FUNDAMENTAL OF ENERGY EFFICIENCY AND CONSERVATION

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

PREFACE

This e-book is specially written for polytechnic students who are pursuing Diploma in Electrical Engineering (Energy Efficiency). The content is designed in line with the latest syllabus prescribed in Malaysian polytechnics, and covers the topic of Fundamental of Energy Efficiency and Conservation.

This is volume 2 edition continues from volume 1 edition. Each chapters begin with main topics and sub-topics and example of questions and answers to improve understanding.

This e-book includes guidelines, chart, diagrams and illustrations. This book is organized into two main chapters. Chapter one briefly explain about technical standards for energy efficiency in Malaysia. Chapter two gives an overview of the energy efficiency awareness at residential and non-residential.

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TOPICS 4:
TECHNICAL STANDARDS FOR ENERGY EFFICIENCY IN MALAYSIA

- Code of Practice on Lighting
- Electrical Power & Distribution
- System for air conditioning and mechanical ventilation(ACMV)
- Index of Green Buildings

START

THE CODE OF PRACTICE ON LIGHTING

Compliance to MS 825 & ISO 8995

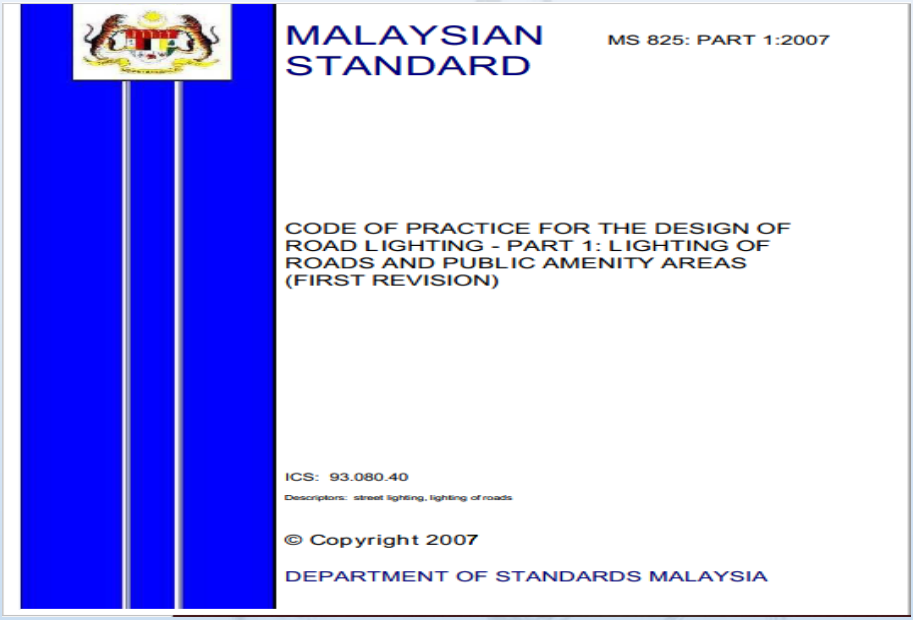


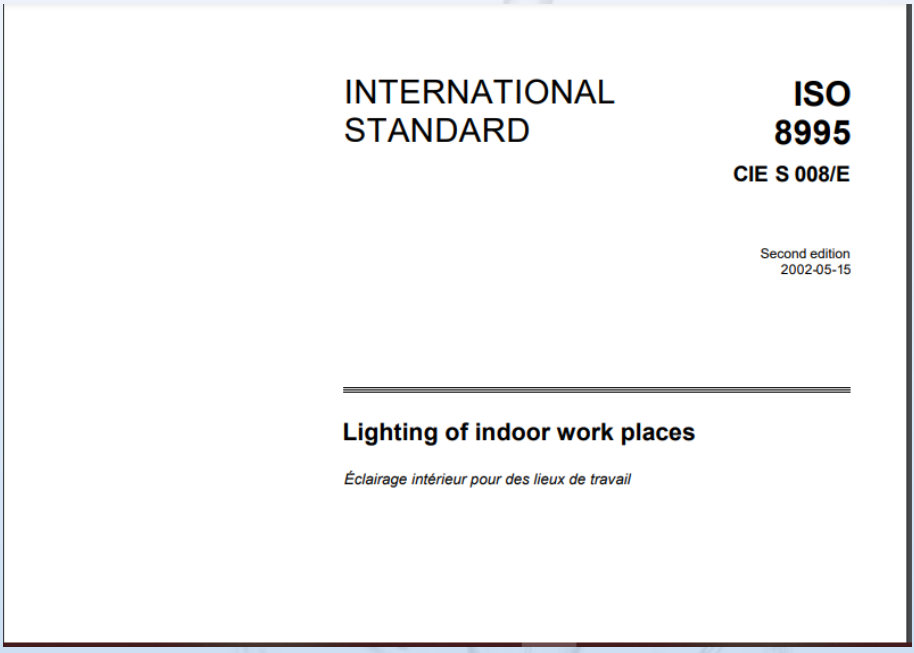
Figure 4(a): Front Cover for MS 825:Part 1:2007

The MS825, Code of practice for road lighting-General principles, is the first revision of the Malaysian Standards. The updated version of MS 825 provides guidelines and recommendations for designing lighting systems for all different kinds of highways, including public through fares, urban center, and public amenity areas, including tunnel. Under the overall heading "Code of practice for the design of road lighting," MS 825 is composed of the following elements:

.Part 1: Lighting up streets and public spaces

Part 2: Tunnel illumination MS 825:1983, which is replaced by this Malaysian Standard, is cancelled.

The Malaysian Standard by itself does not grant immunity from legal responsibilities.


INTERNATIONAL STANDARD

ISO 8995

CIE S 008/E

Second edition
2002-05-15

Lighting of indoor work places

Éclairage intérieur pour des lieux de travail

Figure 4(b): Front Cover for ISO 8995

The International Commission on Illumination, which has been acknowledged by the ISO Council as an international standardising authority, created International Standard ISO 8995 as Standard CIE S 008?E. It was adopted by ISO via a unique method that calls for at least 75% of member bodies to vote in favour of adoption. This edition was then jointly published by ISO and CIE.CIE TC 3-21 and ISO/TC 159, Ergonomics, Subcommittee SC 5, Ergonomics of the physical environment, collaborated to create International Standard ISO 8995.This second version, which is a technical revision of the original edition (ISO 8995:1989), cancels and replaces it. Contributing to the following Sustainable Development Goals is this standard

❖ GENERAL PRINCIPLES OF EFFICIENT LIGHTING PRACTICE:

Criteria of Lighting Design

Luminous environment

More than merely ensuring adequate task visibility is part of effective lighting practices for workplaces. It is critical that duties be completed comfortably and with ease. The illumination must therefore meet the environment's requirements for both quantity and quality.

In general lighting, three things should be ensured:

- visual comfort, where workers feel comfortable,
- visual performance, where workers can perform their visual tasks quickly and accurately even under challenging conditions and for extended periods of time, and
- visual safety, where one can see their way around and identify hazards.
- To meet this, consideration of every factor influencing the luminous environment is necessary.
- The primary factors are:
  - luminance distribution,
  - illumination
  - glare.
  - the direction of the light,
  - the colour of the surfaces and the light,
  - flicker
  ,- daylight
  ,- maintenance

Luminance distribution

The field of view's brightness distribution regulates the eyes' level of adaptation, which has an impact on task visibility. To improve:

- visual acuity (sharpness of vision),
- contrast sensitivity (detection of relatively tiny luminance changes), and
- efficiency of the ocular functions (such as accommodation, convergence, pupillary contraction, eye movements, etc.),

Diverse luminance distribution in the field of view also affects visual comfort and should be avoided:

- too high luminances can give rise to glare.
- too high luminance contrasts will cause visual fatigue due to continuous readaptation of the eyes.
- too low luminances and too low luminance contrasts result in a dull and non-stimulating working environment.
- attention should be given to adaptation in moving from zone to zone within a building.

Illuminance

How quickly, safely, and comfortably a person perceives and completes the visual job depends largely on the amount and distribution of illumination in the task areas and the surrounding area. When a specific area is not identified, the task is assumed to take place in the area where it could. The illuminance values described in this standard are all maintained illuminances that will meet the requirements for visual safety at work and visual performance.

Illuminances at the task area that are advised The figures in clause 5 represent the constant illuminations over the task area on the reference surface, which may be horizontal, vertical, or inclined. Regardless of how old and how well the installation is maintained, the average illumination for each activity must not be lower than the values stated in clause 5. The values take into account the following elements:

- requirements for visual tasks,
- safety,
- psycho-physiological features including visual comfort and well-being,
- economy,
- practical experience.

If the visual conditions deviate from the usual assumptions, the illuminance value may be changed, at least by one step on the scale of illuminance. Illumination levels should be raised in the following situations:

- when the task requires particularly low contrasts;
- when visual work is crucial;
- when errors are expensive to fix;
- when accuracy or higher productivity are crucial; and
- when the worker's visual capability is below average.
- When the task is completed in an extremely quick amount of time or
- when the details are unusually large or high contrast,

The necessary maintained illuminance may be reduce. The maintained illuminance must not be less than 200 lux in places where continuous work is done.

Level of illumination

The smallest significant change in the subjective effect of illumination is around a factor of 1.5. The minimum value chosen for the scale of illuminances is around 20 lux of horizontal illumination, which is needed in typical lighting situations to simply distinguish facial features. 20 - 30 - 50 - 75 - 100 - 150 - 200 - 300 - 500 - 750 - 1000 - 1500 - 2000 - 3000 - 5000 lux is the ideal range of brightness.

Uniformity

The minimum to average value ratio represents the homogeneity of illumination. The brightness will progressively vary. The task area must have as even of an illumination as possible. The task illumination uniformity must not be less than 0,7. The immediate surrounding areas' homogeneity of illumination must be at least 0.5.

Glare

The visual sensation known as glare is caused by bright spots in the field of vision and can cause discomfort or impairment. Another source of glare is reflections on specular surfaces, which are often referred to as veiling reflections or reflected glare. The glare must be kept to a minimum to prevent mistakes, weariness, and accidents. Disability glare is more frequently observed in outside illumination, but it can also be caused by spotlights or other large bright sources, like a window in a room with insufficient lighting. Uncomfortable glare frequently results from bright lights or windows in interior offices. Disability glare is typically not a significant issue if the discomfort glare restrictions are fulfilled.

Protecting from glare

Glare can make it difficult to see objects because it results from excessive luminances or contrasts in the field of vision. For instance, it should be avoided by properly protecting bulbs or covering windows with shades. The values listed in the table below must be met by the minimum shielding angle for lamp luminances for electric lamps:

Lamp luminance kcd/m^2	Minimum shielding angle
1 to 20	10°
20 to 50	15°
50 to 500	20°
$\geq$ 500	30°

Table 4(a): GlareShielding Angle against Luminance

Veiling reflections and reflected glare

The visibility of the job may be altered by specular reflections, also known as veiling reflection or reflected glare, and these changes are typically negative. The following actions can be taken to prevent or lessen veiling reflections and reflected glare:-

- surface finish (use low gloss surface materials), - brightness of luminaires,
- layout of luminaires and work areas (avoid placing luminaires in the offending zone) (limit)

,- increased luminaire luminous area (increasing luminous area),

- surfaces on the ceiling and walls (lighten, avoid bright spots).

Directionality

GlareDirectional lighting can be utilised to draw attention to items, bring out texture, and enhance how people in the area look. The word "modelling" refers to this. A visual job that uses directional illumination may also be more visible.

Modelling

The balance of directed and diffuse light is referred to as modelling. In almost all interior design contexts, it is a reliable indicator of lighting quality. When an interior's structural elements, its occupants, and the items within it are lighted so that form and texture are seen clearly and pleasingly, the overall aesthetic of the space is improved. When the light is clearly coming from one direction, this happens; the shadows that result are crucial for accurate modelling and are generated without any uncertainty. The lighting should not be too directional since it can cast sharp shadows, nor should it be too diffuse because the modelling effect would be completely lost and the area will appear extremely dimly lit.

Directional illumination for visual tasks

When lighting comes from a particular angle, subtleties in a visual task might be revealed, improving their visibility and simplifying the activity. especially crucial for fine-textured activities and scribes/grooves.

Colour aspects

The colour look of a near-white lamp and its ability to render colour, which affects how coloured things and people seem when illuminated by the lamp, are its two defining characteristics.These two qualities must be weighed independently.

Appearance of colour

A lamp's "colour appearance" refers to the light it emits' perceived colour (lamp chromaticity). By its linked colour temperature, it can be described. In general, lamps are categorised into three classes based on their linked colour temperature (Tcp).

Colour appearance	Correlated colour temperature
warm	below 3300 K
intermediate	3300 K to 5300 K
cool	above 5300 K

Table 4(b): Colour Appearance versus Colour Temperature

The selection of colour appearance depends on psychological factors, aesthetic considerations, and what is deemed to be natural. The choice is determined by the use, lighting, colour scheme, furniture, and environment. In general, warmer light colour appearances are preferred in colder areas and cooler light colour appearances in warmer climates.

