours (hr/day)	Chilled water temperature measured		Total power measured			
					Supply temp (°C)	Return temp (°C)	Chiller (kW)	Chilled water pump (kW)	Condenser water pumps (kW)	Cooling tower (kW)
Chiller 1										
Chiller 2										
Chiller 3										

Air Handling Unit (AHU)

AHU No.	Level	Outside air intake				Return air				AHU air intake				Control (manual/ auto)	Measured Power (kW)	Loading factor (%)	Operating hours (hr/day)	Remarks
		Temp (°C)	RH (%)	Vel (m/s)	Area (m^2)	Temp (°C)	RH (%)	Vel (m/s)	Area (m^2)	Temp (°C)	RH (%)	Vel (m/s)	Area (m^2)					
AHU 1																		
AHU 2																		
AHU 3																		

Split Unit No.	Level	Room No / Description	Measured Power (kW)	Loading factor (%)	Operating hours (hr/day)	Control (manual/auto)	Remarks
Split Unit 1							
Split Unit 2							

Field Data Collection

Indoor Air Quality

	Indoor Air Quality						
Level	Place of use	Temperature (°C)	Humidity (%)	CO_2 (ppm)	CO (ppm)	Remarks

Note:

RH - Relative Humidity (%)

Vel - Velocity (m/s)

Temp - Temperature (°C)

FOR BOILER

	Unit	Boiler #1	Boiler # 2	Boiler #3
Design Parameters				
Type of boiler	-			
Pressure	barg			
Temperature	°C			
Steaming Capacity	ton/hr			
Operating Parameters				
Feedwater pressure	barg			
Feedwater inlet temperature	°C			
% blowdown	%			
Steam pressure	barg			
Steam temperature	°C			
Steam production	ton/hr			
Type of fuel	-			
GCV of fuel	MJ/ton or MJ/Nm^3			
Fuel consumption	ton or Nm^3			
Flue gas temperature	°C			
Ambient temperature	°C			
O_2 in flue gas	%			
CO in flue gas	ppm			

FOR THERMAL OIL HEATER

Design Parameters	Unit	Thermal Oil Heater #1	Thermal Oil Heater # 2	Thermal Oil Heater #3
Production Capacity	ton/hr			
Operating Parameters				
Thermal oil pressure	barg			
Thermal oil inlet temp	°C			
Thermal oil outlet temp	°C			
Thermal oil production	ton/hr			
Type of fuel	-			
GCV of fuel	MJ/ton or MJ/Nm^3 or MJ/lit			
Fuel consumption	ton or Nm^3 or litre			
Flue gas temperature	°C			
Ambient temperature	°C			
Humidity in air	$kg/kg_{dry\ air}$			
O_2 in flue gas	%			
CO in flue gas	ppm			

FOR INDUSTRIAL FURNACE

Operation Status					
Amount of steel heated					
Temperature of discharged steel (surface)					
Amount of burning loss					
Temperature of charging steel					
Amount of crude oil used; caloric value					
Temperature of crude oil used					
Temperature of combustion air					
Temperature of flue gas at furnace outlet					
Temperature for each zone (ºC)					
Measurement Results					
Flue gas temperature (ºC) and composition (%)	Temp.	CO_2	O_2	CO	N2
*Flue gas at furnace outlet					
*Flue gas before recuperator					
*Flue gas after recuperator					
Internal pressure					
Temp. and amount of skid rail cooling water					
Temperature of furnace walls					

APPENDIX E: CONVERSION COEFFICIENTS AND EQUIVALENCE

Energy Resources

Energy Resources	Conversion Coefficients/Equivalence
Hard coal	29.3076 GJ/tonne
Coke/oven coke	26.3768 GJ/tonne
Gas coke	26.3768 GJ/tonne
Brown coal coke	19.6361 GJ/tonne
Pattern fuel briquettes	29.3076 GJ/tonne
Lignite/brown coal	11.2834 GJ/tonne
Peat	9.5250 GJ/tonne
Lignite briquettes	19.6361 GJ/tonne
Liquefied Natural Gas (LNG)	45.1923 GJ/tonne
Butane	50.393 GJ/tonne
Propane	49.473 GJ/tonne
Liquefied Petroleum Gas (LPG) (Mixture of Butane and Propane)	0.045544 GJ/kg
	0.13640 GJ/m^3
Natural Gas	1000 GJ/mscf
	1.055 GJ/mmbtu
	0.02898 GJ/m^3
Ethane	1,067.82 GJ/mscf
Methane	1,131.31 GJ/mscf
Solar Photovoltaic	0.0036 GJ/kWh
Solar Thermal	0.0036 GJ/kWh
Biogas	50.4 GJ/tonne
Biodiesel	27.0 GJ/tonne
Charcoal	29.5 GJ/tonne
Empty Fruit Bunch (EFB)	18.8 GJ/tonne
Fuelwood	15.6 GJ/tonne
Mesocarp Fibre	18.8 GJ/tonne
Palm Kernel Shell (PKS)	20.1 GJ/tonne

Note: The listed values are based on the net calorific value of each energy resources and the average calorific values for EFB, Fibre and PKS at 0% moisture content. The values may vary due to the characteristics of the fuel, such as moisture content, hydrogen, and oxygen contents. Therefore, any calorific value used for energy calculation needs to be declared in the online system.

Energy

Energy	Conversion Coefficients/Equivalence
Electricity	0.0036 GJ/kWh
Chilled water	0.01266 GJ/RTH
Steam (saturated condition)	
(a) at 10 bar steam pressure	2.78 GJ/tonne
(b) at 8 bar steam pressure	2.77 GJ/tonne
(c) at 6 bar steam pressure	2.76 GJ/tonne
Hot water (saturated condition)	
(a) at 80°C hot water temperature	0.335 GJ/tonne
(b) at 90°C hot water temperature	0.377 GJ/tonne

Note: The operating conditions listed above are based on industry standard practices. Please refer to the enthalpy values for other operating pressure and temperature conditions of hot water and steam. 1 kJ/kg is equivalent to 0.001 GJ/tonne.

APPENDIX F: ENERGY BILLS

APPENDIX G: CALIBRATION CERTIFICATE