Colour rendering

It is important for both visual performance and the feeling of comfort and well being that colours in the environment of objects and human skin are rendered naturally, correctly and in a way that makes people look attractive and healthy. Safety colours according to ISO 3864 shall always be recognisable and clearly discriminated. To provide an objective indication of the colour rendering properties of a light source the general colour rendering index Ra has been introduced. The maximum value of Ra is 100. This figure decreases with decreasing colour rendering quality. Lamps with Ra less than 80 should not be used in interiors where people work or stay for long periods. Exceptions can be high-bay lighting and outdoor lighting. (Industrial downlights used at mounting height in excess of 6 m.) But even here suitable measure must be taken to ensure that higher colour rendering lamps are used in continually occupied work places and where safety colours have to be recognised.

Daylight

Daylight may provide all or part of the lighting for visual tasks. Daylight varies in level and spectral composition with time and therefore provides variability within an interior. Daylight may create a specific modelling and luminance distribution due to its nearly horizontal flow from side windows. Daylight can also be provided by roof lights and other fenestration elements. Windows can also provide a visual contact with the outside world, which is preferred by most people. Avoid excessive contrast and thermal discomfort caused by direct sunlight in work areas. Provide adequate sun control such as blinds or shades, so that direct sunlight does not hit workers and/or surfaces within their field of view.

Maintenance

The sustained illuminance value indicates the recommended lighting settings for each work. The maintenance characteristics of the lamp, the luminaire, the setting, and the maintenance schedule all have a role in maintaining illumination. The chosen lighting equipment, the surroundings of the space, and the designated maintenance plan should all be taken into account when designing the lighting scheme. The computed maintenance factor should not be less than 0.70.

Energy considerations

An interior, task, or activity's lighting needs should be satisfied by the lighting installation without energy being wasted. However, it's crucial to avoid sacrificing the aesthetic appeal of a lighting design in the sake of energy efficiency. For this, suitable lighting systems, tools, controls, and the exploitation of daylighting opportunities must be taken into account. It is important to respect any country's restrictions on the amount of energy that can be used for lighting. By selecting a lighting system carefully, using automated or manual switching, or dimming the lamps, these constraints can be met.

Different Types of Light Bulbs

What types of light bulbs are there? You've probably heard of the "standard" household bulb, the incandescent light bulb, if you frequently purchase lights and bulbs for your home or place of business. Of course, there are many more sorts of bulbs, and the ones you buy for your home will come in many different variants, but for the purposes of this article, let's stick with the most popular of them all.

HALOGAN INCANDESCENT

To improve bulb efficiency, halogen incandescent bulbs contain a capsule that traps gas around a filament. They can be utilised with dimmers and come in a variety of sizes, colours, and forms. Although halogen incandescent bulbs fulfil the minimal energy efficiency requirements set by the federal government, there are now a lot more energy-efficient solutions available to suit your lighting demands.

Figure 4 (c): Halogan Incandescent Lamp

CFL's

The long tube fluorescent lights you might already have in a kitchen or garage are essentially curved variants of compact fluorescent bulbs. The typical CFL may pay for itself in less than nine months and then start saving you money each month because they use less electricity than standard incandescent lighting. When compared to an equivalent traditional incandescent bulb that produces the same amount of light, an Energy Star-qualified CFL uses around one-fourth the energy and lasts 10 times longer. less than nine months, saving you money each month.

Figure 4 (d): CFL Lamp

Fluorescent Light Bulbs

One of the most popular types of light bulbs used in homes and offices are fluorescent bulbs. They do not produce dangerous UV and UVB radiation levels and are quite safe for human eyes, especially those of children. Additionally, compared to other types of bulbs, fluorescent light bulbs consume one of the least amounts of electricity, making them an economical choice for usage in residential and commercial settings.

These fluorescent light bulbs last up to 50 years or longer without needing to be replaced and need minimal maintenance. For many uses, fluorescent light bulbs also provide a very strong light. Fluorescent light bulbs come in a wide variety that consumers can choose.

LEDs

Solid-state lighting semiconductors that turn electricity into light are typically light emitting diodes. Although they were formerly only used for traffic and indicator lights, LEDs are currently one of the most energy-efficient and quickly-evolving technologies available. The typical incandescent lights that Energy Star-qualified LEDs replace utilise only 20%–25% of the energy and last 15–25 times longer. LEDs run 8 to 25 times longer than halogen incandescent bulbs while using 25% to 30% less energy.

Figure 4 (e): LED Lamp

MAINTAINED ILLUMINANCE LEVELS WITH CORRESPONDING CRI FOR GENERAL BUILDING AREAS

(Mostly above the minimum proposed lux level but with low installed capacity)

	Monitored illumination and installed lighting power		MS1525 recommendations	
	Lux	W/m²	Lux	W/m²
Office	359 (300-500)	11.2 (9.4-13.4)	300-400	15
Lobbies	404	8.9	100	20
Atrium / Hall	654 (300-900)			20
Corridors	314	9.3	100	10
Staircase	317	21.5	100	10
Car park	171	1.5	50	5
Lift lobby	239	18.8	100	20
Lavatories	328	22.1	100	10
Canteen	340	12.7	200	15

Table 4 (f): External Benchmarking : Services - Lighting

Alternative current (AC) electric motors

- powered by alternating current (AC)
- typically consists of two fundamental components: an inside rotor coupled to the output shaft producing a second spinning magnetic field, and an outside stator with coils supplied with alternating current to produce a rotating magnetic field.
- Permanent magnets, reluctance saliency, or electrical windings can all generate the magnetic field of the rotor.
- operate on similar principles as rotating motors but have their stationary and moving parts arranged in a straight line configuration, producing linear motion instead of rotation.
- AC motors can be single- or three-phase, with three-phase motors typically being used for converting large amounts of electricity. Small power conversions employ single phase AC motors.

- Induction and synchronous motors are the two categories of AC motors.
- In synchronous motors, multiphase AC electromagnets on the stator create a rotating magnetic field while the shaft rotates at the same rate as the applied current's frequency.
- An induction motor, also known as an asynchronous motor, is a single-excited motor in which the stator receives current. The short circuited coil in the rotor is cut off by flux from the stator, which causes torque that causes the rotor to rotate.

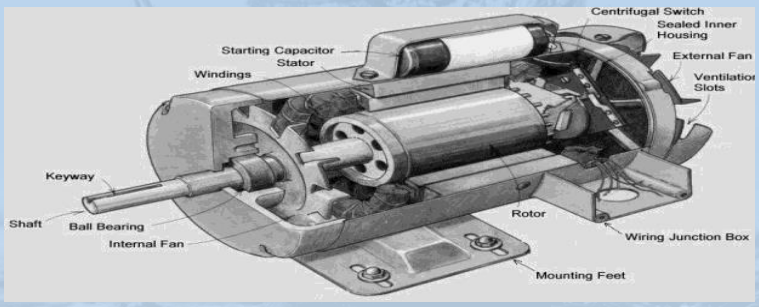


Figure 4 (f): Induction or Asynchronus motor

Operating Principles

- The two main types of AC motors are induction motors and synchronous motors.
- To induce rotor current in the rotor AC winding, the induction motor (also known as an asynchronous motor) always relies on a negligible difference in speed between the spinning magnetic field of the stator and the speed of the rotor shaft.
- Near synchronous speed, where induction (or slip) is irrelevant or disappears, the induction motor is unable to create torque.
- The synchronous motor operates either by the employment of permanent magnets, salient poles (which have projecting magnetic poles), or an independently stimulated rotor winding, all of which do not rely on slip-induction.
- A synchronous electric motor is an AC motor in which the rotation of the shaft is precisely equal to the frequency of the power supply current at steady state; the rotation period is an integral number of AC cycles.
- At precisely synchronous speed, the synchronous motor generates its rated torque. The brushless wound-rotor doubly fed synchronous motor system uses a rotor winding that is independently stimulated and does not rely on slip-induction of current theory.
- The brushless wound-rotor doubly supplied motor is a synchronous motor that can run at the supply frequency perfectly or at a frequency that is sub- to super-multiple of it.

Figure 4 (g): Synchronus Motor

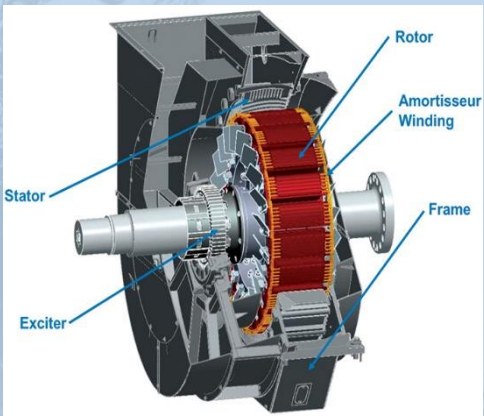


Figure 4 (h): Synchronus Motor

Why use an AC motor?

Efficiency – The great performance that AC motors provide without overheating, stopping, or degeneration is due to their high speed to torque characteristic. Because of their effectiveness, AC motors are employed in high demand applications. The outgoing mechanical energy is produced using about 85% of the entering energy.

Lifespan – Even under the worst conditions, AC motors remain reliable. Bearing replacement is the only component that might be necessary; it is a quick, simple, and inexpensive fix. Two bearings on AC motors require lubrication on occasion. One of the reasons AC motors are preferred for off-road applications or use in demanding environments is their longevity.

Quiet – Since AC motors produce relatively little noise, they are preferred in commercial settings where providing excellent customer service or serving meals is necessary. AC motors provide a low hum as their sound.

Adaptability – The adaptability and flexibility of AC motors is a result of a number of things. They are turned on via a straightforward, reversible on/off switch. They are flexible to settings with numerous users thanks in part to their variable speed and power output.

Accessibility – Every industrial operation has different circumstances that call for a number of different energy and power sources. Since AC motors are available in a variety of shapes, sizes, and power outputs, they may be simply adapted to any scenario or specially made and created to match specific and unusual circumstances.

Simplicity – One of the main advantages of using AC motors is that there is just one moving part. Both synchronous and asynchronous AC motors have the same stator. Because of their straightforward construction, they operate quietly, are inexpensive, and have a long lifespan.

Brushless – In a brush motor, the magnetic coils on the armature are powered by brushes and a commutator. This process results in energy loss, heat, and friction. By removing the brushes and commutator, a brushless motor, AC motor produces a cooler, more effective, and less wearable motor.

Self-Starting – An AC motor can only be operated via AC stimulation. An AC motor can start without the use of an additional component due to the starting mechanism's simplicity.

Speed Regulation – By altering the frequency that is transmitted to an AC motor, the speed of the motor can be made to increase or decrease..

Single Phase Input – An AC motor's capacity to function on a single phase input for a three phase motor even though the site might not have a three phase input is one example of its versatility.

MOTOR EFFICIENCY

Pole

- Poles in a induction Motor or say **magnetic poles** induction motor regulates the **speed** of the motor . As we know **sync. Speed** of induction motor is ,
- **Ns = 120 f / P**
- Where , f = frequency , **P = number of poles**
- Our supply **frequency** almost **constant** 50/60 Hz. Now the **variable parameter** to change the speed of induction motor is a pole .

- Why are motors with different number of poles? (2,4,6 or 8)
- In a 2-pole (single pole pair) motor the poles are spaced so that the rotating magnetic field makes a complete 360 degree rotation every phase period of the mains cycle.

- If you halve the pole spacing the field only rotates 180 degrees. That leaves you room to put another set on the other side of the casing to do another 180 degrees on the next time interval.
- Thus with twice the number of poles the rotating magnetic field takes twice as long to complete a revolution. It turns at half the speed.

- Since the rotor follows, (nearly in an induction motor, exactly in a synchronous motor) the rotating field , then the shaft speed is halved too.
- On an induction motor, the number of poles determines the speed given the frequency of the power. For a 2 pole motor, at 60hz, it will spin 60 times a second, or 3600rpm.
- For a 4 pole motor, the speed is halved - 1800 rpm, 6 pole, 1200 rpm and so on.

- As speed decreases, torque increases so an 8 pole motor has 4x the torque of a 2 pole motor (but 1/4 the speed).
- The synchronous speed of motor depends on number of poles so in order to achive different speed number of poles used are different.
- Ex synchronous speed = 120 f/ p
- Where p= number of poles. f= frequency
- So for f=50 and p = 2,4,6,8
- Synchronous speed = 3000, 1500, 1000, 750.
- Case 1. If number of **poles increases** then **speed** of the motor **decreases**.
- Case 2. If number of **poles decreases** the speed of the induction motor **increases**..
- **Poles** are **always in a pair** Like N - Pole and S - Pole always **exists** in a magnetic system . Separate N or S pole can't be exists. Therefore we can say maximum speed at **minimum 2 pole** we can get .
- Example: Suppose supply frequency is 50Hz and number of **poles** created by stator is **2** then,
- Ns = 120 f / P
- Ns = 120 × 50 / 2
- **Ns = 3000 RPM**
- If we increase the number poles (in pairs) then speed will be consequently decrease . If 4 poles then speed will be 1500 RPM.

2 Pole Motors vs. 4 Pole Motors

- An appliance known as a motor converts electrical energy into mechanical energy in the form of torque delivered through a shaft. It works according to Michael Faraday's definition of electromagnetic induction. Different motor types exist, including 2 pole and 4 pole motors, among others.

- A two-pole motor is one that has two magnetic poles or a pair of them, i.e. north and south. The opposite is a four-pole motor, which has two pairs of magnetic poles that are present in alternating directions, or north-south-north-south.
- The number of poles and speed are inversely related, meaning that the more poles a motor has, the slower its speed will be. Consequently, a 2 pole motor is faster than a 4 pole motor. However, a 4 pole motor is preferable over a 2 pole motor for heavy power. A 2 pole motor will always need a gearbox with a speed below 3000 rpm. On the other hand, a 4 pole motor typically does not require a gearbox.

TRANSFORMER LOSSES

Transformer

- has an iron core with two windings or coils wound on it.The core is laminated to reduce eddy currents and energy losses.
- The primary winding's magnetic flux is transmitted and trapped by the iron core.

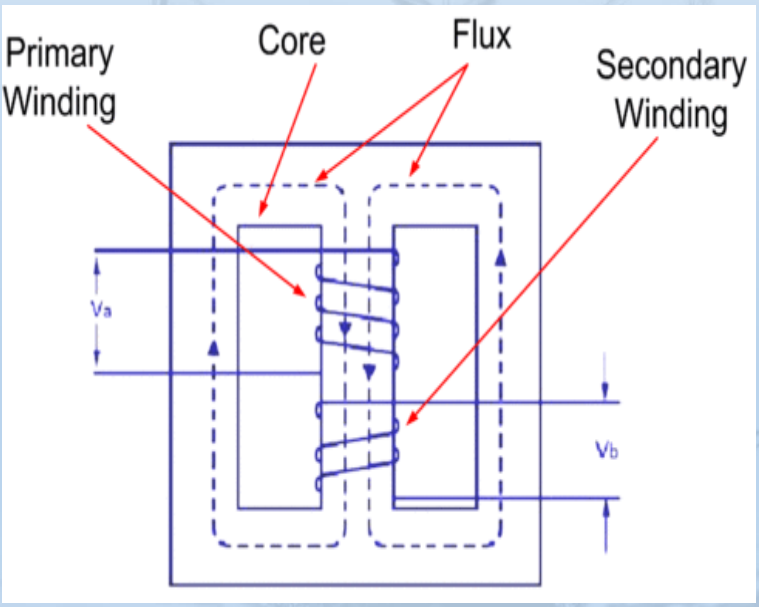


Figure 4 (i): Transformer model

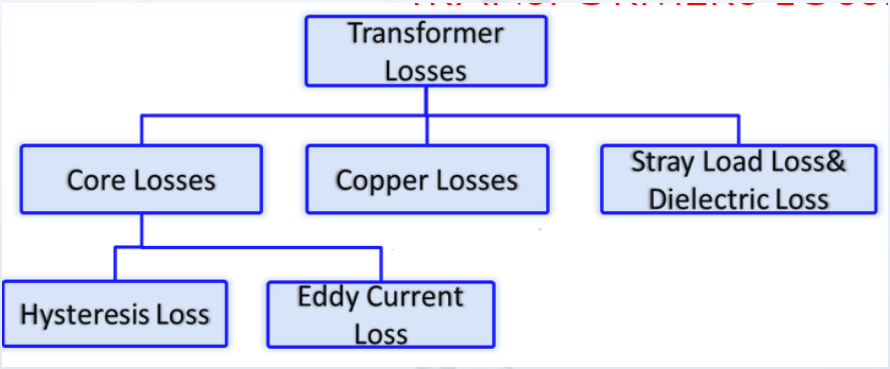


Figure 4 (j): Transformer Lossess

- A real transformer is not 100% efficient.
- Due to induction, eddy currents develop in the iron core. Laminating the iron core helped to limit this by reducing the region of induction and, thus, the size of the induced current.
- To minimise heating and losses, transformer windings are often built of thick copper.
- When the iron core is magnetised and demagnetized, hysteresis losses occur. As a result, energy is lost and heated.

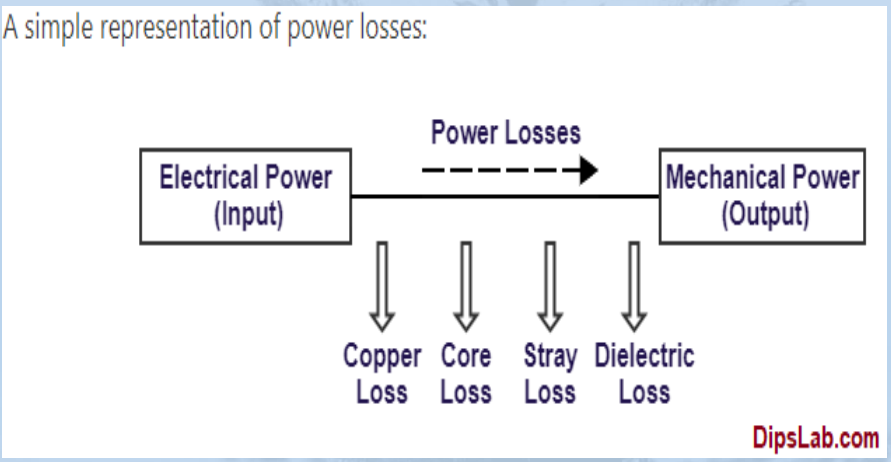


Figure 4 (k): Representation of Power Lossess

Why is transformer energy efficient?

As an electrical machine has more moving elements, such as a rotor, it often experiences more losses. In an electrical machine, the transformer is one of the static components. Mechanical loss (friction loss, bearing loss), which happens with moving parts, does not happen with static devices. The transformer only experiences winding or core loss. As a result, compared to the other components of the electrical machine, transformer losses are quite minimal. This contributes to the transformer's greater power efficiency.

In comparison to other losses (stray or dielectric losses), copper and core losses are significant losses. In transformer body parts such a transformer tank, conservator oil tank, breather, winding, etc., stray and dielectric losses have rarely happened.

Copper Loss

Ohmic loss, variable loss, and resistive loss are all terms used to describe copper loss.It happens in the copper (Cu) conductor-based transformer's primary and secondary windings, where it is common. So, core loss can also occasionally be referred to as "winding loss."

How to reduce copper losses in a transformer?

Electric current and the transformer winding's ohmic resistance (R) are the two factors that contribute to copper loss (I).

The transformer's core copper losses can be decreased in one of two ways.Vacuum Pressure Impregnation is implemented by making the transformer's winding thick in order to reduce resistance (VPI)

Core Loss or Iron loss

Core loss may also be referred to as "Magnetizing Current Loss" or "Constant Loss."It results from the alternating flux that is produced in the transformer core.It is dependent upon the design of the core and the magnetic characteristics of the materials used to make the core, such as component density, winding thickness, and lamination resistance.

How core loss is determined in transformer?

The Open circuit test or No-load test is used to calculate these losses. Two different sorts of losses make up core loss.

- Eddy Current Loss(Pe)
- Hysteresis Loss (Ph)

Eddy current loss and hysteresis loss are both influenced by the magnetic field's maximum flux density (Bmax) and frequency (f).

I. Eddy Current Loss

Eddy current is brought on by the transformer core's shifting magnetic field. Utilizing core thin lamination will allow for a reduction.

II. Hysteresis Loss

The motion of the magnetic field is what causes hysteresis loss. The reversal of magnetism causes this loss to occur.Silicon-based materials can help to decrease it.

Eddy current loss and hysteresis loss are combined to get the overall core losses.

By utilising a silicon-rich core and a thin lamination, these core losses are minimised. As a result, it offers a high permeability and low reluctance channel for the flux in the magnetic circuit.

Core type transformers experience greater power losses due to lamination than shell type transformers.

Formula

- Transformer efficiency in terms of load and no load losses may be effected using the following:

$$\text{Transformer loss percentage} = \frac{(LL + NLL) \times 100}{P.F \times KVA}$$

Where

LL is load losses in kW (winding losses);

NLL is no load losses in kW (iron losses);

$P.F$ is power factor of load; and

KVA is rated transformer capacity in KVA.

- Loss calculations would be: Iron (no load) loss + copper (load) loss.
- Iron losses = *NLL* x 8760 kWh/year, where *NLL* is the iron (no load loss) loss in kW Copper,
- load losses = *LLF* x *LL* x 8760 kWh/year, where *LLF* is the loss load factor (nominally 0.3 x *LF* + 0.7 x *LF*^2) and the *LL* is the copper loss in kW at full load.

- The total loss should be summed over the transformer life and calculated on a "net present worth" basis over that period at a reasonable discount factor, and at estimated escalating economic tariffs over the same period.
- Other methods for selection of transformer that can be adopted include assessment of "Total Present Worth" of "Capital cost plus the capitalization of the energy losses over the transformer lifetime".

Inverter

- For motors handling varying loads, variable speed drives (VSDs) or inverters should be employed.
- By altering motor speeds to accommodate for variable torque loads like fans and pumps, which generally vary their output by energy-consuming mechanical means, VSDs can cut energy usage.
- Due to their high beginning current requirements, these inverters can also be used as motor starting mechanisms or devices to reduce voltage fluctuation disturbances to nearby customers.
- The beginning mechanisms employed must be appropriate for the location's total "system stiffness," starting frequency, and load capability.
- "Soft-start" techniques should generally be the preferred choice..

Figure 4 (I): Inverter

Power Factor

- To reduce losses caused by reactive currents in the cables leading back to the main switchboard, power factor for motors must be rectified to better than 0.85 when operating at duty point.
- The utility tariff's baseline penalty of 0.85 should be the upper limit for the average power factor of the loads being supplied by the transformer. When load power factors are below the baseline penalty value, power factor correction—whether automatic or manual—to a value above the baseline penalty value should be made available.
- Power factor correction capacitors need to be of the low loss variety, with losses per kVAR at the upper temperature limit not exceeding 0.35 W, discharge resistor losses excluded.

Sub metering

- Electrical energy metres should be installed at strategic load centres to identify consumption by functional usage, facilitating the monitoring of energy consumption and energy management (air conditioning, lighting etc.)
- Electricity, water, and natural gas are delivered to buildings using meters that measure the amount of resource consumed. These master meters provide the data to bill the property, but don't break down the amount used by individual tenants or residents. In a multifamily scenario, in order to bill residents for their usage, submeters are required. Submeters allow the owner of the property to charge residents or tenants just for the amount of utilities they consumed.
- Submeters are required in many jurisdictions in new construction projects, but they can also be retrofit into existing properties.

- In essence, electric submeters are energy monitors that are connected after electric metres. Each one breaks down how much electricity is used by particular residents or housing units. In order to provide a landlord or property owner with a more accurate utility bill during the billing period, it is monitored and then broken down. Water and natural gas submetering are two other types of utility submetering.

The benefits of electrical submetering:

Successful Energy Management

In order to successfully implement an energy management system, you must collect detailed information about your energy use. Without this information, there will be no way to use effective strategies to reduce energy consumption or to determine how much energy operational processes will require. Without all of the necessary data, you'll essentially be shooting in the dark with no concept of the proper direction to go. This will result in excessively ineffective energy consumption. This will cost you a significant amount of money in the long run. It is important to gather all of the necessary tools when you begin to oversee energy management for your business.

Electrical Submetering

Electrical submetering begins with installing a power meter that measures energy use. These power meters can be implemented to measure the energy use of individual tenants, departments, buildings, appliances, and more. It can be designed to separate energy use in whatever way you want the energy to be monitored. Electrical submetering also collects the data in a single, centralized location, which makes it easy to compare and analyze the data. This can help you find where energy is being wasted, where energy efficiency could be improved, how much energy a process needs, and many other things. It will also allow you to find a pattern regarding your company's energy use. This will help you detect and resolve any significant abnormalities.

Tenant Benefits

Electrical submetering can help draw tenants to a landlord's property, as well as significantly increase their overall satisfaction. People care about energy efficiency and management, both because of how it affects their cost of operating and how it impacts the environment. Tenants will be much more likely to choose a property that implements an electrical submetering system, rather than one that uses another system or doesn't practice energy management processes. This helps to increase their overall satisfaction, because submetering allows tenants to have direct control over a portion of their overhead costs. They are able to use energy conservation strategies to lower their utility expenses.

Accurate Measurements

Electrical submetering results in effective, accurate measurements. Other methods of energy management require a certain level of estimation regarding energy consumption. Ratio utility billing, for example, separates utility bills by a percentage based on factors like the number of tenants or rooms in a unit. Though this is a superior method for splitting the bill equally between all of your tenants, it may not always accurately reflect the actual energy consumption of your tenants. A power meter measures the electrical use accurately, which will give you an exact knowledge regarding how energy is used in your business.

Figure 4 (m): Submetering

Optimize Energy Use

It is only possible to completely optimize your energy use when you have all of the necessary data. Electrical submetering will allow you to monitor every aspect of your regular energy consumption, right as it is being used. This will allow you to create and implement effective techniques to make the best possible use of your energy. Gathering all of the applicable data will allow you to determine what energy conservation methods will be the most effective for your situation.

Find Wasted Energy

Not only will electrical submetering help you determine how to optimize your energy use, but it will also help you find where energy is used excessively or wastefully. This can ultimately alert you to problems with your appliances, tools, or many other kinds of energy use. By finding where energy is being wasted, you can quickly eliminate any issues. This will save a significant amount of money for you, your company, or your tenants. It can also alert you to older, energy-guzzling appliances that are in need of an upgrade.

Understand your Energy Use

Electrical submetering gives you a very detailed picture regarding your energy use. This will help you understand how you are using energy, where you could be conserving more energy, and how much money you should budget for necessary energy expenses. Submetering services are invaluable for implementing the best energy management system possible

THE AIR CONDITIONING AND MECHANICAL VENTILATION SYSTEM (ACMV)

Air Conditioning & Mechanical Ventilation

The terms "ACMV Systems" are used to refer to two different categories for the purposes of this part:

a) central system

This kind of system further consists of:

i) Water distribution

This component provides chilled water for a central piping system, which then distributes the chilled water as needed to the conditioned space(s) of a building. The chilled water may be generated by a centrifugal, rotary, screw, scroll, or reciprocating water-chilling package.

ii) Distributed

This part is made up of terminal units that take recirculated room air from a central duct system and add outside air as needed, perform the necessary ventilation and/or air conditioning tasks, and then return the conditioned air to the central duct system for delivery to the building's conditioned space(s). These terminal units perform the cooling and dehumidification processes using chilled water that is supplied by the central piping system.The heat-rejecting element, pumps, and terminal units that are part of the water chilling package are referred to as ACMV System Components.

b) Distributed Heating & cooling (Unitary System)

This system uses one or more assembled components to chill and dehumidify the recirculated air from the conditioned space. These units contain an evaporator or cooling coil, compressor, and condenser (plus outside air as required).It is possible for the air distribution from the unitary system to the conditioned area to be either non-ducted or ducted.

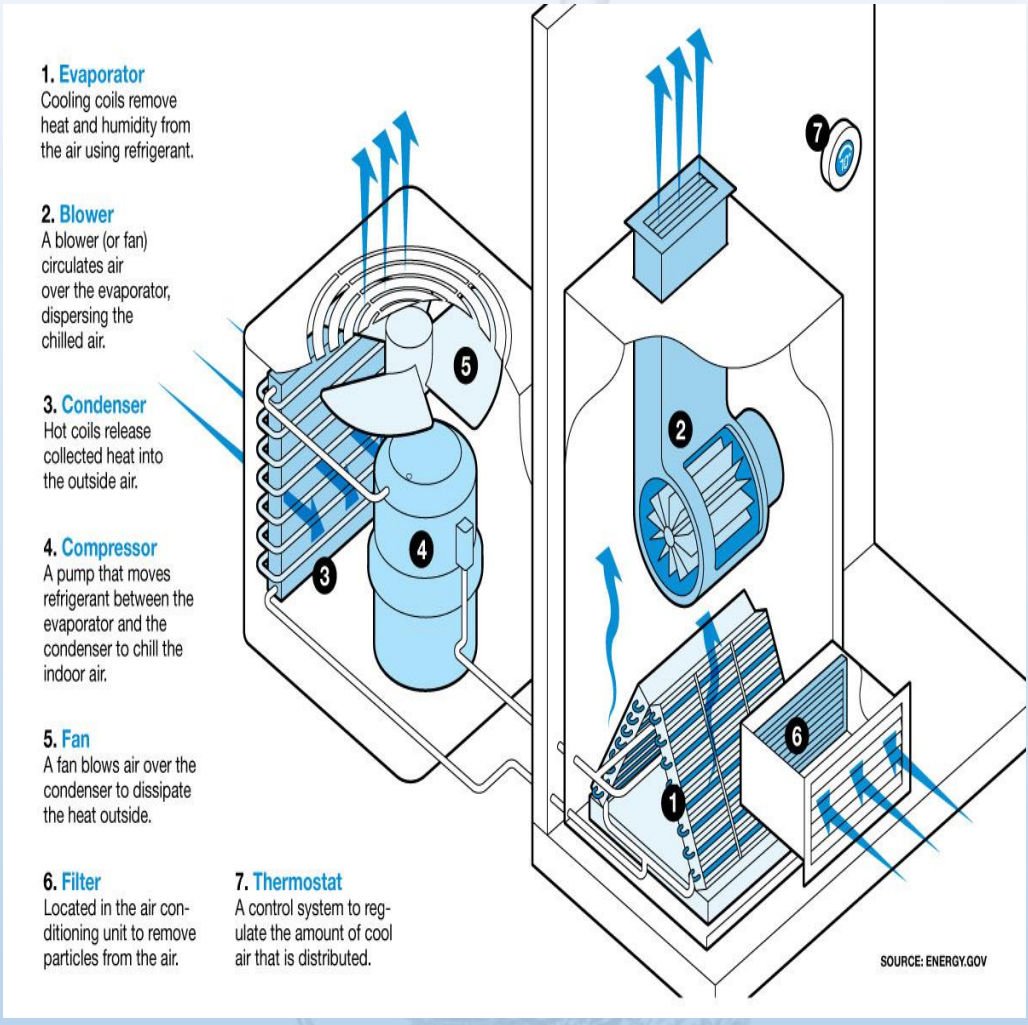
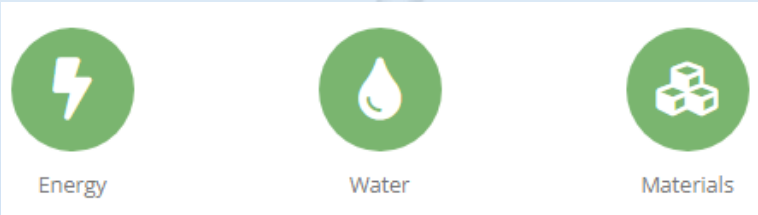


Figure 4 (n): Air Condition Diagram System

THE GREEN BUILDING INDEX (GBI)

Why Green Building Index (GBI)

A green building prioritises better siting, design, construction, operation, maintenance, and removal to maximise resource efficiency (energy, water, and material consumption), while minimising the impact of the building on human health and the environment over its lifetime. Green structures should be created and maintained in a way that lessens the overall impact of the built environment on the environment.



Green Building Index in Malaysia

- Green buildings are made to use less energy and resources, recycle more materials, and reduce the release of harmful substances throughout the course of their lifetimes.
- Green constructions blend well with the surroundings, local traditions, culture, and climate.
- Green structures preserve and enhance human existence while preserving the ability of the ecosystem on a local and global scale.
- Green buildings use resources wisely, save a lot of money on operations, and boost employee productivity.
- Building sustainably conveys the proper message about a business or organisation, demonstrating its sound management, accountability, and commitment to the long term.

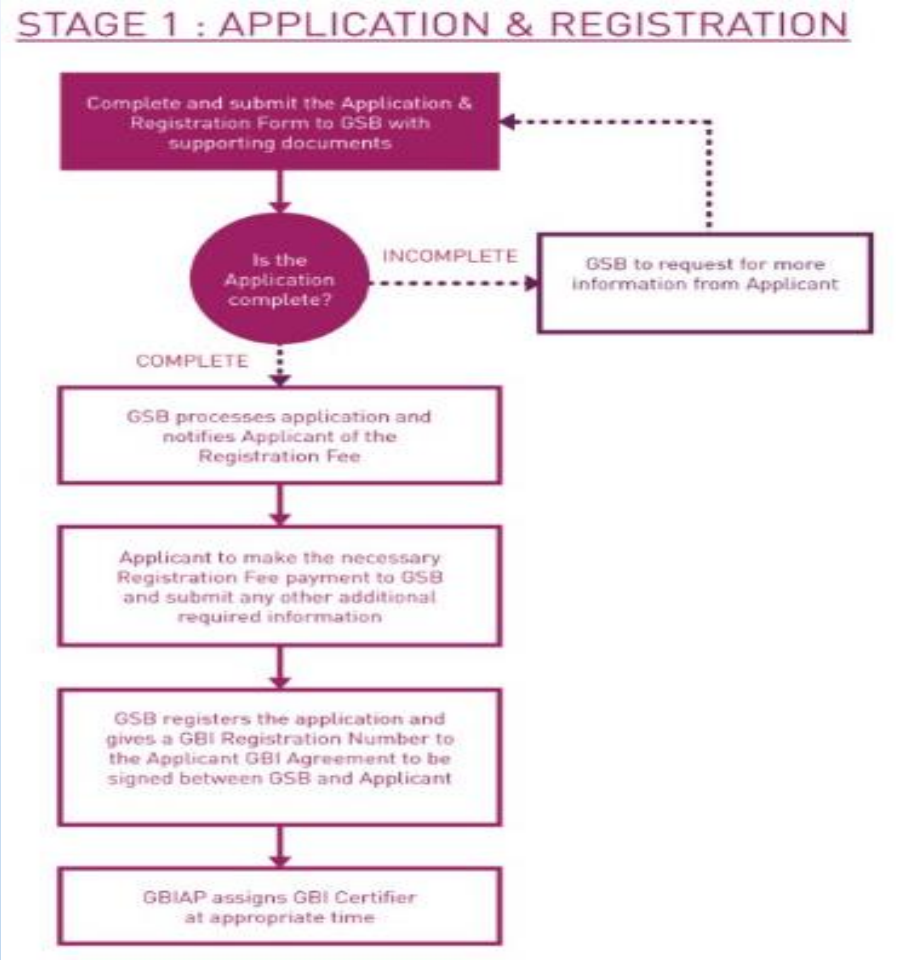


Figure 4 (o): Stage 1

STAGE 1

Application & Registration

Complete and send the GBI Application Form to Green building index Sdn Bhd with the applicant's contact information, project details, and supporting documentation (GSB). The size of the project will determine the Registration Fee. After the fees have been paid, the applicant and GSB will sign the GBI Terms & Conditions and receive a GBI registration number. The project will subsequently be assigned a GBI Certifier.

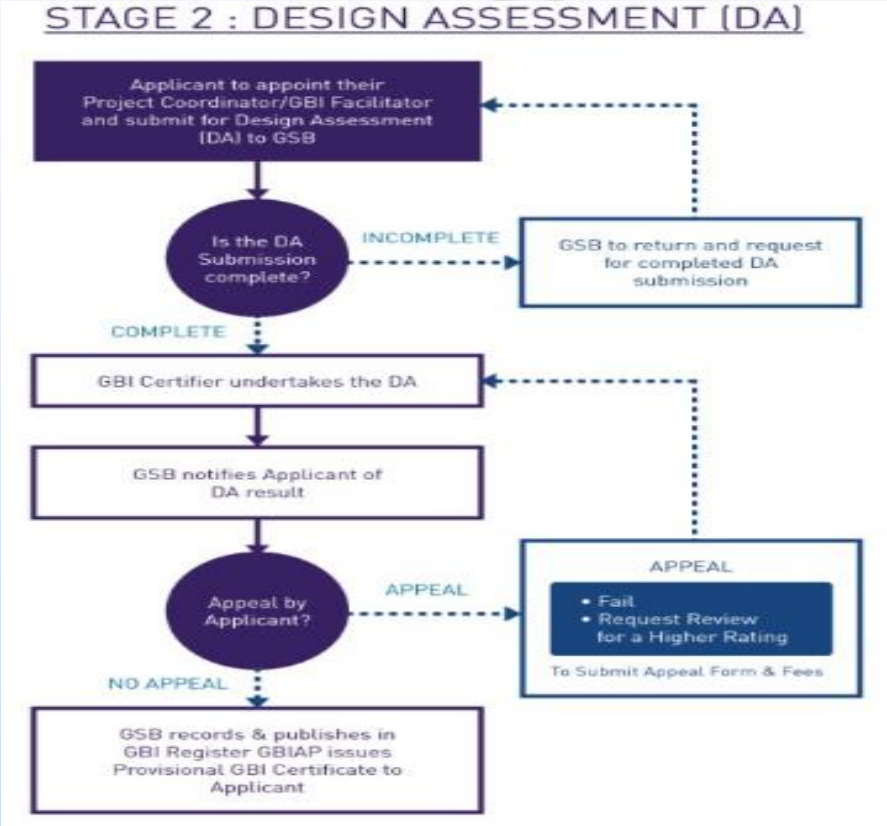


Figure 4 (p): Stage 2

STAGE 2

Design Assessment (DA)

Once the applicant is prepared, he may either submit the project directly for the GBI Design Assessment (DA) or through a designated GBI Facilitator. To enable the project to be monitored and evaluated holistically, submission should be made once all important design requirements have been resolved, ideally prior to the start of construction.

The Design Assessment for GSB will thereafter be carried out by the GBI Certifier. The GBI Facilitator or the Applicant and their Project Design Team may appear at this. Upon completion, the GBI Certifier will forward the assessment report to the GBIAP for registration and certification issuance. The GBI score sheet that goes along with the provisional GBI Design Assessment certification will then be sent out along with the results.

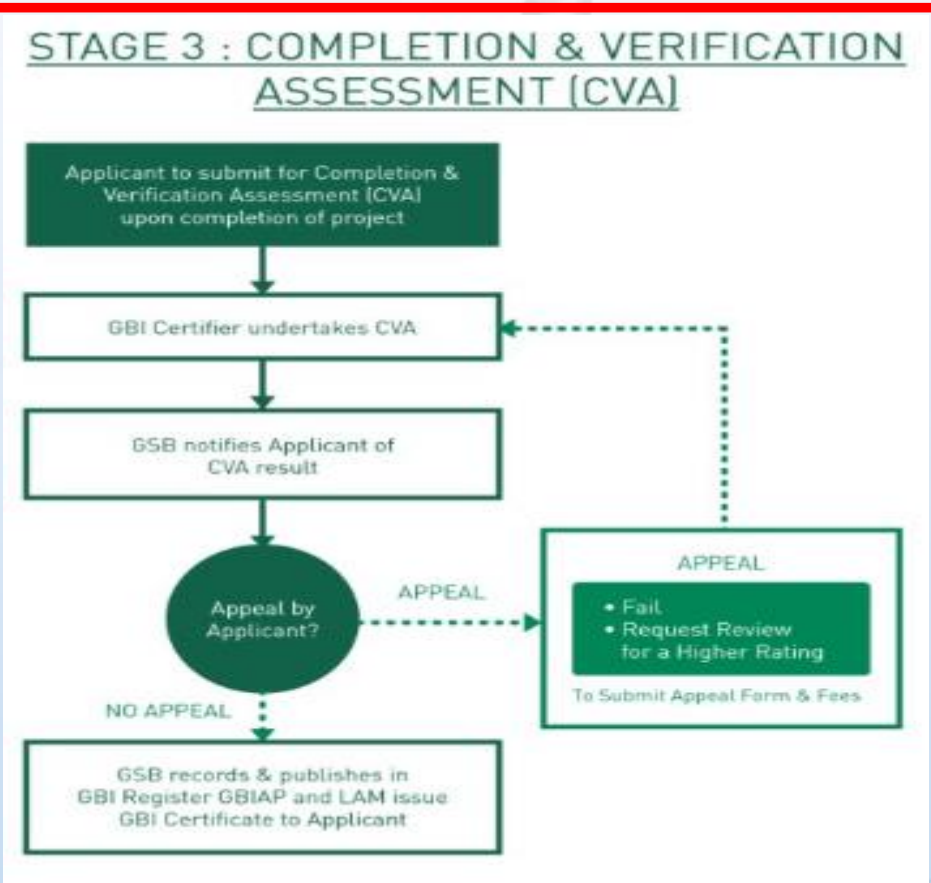


Figure 4 (q): Stage 3

STAGE 3

Completion & Verification Assessment (CVA)

The applicant should apply for the Completion and Verification Assessment once the project is finished (CVA). This must be completed within a year of the building's construction or as soon as it is 50% inhabited, whichever comes first. Upon completion of this CVA examination, the GBIAP will give the final GBI award.

Buildings are awarded GBI – Depending on the results, ratings such as Platinum, Gold, Silver, or Certified may be given. Buildings will need to undergo re-evaluation every three years in order to keep their GBI rating, which will guarantee that they are kept in good condition.

THE GBI RATING SYSTEM

The building will probably be more environmentally friendly than those that do not address the challenges if it receives points in these targeted areas. Points will also be given under the GBI assessment system for achieving and adopting environmentally friendly elements that go above and beyond standard industry practise.

ENERGY EFFICIENCY (EE)

Optimize building orientation, reduce solar heat gain through the building envelope, harvest natural illumination, embrace best practises in building services, including the use of renewable energy, and ensure proper testing, commissioning, and routine maintenance to reduce energy usage.

INDOOR ENVIRONMENT QUALITY (EQ)

Obtain high performance in the areas of thermal comfort, acoustics, visual comfort, and indoor air quality. These will entail using low volatile organic compound materials, good air filtration, and effective humidity, temperature, and air movement control.

MATERIALS & RESOURCES (MR)

Encourage recycling and the use of environmentally friendly materials that come from sustainable sources. Organize, collect, and reuse recyclables as well as construction formwork and debris as part of good construction waste management.

SUSTAINABLE SITE PLANNING & MANAGEMENT (SM)

choosing suitable locations with planned access to community amenities, open areas, and landscaping. by redeveloping existing lands and brownfields, environmentally sensitive regions can be avoided and preserved. putting in place proper construction management, storm water management, and easing the burden on the capacity of the current infrastructure

WATER EFFICIENCY (WE)

Rainwater harvesting, water recycling and water-saving fittings.

INNOVATION (IN)

Innovative design and initiatives that meet the objectives of the GBI.

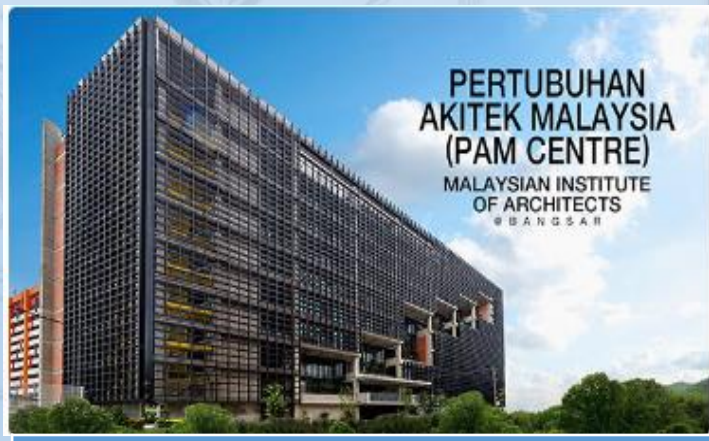
POINTS	GBI RATING
86 to 100 points	Platinum
76 to 85 points	Gold
66 to 75 points	Silver
50 to 65 points	Certified

Table 4 (g): GBI rating system

Example of Green Building

Project Description	
GBI RATING	Gold
CERTIFICATE NO	GBI-NRNC-0089
VALIDITY DATE	20 May 2024
BUILDING CATEGORY	Non-Residential New Construction (NRNC)

Figure 4 (r): GBI Rating Gold



Project Description	
GBI RATING	PLATINUM
CERTIFICATE NO	GBI-NRNC-0065
VALIDITY DATE	2nd May 2019 – 1st May 2022
BUILDING CATEGORY	Non-Residential New Construction (NRNC)

Figure 4 (s): GBI Rating Platinum

Project Description	
GBI RATING	CERTIFIED
CERTIFICATE NO	GBI-NRNC-0086
VALIDITY DATE	01-04-2024
BUILDING CATEGORY	Non-Residential New Construction (INC)

Figure 4 (t): GBI Rating Certified

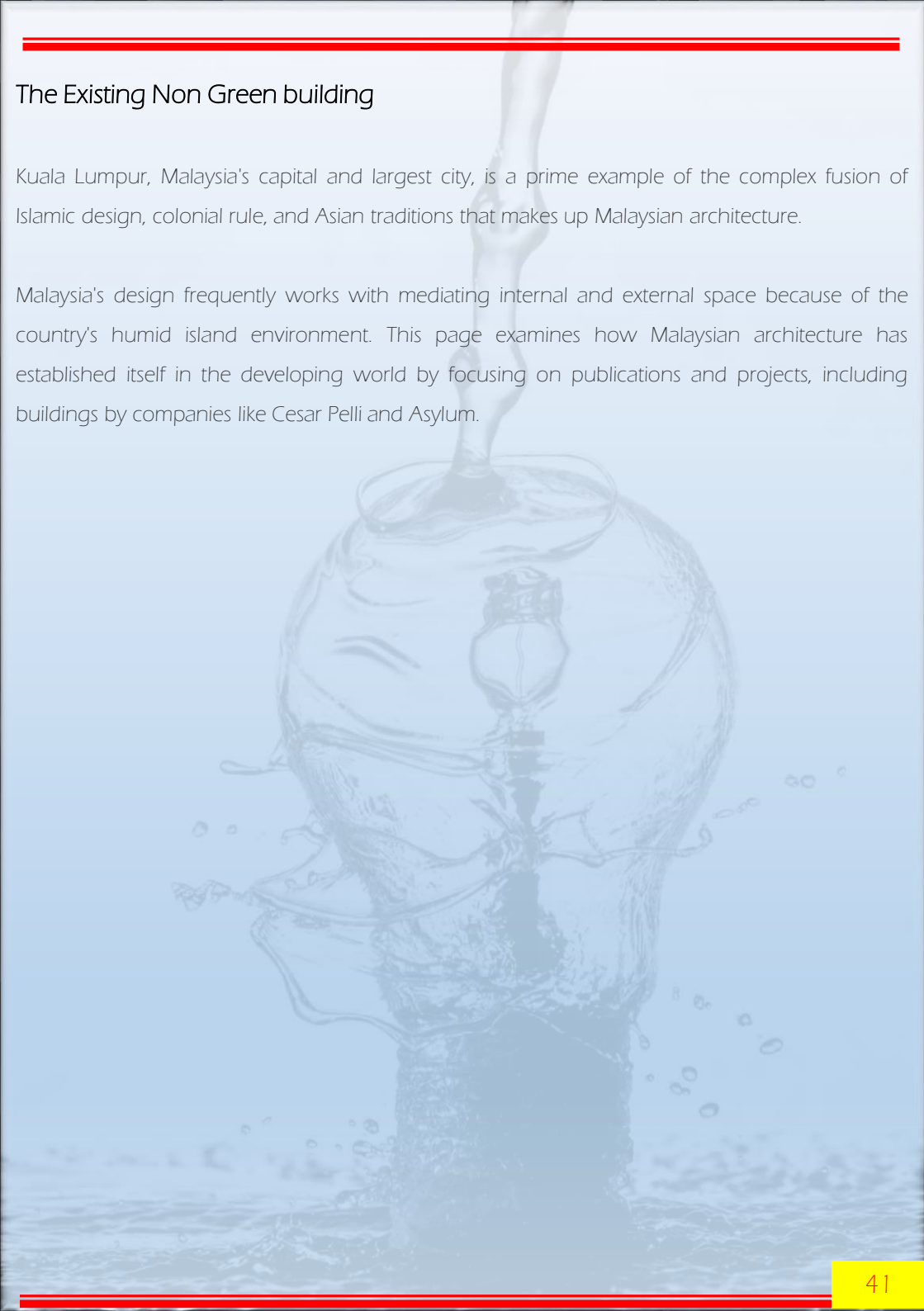
Project Description	
GBI RATING	CERTIFIED
CERTIFICATE NO	GBI-INC-0002(RVA1)
VALIDITY DATE	9th Dec 2016 – 8th Dec 2019
BUILDING CATEGORY	Industrial New Construction (INC)

Figure 4 (u): GBI Rating Certified

The Existing Non Green building

Kuala Lumpur, Malaysia's capital and largest city, is a prime example of the complex fusion of Islamic design, colonial rule, and Asian traditions that makes up Malaysian architecture.

Malaysia's design frequently works with mediating internal and external space because of the country's humid island environment. This page examines how Malaysian architecture has established itself in the developing world by focusing on publications and projects, including buildings by companies like Cesar Pelli and Asylum.



Tutorial & Answer

1. Assign why needs implement Green Buildings?

Answer

i. Designed to save energy and resources, recycle materials and minimise the emission of toxic substances throughout its life cycle,
ii. They harmonise with the local climate, traditions, culture and the surrounding environment, and
iii. Able to sustain and improve the quality of human life whilst maintaining the capacity of the ecosystem at local and global levels
iv. Have many benefits, such as better use of building resources, significant operational savings, and increased workplace productivity
v. Building green sends the right message about a company or organization – that it is well run, responsible, and committed to the future.

2. A 200 kVA rated transformer has a full-load copper loss of 1.5 kW and an iron loss of 1 kW. Determine the transformer efficiency at full load and 0.85 power factor.

Answer:

$$\text{Efficiency } \eta = \frac{Output\ power}{Input\ power}$$

$$= \frac{Input\ power - losses}{Input\ power}$$

$$= 1 - \frac{Losses}{Input\ power}$$

Full load output power = VI cos θ

= (200)(0,835) = 170 kW

Total losses = 1.5 kW + 1kW = 2.5 kW

Input power = output power + losses = 170kW + 2.5kW = 172.5 kW

Hence efficiency, $\eta = 1 - \left(\frac{2.5\ kW}{172.5\ kW}\right)$ x 100%

η = (1 - 0.01449) x 100%

= 98.55%

3. List general principle of efficient lighting practices.

Answer:

- Luminous
- Illuminance
- Glared
- Directionality
- Colour appearance
- Colour rendering
- Daylight
- Maintenance
- Energy consideration

4. What standard need to comply for code of practice on lighting?

Answer:

Compliance to MS 825 & ISO 8995

5. Describe alternative current (ac) electric motor.

Answer:

Alternative current (AC) electric motors

- is an electric motor driven by an alternating current (AC)
- commonly consists of two basic parts, an outside stator having coils supplied with alternating current to produce a rotating magnetic field, and an inside rotor attached to the output shaft producing a second rotating magnetic field.
- The rotor magnetic field may be produced by permanent magnets, reluctance saliency, or DC or AC electrical windings.

6. Why are motors with different number of poles?

Answer:

- In a 2-pole (single pole pair) motor the poles are spaced so that the rotating magnetic field makes a complete 360 degree rotation every phase period of the mains cycle.
- If you halve the pole spacing the field only rotates 180 degrees. That leaves you room to put another set on the other side of the casing to do another 180 degrees on the next time interval.
- Thus with twice the number of poles the rotating magnetic field takes twice as long to complete a revolution. It turns at half the speed.
- Since the rotor follows, (nearly in an induction motor, exactly in a synchronous motor) the rotating field , then the shaft speed is halved too.
- On an induction motor, the number of poles determines the speed given the frequency of the power. For a 2 pole motor, at 60hz, it will spin 60 times a second, or 3600rpm. For a 4 pole motor, the speed is halved - 1800 rpm, 6 pole, 1200 rpm and so on

7. Find synchronous speed related to number of pole given below:

f = 50 Hz pole = 2,4,6,8

Answer:

Formula:

Speed = 120 f/p

Pole = 2; Speed = 120(50)/2 = 3000 rpm

Pole = 4; Speed = 120(50)/4 = 1500 rpm

Pole = 6; Speed = 120(50)/6 = 1000 rpm

Pole = 8; Speed = 120(50)/8 = 750 rpm

8. List the benefits of electrical submetering?

Answer:

- Successful energy management
- Tenant benefit
- Accurate measurement
- Optimize energy use
- Find wasted energy
- Understand your energy use

END OF TOPICS 4

TOPICS 5: ENERGY EFFICIENCY AWARENESS AT RESIDENTIAL AND NON-RESIDENTIAI

- The Energy Efficiency Awareness Opportunity for Residential and Non-Residential
- The Energy Efficiency Rating and Labelling in Electrical Appliances
- The Formula to Calculate the Cost of Using Electrical Appliances
- The Electricity Consumption at Residential

START

Energy efficiency awareness opportunity for residential and non-residential

The majority of the electricity is produced using fossil fuels. Utilising electricity wisely and efficiently will lower costs while also preserving the environment and preserving the environment

What is Energy Efficiency (EE)?

EE is energy-efficient, which means using the least amount of electricity while maintaining user comfort. This entails using less electricity while still getting the same facilities and services.

Why do we need to use electricity efficiently?

- To reduce dependency on fossil fuel because:
- The supply is depleting
- The operating cost is increasing
- The greenhouse effect from carbon emission
- To preserve the environment
- To reduce the household expenses

Awareness of energy efficiency for residential and non-residential in terms of:

a) Behavior changes
b) Indoor temperature
c) Reduce heat
d) Lighting
e) Auditing on home usage
f) Use energy efficient equipment and appliances

a) Behavior changes

i. Residential

- leaving appliances (such as lights, computers, and radiant heaters) on when it's not needed or won't be for a reasonable amount of time.
- faulty equipment that isn't reported or fixed promptly, such as thermostats or lighting.
- The set-point temperatures for heating and cooling are modified rather than returned to their initial values.

ii. Non-Residential

- Make an organization-wide commitment to energy efficiency and let everyone on staff know about it.
- Launch training and educational initiatives to increase knowledge of energy efficiency, its benefits to the company, and the steps that can be taken to lower energy consumption.
- Create and implement energy-efficient operating procedures for the company's systems and equipment.

- Encourage employees to participate in the company's energy efficiency goals, such as by offering suggestions for ways to use less energy.
- Create an energy management system and allocate the necessary resources to developing, carrying out, and managing the plan.
- Look for ways to lower energy consumption for the company.
- Consider or identify a chance to increase energy efficiency. I'll give it to the Energy Champion.

b) Indoor temperature

- Follow all instructions and warnings when using the heating and cooling systems.

- Ensure the thermostats for heating and cooling are set to the appropriate temperatures. Not all areas should be at the same temperature. If you do adjust a thermostat, make sure to get it back to the original setting as soon as you can.

- Wear appropriate clothing for the season before turning on the heater or air conditioner.

c) Reduce heat

- Switching on/off the air conditioner is preferable to using a nearby fan.
- If you're using an air conditioner, make sure that all of the windows and doors are shut.

d) Lighting

- When space is empty, turn off the lights.
- Inform maintenance about broken lamps so that they can be replaced.
- Control lighting usage
- Using daylight
- Use energy efficiency lamp
- Use task light

e) Auditing on home usage

Understanding the overall picture of the home's energy usage will be made easier with the help of a home energy audit. An audit can assist in determining how much energy is used in a home, where energy is lost, and which issues and improvements should be prioritised to make the home more effective and comfortable. Conduct a home energy audit before making improvements to reduce energy consumption or installing a renewable energy system.

A qualified home energy audit will offer a thorough evaluation of the building's energy usage. In addition to evaluating the property room by room, an auditor may use tools like blower doors, infrared cameras, and (rarely) fluorocarbon tracer gas. A thorough self-assessment can help to identify problem areas and prioritise energy efficiency solutions, even though a professional energy audit offers the complete picture of the home's energy use.

f) Use energy efficient equipment and appliances.

The use of energy-intensive home appliances by households continues to make them one of the main producers of harmful greenhouse gases. Because of this, it may be ideal to utilise modern innovations to lower carbon footprint emissions, such as using energy-efficient appliances.

To help homeowners save money and energy, protect the environment, and improve lifestyles, it is crucial to have energy-efficient furniture and appliances, as shown in figure 5(a). As a result, utility costs will decrease as more energy-efficient home appliances are used and protect the environment from dangerous gases like carbon dioxide.

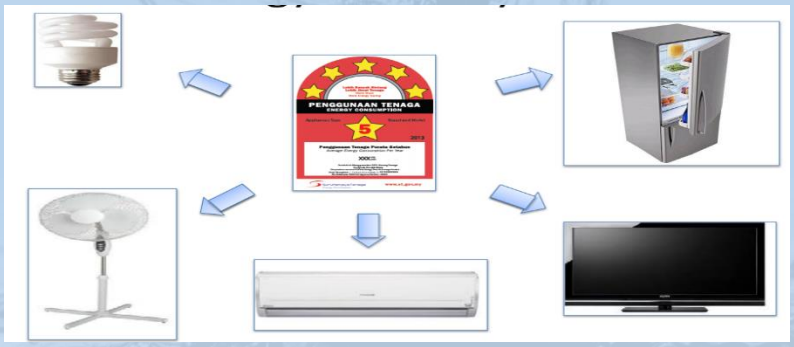


Figure 5 (a): Electrical Appliances with Star Rating

Awareness Energy Efficiency Conservation for Non-Residential

a) Energy saving policy
b) Energy saving guideline
c) Awareness campaign
d) Energy performance contracting (EPC)
e) Maintenance

a) Energy saving policy

Energy-saving policies can encourage implementing initiatives that minimise or reduce energy use during system or machine operation and/or production of a good or service.

- Energy Commission Act 2001
  - To encourage effectiveness, economy, and safety in the generation, production, transmission, supply, and consumption of electricity
  - To encourage the use of renewable energy sources and non-renewable energy preservation
- Electricity Supply Act 1990
  - To encourage the effective use of electricity efficient use of electricity
  - To establish the requirements, guidelines, procedures, and controls for the effective use of electricity
  - installation of a device to satisfy demands for the efficient use of electricity.

- Sustainable Energy
  - The provision of energy so that it satisfies current needs without endangering the ability of future generations to fulfill their own needs
- Energy Efficiency
  - Energy efficiency is using electricity sensibly or sparingly to complete the same tasks, whether at home or the office.

- Efficient Management of Electrical Energy Regulations (EMEER) 2008
  - Gazette on December 15, 2008
  - requires the appointment of a Registered Electrical Energy Manager for all installations that use or produce 3,000,000 kWh of electricity for six consecutive months.
  - Prepare an energy management goal and installation plan, and submit a six-monthly report to the Energy Commission detailing the plan's accomplishments.

- Registered Electrical Energy Manager
  - Electrical energy managers must be registered to comply with the regulations.
  - Under these Regulations, no person may engage in, hold himself out as, or be employed as, a registered electrical energy manager unless the person has first been registered by the Commission.

- Functions and Duties of Registered Electrical Energy Manager
  - to analyse and audit the total electrical energy consumption
  - to guide on creating and implementing measures to make sure effective control of the installation's electrical energy
  - to evaluate whether the measures are being applied effectively
  - to keep track of and ensure the accuracy of records regarding the installation's effective use of electrical energy
  - to make sure that reports and information are submitted on time in accordance with the rules.

- Functions and Duties of Registered Electrical Energy Manager
    - to examine and audit the overall generation or consumption of electrical energy
    - providing guidance on creating and putting into place procedures to ensure effective management of electrical energy at the installation

- Incentive for Energy Efficiency Project
    - Since 2009, the government has provided incentives to every business that wants to start energy saving projects in their installation.
    - Energy Commission will assess the projects' viability and suggested for approval in order to submit an application to MIDA.
    - Exemption from sales tax and import duties, pioneer status, and investment tax allowance through December 2015

- 24°C Policy in Government Buildings
    - All government departments and agencies have received instructions about the 24 Degree policy in government buildings from the secretary general of KeTTHA. It has been given to Suruhanjaya Tenaga to oversee and enforce the implementation. However, the monitoring is now concentrated on Putrajaya's government buildings that have signed up for the Building Consumption Input System (BCIS), which is run by the Malaysian Green Technology Corporation (MGTC).

b) Energy saving guideline

These recommendations were created by the Energy Commission with the goal of assisting building owners or occupiers in implementing energy-saving measures that call for:

- No-Cost actions that can be taken right away without paying any money. They only need your time, focus, imagination, discipline, and persistence.
- Low-cost strategies that demand little financial investment
- High-cost actions that demand large financial outlays

Measures	Examples
NO COST	• Resetting controls • Switch off when required • Reschedule loads/usage/ running hour
LOW COST	• Maintenance • Meters • Repairing leakage • Simple controls • Insulation • Training end users
HIGH COST	• Heat recovery systems • Cogeneration of heat and power • Fuel conversion • Energy management systems

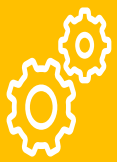


Figure 5 (b): Energy Saving Guideline

- These measures do not address or involve projects which require heavy investments. However, in many cases, it can result in significant savings. They can in fact, create the efficiency culture and behaviour change to the people as well as an organization and prepare the way for more investments in energy saving measures.
- Typical electricity distribution in Malaysian buildings as shown in figure 5(c) , consist of air-conditioning load (usually with the highest percentage), lighting, office equipment and others.

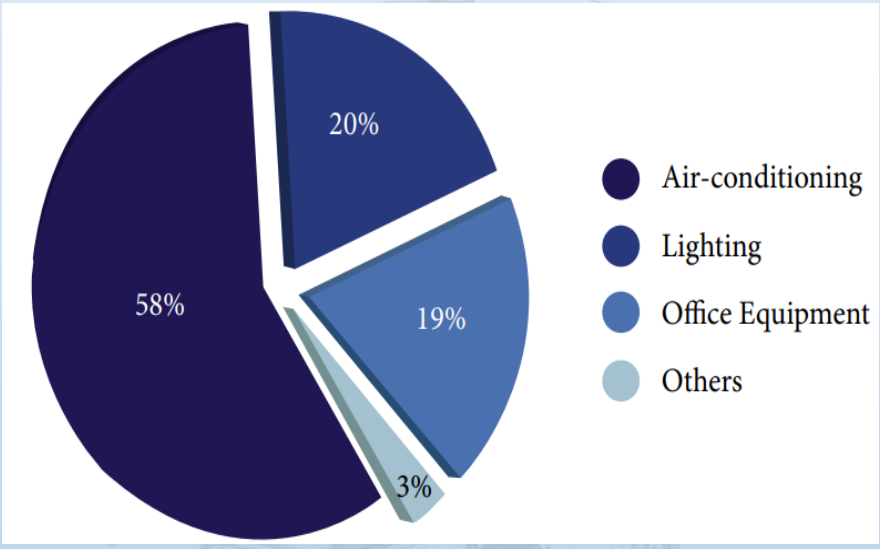


Figure 5 (c): Typical Electricity Distribution in Malaysia

➢ Initial Management Initiatives

- Create a straightforward energy management strategy with goals and make it accessible to all employees, contractors, and building occupants
- A specific individual should be chosen to handle energy management tasks. Establish an energy management team with members from diverse areas and departments

;

- Consider having a suggestion box for potential energy-saving ideas
- Give straightforward rewards for implementing energy-saving techniques
- When creating specifications and purchasing new equipment, take energy efficiency into account
- Maintain a record of the facility's energy usage. To track changes or excessive use and the reasons behind it, utilise trend consumption data
- Promote energy conservation triumphs to promote employees' commitment
- Reinvest some of the savings in more cost-cutting strategies.

➢ Energy Audit

- It is crucial to conduct an energy audit at the facility in question before beginning any energy-saving initiatives. A structure, process, or system's electrical energy usage is inspected, surveyed, and analysed as part of an energy audit. The goal is to reduce the amount of energy going into the system without adversely effecting output. Before making energy-saving retrofits, energy audits must be sufficiently accurate and reputable in order to serve as the baseline value.

- Opportunities for energy consumption reduction should be found when an energy audit is conducted in an occupied building without sacrificing the comfort, health, and safety of occupants, which are a building's main goals.

- The electrical energy that is typically used most in an industrial energy audit is that used by manufacturing equipment, lights, compressed air, and cooling. Scrubbers, vacuums, and clean rooms all use a lot of electricity
- at specialist plants.

- There are three commonly used methods in energy auditing described below;
    - In order to discover excessive or inappropriate operating costs, benchmarking or establishing baseline consumption mostly involves comparing the measured consumption to reference consumption of other buildings that are comparable to the one being measured or consumption produced by simulation tools. If the facility has a consistent load, such as a naturally ventilated school building, a benchmark can be as straightforward as kWh.

    - Benchmarking is also required to find buildings with intriguing potential for energy savings. The usage of performance indicators to describe the construction is a crucial aspect of benchmarking. These indices can be;
    - Comfort indices, which compare actual comfort levels to desired comfort levels
    - Energy indices, which split energy demands by air-conditioned space and allow comparison with reference values of the indices originating from regulations or similar structures
    - Inspection, or Initial Audit
    - The most straightforward and rapid type of audit is the preliminary audit..

- In order to become familiar with how the building operates and find any obvious areas of energy waste or inefficiency, it involves conducting only a few brief interviews with site-operating personnel, quickly reviewing facility utility bills and other operating data, and walking through the facility.
- Typically, during this kind of audit, only significant issue areas will be examined. Short descriptions of the corrective actions are given, together with quick calculations of the implementation costs, anticipated operating cost savings, and straightforward payback times.

- Also included is a list of energy conservation strategies (ECMs) that need more thought.

- The general audit builds on the preliminary audit previously discussed by gathering additional data regarding facility operations and conducting a more thorough evaluation of energy conservation and efficiency methods. For a period of 6 to 12 months, utility bills are gathered, enabling the auditor to assess the facility's energy demand rate structures and energy usage patterns. To acquire insight into short- and long-term energy consumption patterns and to better understand the principal energy-consuming systems, in-depth interviews with facility rating staff are done.

- Given the facility's operational characteristics, this kind of audit will be able to pinpoint every energy-saving technique that is suitable for the operation. Based on precise execution of cost estimates, site-specific operating cost savings, and the customer's investment criteria, a thorough financial analysis is carried out for each measure.

- BEMS & CONTROL SYSTEM
    - In order to monitor and manage the building's energy requirements, a building energy management system (BEMS) is used. The system may manage and control a wide range of other building functions, such as lighting, heating, ventilation, and air conditioning, as well as other features like illumination and security. All types of structures can use BEMS technology, however commercial buildings are where they are most widely used.

    - A crucial phase of the BEMS' implementation is commissioning. The quality assurance procedure, known as commissioning, starts with the preliminary design stages. To maximise the operation's potential and subsequently the technology's ability to save energy, it is crucial to take the BEMS technology and its necessary functions into account during the earliest stages of design.

- Incorporating a BEMS into the building's architecture is more practicable than retrofitting one into an already-existing structure. Clear design intent is ensured via the commissioning phase. The operation of the building can save a large amount of energy with the use of proper commissioning processes. A BEMS's typical functional abilities include the following.:-
    - optimising plant and building operations;
    - information about energy management;

    - Remote service and function monitoring and management for one or more buildings
    - the ability to automatically control services and tasks, such as the automated on and off of appliances;
    - monitoring of environmental and building conditions.

- One key feature of BEMS is its ability to give the site management significant real-time data on energy consumption.
- The system as a whole can be made more energy-efficient by further processing and using this data. Additionally, by streamlining the functioning of the equipment it monitors and regulates, the BEMS itself enhances energy efficiency.

c) Awareness Campaign

People are just as important as technology in making energy efficiency initiatives or programmes successful. The owners, managers, executives, operations staff, tenants, and suppliers must all be made aware of the building's potential for energy savings through an energy efficiency awareness campaign in order to maximise that potential. When developing an energy efficiency awareness programme, several stages need to be taken into account. They include:

Stage 1: Commit

The overall success of such a campaign depends on the co-operation and involvement of everyone within an organization including senior and middle management. This commitment is essential to driving an energy awareness campaign and showing staff that they are serious about making the campaign a success.

Stage 2: Identify

The identify stage is where you find out the level of energy awareness that employees currently have, what will encourage them to change behaviour and how they will get involved. It is also the stage where you will identify your message and audience.

Stage 3: Plan

It's time to start planning your programme once you've evaluated your audience and their motivation and awareness levels.

Stage 4: Take Action

Taking action should be quite simple if you have carefully planned your activities, but it still requires time, effort, and commitment.

Stage 5: Review

It's crucial to review and assess your awareness campaign at this stage. You and your team will undoubtedly have a "feel" for the campaign's reception and its effectiveness. To ensure that goals and targets are being reached, it is crucial to conduct an objective evaluation.

d) Energy Performance Contracting (EPC)

- The Energy Performance Contracting (EPC) to be implemented in government buildings was approved by the Cabinet in January 2013.
- EPC was created to get around the financial and capital costs that prevent the implementation of cost-effective energy efficiency measures.
- a wide range of energy efficiency, renewable energy, distributed generation, and efficiency measures are made available to clients. Frequently, these measures come with guarantees that the cost of the project will be covered in full by the savings generated by the project.
- Energy Performance Contracting (EPC) in government sector
  - to use an ESCO's services for a facility's energy efficiency improvement project
  - to conduct an energy audit at a site in order to assess the potential for savings
  - ESCO will propose carrying out and funding the project
  - Ensure the savings over the contract terms

  - ESCO is paid depending on the guaranteed savings realised.
  - The precise payment will be determined by a value-sharing agreement between the ESCO and the proprietor of the government facility.
  - All systems and equipment installed at the facility will be transferred to the facility's owner (Government) after the agreement expire.

e) Maintenance

- The most energy and financial savings are expected to be made at minimal expense in the area of operation and maintenance. The following popular practises provide instant savings at little or no cost:

  - Switch off lights, computer monitors, and other devices when not in use. The majority of modern machinery is built to tolerate repeated on-off cycles. The financial advantages of turning off machinery outweigh those of extending its life by leaving it on.
  - Maintain a clean environment. When encrusted with dust, grime, or scale, lighting and cooling systems produce far less than they should..
  - Utilize windows and window coverings to actively control the indoor temperature. Make sure the thermostat is calibrated appropriately as well..
  - Recognize system requirements; for instance, a compressed air plant may deliver 8 bar of compressed air whereas only 5 bar may be needed

  - The idea of reducing pressure was never considered because of erroneous information and accepted practise.
  - Utility costs should be actively handled because they are not fixed expenses. Graphing your utility bills is a useful tool for tracking energy consumption.

Energy Efficiency Rating and Labelling in Electrical Appliances

The importance of energy efficiency rating and labelling.

- Energy rating label creates awareness on the existence of electrical products that saves monthly energy bill.
- Energy rating label encourages manufacturers, importers, and dealers to promote electrical product that are energy efficient.
- Consumers can learn about an electrical appliance's energy consumption through its energy rating label..
- Based on an energy efficiency rating system, the energy rating label displays the estimated energy consumption of each piece of electrical equipment.

Energy Efficiency Label

- The Energy Commission began issuing energy efficiency labels in 2006 to electrical appliance makers who meet the rules and specifications of energy performance tests
- Based on a star rating system, the energy efficiency label for an electrical item displays its predicted energy usage. Five stars denote the best efficiency, while one star denotes the worst. It is possible to gauge how much power (kWH) the appliance uses using the star ratings.
- The simplest technique to spot energy-efficient equipment when purchasing electrical appliances is to look at its energy efficiency label.
- The energy efficiency label serves as a representation of how efficiently electrical equipment use energy.

- The Malaysian Energy Commission began enforcing the Minimum Energy Performance Standards (MEPS) regulations for standards and labelling on household electrical equipment in May 2013.
    - Refrigerator
    - Television
    - Air conditioner
    - Fan
- Benefit - Be sure to read the label when purchasing a new appliance. The most energy-efficient model can be chosen with the help of information on how much energy it uses. The most energy-efficient appliances are those with five stars, which will ultimately save you money.
    - lower the carbon impact of electrical generation
    - improve your quality of life

The Energy Efficiency Label

- Guidelines for Electrical Appliance Energy Efficiency Labeling
- Based on Electricity Regulation 1994 (Amendments 2013) Regulation 101A (3) "Any equipment that meets all the requirements of efficient use of electricity under subregulation (1) shall be affixed with an efficiency rating label in such form and manner as may be determined by the Commission." *(source: Malaysia energy Commission)*
- Before a product may be supplied to a customer, all producers and importers of the following items must attach the Energy Efficiency Label to it: television, refrigerator, home fan, air conditioner, and washing machine.

- The Energy Efficiency Label to be affixed on the appliances must be in accordance to the following specification
    - Font Specification
    - Colour Specification
    - 2-Star rating until 5-Star rating

Figure 5 (d): Energy Efficiency Label

Label 2 Star to 5 Star

Figure 5 (e): Energy Label from 2 Star to 5 Star

Discuss the energy efficiency rating and labelling for:

a) Refrigerator
b) Domestic electrical fan
c) Television
d) Air conditioner
e) Electrical lamp

a) Refrigerator

"FOURTH SCHEDULE

(Subregulation 101A (1))

ELECTRICITY SUPPLY ACT 1990

ENERGY PERFORMANCE TESTING STANDARDS, MINIMUM ENERGY PERFORMANCE STANDARDS AND EFFICIENCY RATINGS FOR THE PURPOSE OF EFFICIENT USE OF ELECTRICITY

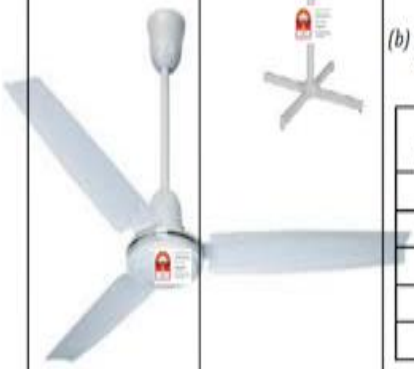
Equipment	*Type of Equipment*	*Energy Performance Testing Standards*	*Minimum Energy Perf ormance Standards (MEPS)*	*Efficiency Ratings*
Refrigerator	*(a)* one -door *(b)* two -doors	MS IEC 62552:2011 (Household refrigerating appliances - Characteristic and test methods)	MEPS's value = 2 Star	

Star Rating	Star Index Value
5	+25% <Star Index
4	+10% <Star Index <=+25%
3	-10% >Star Index <=+10%
2	-25% > Star Index > -10%
1	-35% >Star Index < -25%

Figure 5 (f): Energy Performance Testing for Refrigerator

b) Domestic Electrical Fan

Equipment	*Type of Equipment*	*Energy Performance Testing Standards*	*Minimum Energy Performance Standards (MEPS)*	*Efficiency Ratings*
Domestic fan	*(a)* wall *(b)* desk *(c)* pedestal *(d)* ceiling	*MS 1220:2001* *(performance and construction of electric circulating fans and regulators) second revision*	MEPS's value = 2 Star	*(a)* Ceiling fan: *(b)* Pedestal, wall and desk fan:



Star Rating	Star Index Value
5	≥ 3.00
4	2.74 - 2.99
3	2.66 - 2.73
2	2.58 - 2.65
1	2.50 - 2.57

Star Rating	Star Index Value
5	≥ 1.20
4	1.12 - 1.19
3	1.08 - 1.11
2	1.01 - 1.07
1	0.93 - 1.00

Figure 5 (g): Energy Performance Testing for Domestic Electrical Fan

c) Television

Equipment	*Type of Equipment*	*Energy Performance Testing Standards*	*Minimum Energy Perf ormance Standards (MEPS)*	*Efficiency Ratings*
Television	The type of television are of the following list and of size up to or equal to 70 inches: *(a)* plasma *(b)* liquid crystal display (LCD) *(c)* light emitting diode (LED) *(d)* cathode ra y tube (CRT)	*(a)* IEC 62087 Edition 2.0 2008 -10 for power measurement at On Mode *(b)* MS IEC 62301:2006 for power measurement at Standby Mode l	MEPS's value = 2 Star	Star Rating / Star Index Value 5 — +20%>Star Index 4 — +10%> Star Index <+20% 3 — -10%> Star Ind ex <+10% 2 — -20%> Star Index < -10% 1 — -30%> Star Index < -20%

Figure 5 (h): Energy Performance Testing for Television

d) Air Conditioner

Equipment	*Type of Equipment*	*Energy Performance Testing Standards*	*Minimum Energy Perf ormance Standards (MEPS)*	*Efficiency Ratings*
Air conditioner	Single split wall mounted air conditioner capacity up to 25, 000 Btu/h	MS ISO 5151:2004 (Non -ducted air conditioners and heat pumps : Test ing and rating for performance)	MEPS's value = 2 Star	*(a)* Cooling capacity < 4.5kW: Star Rating / Star Index Value 5 / >11.94 4 / 11.16 -11.93 3 / 10.37 - 11.15 2 / 9.56 - 10.36 1 / 9.00 - 9.55 *(b)* 4.5kW < cooling Capacity < 7.1kW: Star Rating / Star Index Value 5 / >10.71 4 / 9.83 - 10.70 3 / 8.94 - 9.82 2 / 8.03 - 8.93 1 / 7.50 - 8.02

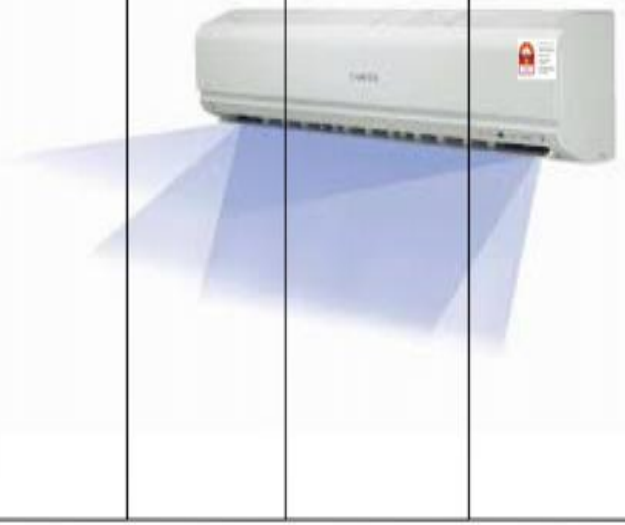
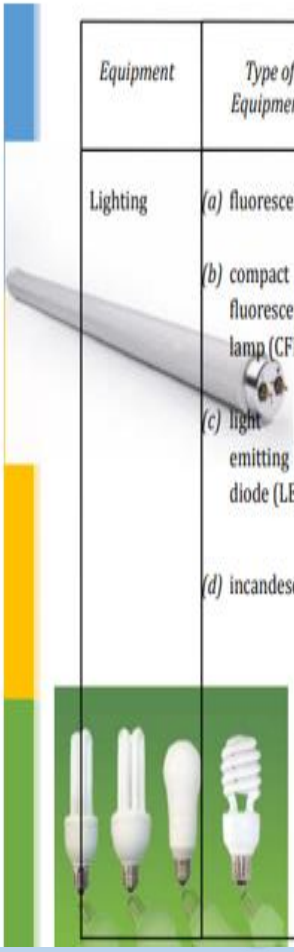


Figure 5 (i): Energy Performance Testing for Air Conditioner

e) Electrical Lamp



Equipment	Type of Equipment	Energy Performance Testing Standards	Minimum Energy Perf ormance Standards (MEPS)	Efficiency Ratings
Lighting	(a) fluorescent (b) compact fluorescent lamp (CFL) (c) light emitting diode (LED) (d) incandescent	(a) MS IEC 60969: (Self -ballasted lamps for general lighting services - Performance requirements) for fluorescent lamp (b) LM 79 -08 (IESNA Approved Method f or the electrical and photometric measurement of solid -state lighting products) for LED lights	(a) Tubular Fluorescent: (b) Other lighting type:	NIL

Type	(W)	MEPS (lm/W)
T8	18-30	70
	≥31	85
T5	14	80
	≥15	85

Figure 5 (j): Energy Performance Testing for Electrical Lamp

Equipment	Type of Equipment	Energy Performance Testing Standards	Minimum Energy Performance Standards (MEPS)		Efficiency Ratings
		(a) MS IEC 62612 (P) (Self-ballasted LED-lamps for general lighting services - performance requirement)	Type	MEPS (lm/W)	
			CFLi (Self ballasted)		
			< 9 W	55	
			9 - 15 W	60	
			16 - 24 W	60	
			≥25 W	60	
			CFL (Non integrated lamps)		
			?10 W	60	
			11 - 26 W	65	
			≥ 27 W	85	
			LED Lamp	55	
			Incandescent Lamp*	20	

Figure 5 (k): Energy Performance Testing for Electrical Lamp

Formula to calculate the cost of using electrical appliances

- Energy consumption in kWH
- Cost of energy in kWH
- Electricity consumption at residential

Calculating Energy Usage

Energy consumption in a home depends on the size of the family, lifestyle, age of equipment and fittings that are available in the house. You can calculate the approximate energy consumption at home by using this formula:

$$\text{Energy (kWh)} = \frac{\text{(Power (kW) x hour}}{1000}$$

Formula for calculating energy costs is:

$$\text{Energy Costs (RM)} = \text{Energy Usage (kWh) x Electricity Tariff (RM/kWh)}$$

The calculation is as follows:

[number of hours' use] x [number of days' use] x [[capacity of appliance expressed in watt] / 1,000] = number of kWh

To convert the amount of watts into the number of kilowatts, divide the capacity by 1,000. This provides us the number of kWh (kilowatt hours).

Example 1

Calculation for the energy consumption of a radio alarm. A radio alarm is on all the time and therefore uses energy continuously.

Hours/day	24 hours
Days/years	365
Capacity of radio alarm	10 watts
Annual energy consumption of radio alarm: 24 x 365 x (10 watts / watts / 1,000) = 87.6 kWh	

Table 5 (a): Energy Use and Calculation

Example 2

Calculate how much energy a vacuum cleaner uses. The vacuum cleaner is operated for two hours once a week, as shown in the table below.

hours / day	2 hours
days / year	52 days
Capacity of vacuum cleaner	2000 watts
Annual energy consumption of vacuum cleaner: 2 x 52 x (2,000 watts / 1,000) = 208 kWh	

Table 5 (b): Energy Use and Calculation

Example 3

Determine how much energy a refrigerator and vacuum cleaner used overall in June. Assume that a refrigerator is always on and a vacuum cleaner is used for two hours once a week. Both appliances have a 1500 watt and an 800 watt capacity, respectively.

Answer

Annual energy consumption of refrigerator: 24 x 30 x (800 watts / 1,000) =576 kWh

Annual energy consumption of vacuum cleaner: 2 x 4 x (1,500 watts / 1,000) =12 kWh

Hence, total energy consumption on June = 576 kWh + 12 kWh = 588 kWh

Investigate the Electricity Consumption at Residential

Residential energy audit

A home energy audit, also known as a home energy assessment, can help understand the whole picture of home energy use. An audit can help to determine how much energy uses, where the home is losing energy, and which problem areas and fixes should prioritize to make home more efficient and comfortable.

A home energy audit should be the first step before making energy-saving home improvements, as well as before adding a renewable energy system to the home.

Equipment	Power (watt) [a]	Daily usage (hour) [b]	Total per day (Wh) [a] x [b]
Refrigerator (1 (1 unit)	700	24	16800
Air Conditioner	1864	8	14912
Television (1 unit)	120	4	480
Iron (1 unit)	1500	0.5	750
Fan (1 unit)	75	8	600
Total			33542
1 hp equivalents to 745.7 watt			

Table 5 (c): Energy Use by Electrical Appliances

Overall, the total daily energy consumption at home can be estimated through the formula,

Energy Usage = 33,542 Wh

1 kilowatt = 1000 watt. Thus, the total energy consumption in kWh is:

Energy Usage (kWh) = (33,542 Wh)/1000
Energy Usage = 33.5 kWh per day
Or 33.5 kWh x 30 days = 1005 kWh per month

By using electricity tariffs, domestic (tariff A), it can be concluded that the energy cost for a month is:

Energy Usage (kWh) [a]	Tariff Rate (sen/kWh) [b]	Total (RM) [a] x [b]
0 – 200 (200)	21.80	43.60
201 – 300 (100)	33.40	33.40
301 – 600 (300)	51.60	154.080
601 – 900 (300)	54.60	163.80
901 – 1005 (105)	57.10	59.95
	TOTAL	455.55

With this energy consumption trend, the user will pay RM455.55 a month or RM 5466.60 per year. The next example will discuss ways to choose energy efficient appliances and how to ensure this appliance operate at optimum level.

Example 1

Table below shows the types of loads in residential areas. Investigate and complete the total annual energy consumption and apportioning (in percentage) for each load in a year. If we replace all the lighting from 30 WATT to led light bulb 10 Watt and given the average tariff is 33.40 cent/kWh, analyze annual electricity savings in kWh and RM.

Type of load	Power (W)	Daily Operation Hours	Annual Energy (kWh)	Load Percentage (%)
1 water dispenser	900	24		28.02
2 ceiling fan	150	8		
1 iron	1200	5	2190000	
1 Rice Cooker	700	0.75		
10 light bulb	30	5		
1 refrigerator	1700	24		52.94
1 Air Conditioner	850	5	1551250	

Annual Energy (kWh)

Water dispenser = 1 x 900 x 24 x 365 days = 7884000 kWh

Ceiling fan = 2 x 150 x 8 x 365 days = 876000 kWh

Iron = 1 x 1200 x 5 x 365 days = 2190000 kWh

Rice cooker = 1 x 700 x 0.75 x 365 days = 191625 kWh

Light Bulb = 10 x 30 x 5 x365 days = 547500 kWh

Refrigerator = 1 x 1700 x 24 x 365 days = 14892000 kWh

Air Conditioner = 1 x 850 x 5 x 365 days = 1551250 kWh

Total annual in kWh = 7884000 + 876000 + 2190000 + 191625 + 547500 +14892000 + 1551250

= 28,132,375 kWh

Load Percentage (%)

Water dispenser = (7884000/28132375)x100%=28.02%

Ceiling fan = (876000/28132375)x100%=3.11%

Iron = (2190000/28132375)x100%=7.78%

Rice Cooker = (191625/28132375)x100%=0.68%

Light Bulb = (547500/28132375)x100%=1.95%

Refrigerator = (14892000/28132375)x100%=52.94%

Air Conditioner = (1551250/28132375)x100%=5.51%

Light Bulb Replacement

Light Bulb = 30 Watt to LED light Bulb = 10 Watt

Different between light bulb 30 Watt and LED light bulb = 30–10 = 20 Watt

Saving in kWh = 20 Watt x 10 unit = 200 Watt = 200 x 5 hours = 1.0 kWh

Saving energy charge = 1.0 kWh/day x 365 days = 365 kWh/year =365 kWh/year x RM 0.334/kWh= RM 121.91

Potential Ways to Reduce the Energy Consumption

- Turn of all unnecessary light
- Use the stairs
- Switch PC to sleep mode when unused
- Use electrical appliance wisely
- Keep windows shut when the air-condition us switched on
- Ensure all electrical appliances are turn off before leaving the house or office
- Set up air conditioner not less than 24^{o}C
- Try to iron clothes in one time rather than rapidly
- Use energy efficient lamps/bulbs
- Use electrical appliances with 5-Star labelling

Tutorial & Answer

1. Discuss the importance of energy efficiency rating and labelling.

Answer:

- Energy rating label creates awareness on the existence of electrical products that saves monthly energy bill.
- Energy rating label encourages manufacturers, importers, and dealers to promote electrical product that are energy efficient.
- Energy rating label provides information to consumers about the energy consumption of an electrical appliance.
- Energy rating label shows the estimated energy consumption of each electrical equipment based on energy efficiency rating system.

2. Calculate total annual energy consumption of an oven and radio . Assume the oven is used for 1.5 hours once a week and a radio is used 12 hours everyday. The capacity for both appliances are 1500 watts and 50 watts respectively.

Answer:

Radio	Oven
Annual energy consumption of radio: 12 x 365 x (50 watts / 1,000) = 219 kWh	Annual energy consumption of radio: 1.5 x 52 x (1500 watts / 1,000) = 117 kWh

3. Calculate the electricity bill of the month for the list of appliances below. Given the tariff A for domestic usage in Table 1.

Appliance	Power (Watt)	Operation hours/day
3 Fan	60	4
8 Fluorescent lamp	38	5
1 Refrigerator	700	24
1 Television	100	4

Energy Usage (kWh)	Tariff Rate (sen/kWh)
0 – 200 (200)	21.80
201 – 300 (100)	33.40
301 – 600 (300)	51.60
601 – 900 (300)	54.60
901 – 1005 (105)	57.10

Answer:

Appliance	Power (Watt)	Operation hours/day	Energy Usage (kWh)
3 Fan	60	4	0.72
8 Fluorescent lamp	38	5	1.52
1 Refrigerator	700	24	16.8
1 Television	100	4	0.4
Total for 1 day			19.44
Total for 1 month	30 x 19.44 = 583.2		
Electricity bill	For 200 kWh = 200 x 21.8 = RM 43.60 For 100 kWh = 100 x 33.4 = RM 33.40 For 283.2 kWh = 283.2 x 51.6 = RM 146.13 Total = RM 223.13		

4. Calculate the active power (kW), apparent power (kVA), energy (kWh) and load percentage in Table 1. Which the percentage of load are major?

Load	Volt	Amp	PF	Hours	Power (kW)	Power (kVA)	Energy (kWh)	Load Percentage
Chiller	415	425	0.8	12				
CHWP	415	45	0.8	12				
CDP	415	33	0.8	12				
CT	415	14	0.8	12				
AHU	415	42	0.8	12				

Answer

Load	Volt	Amp	PF	Hours	Power (kW)	Power (kVA)	Energy (kWh)	Load Percentage
Chiller	415	425	0.8	12	141.1	176.38	1693.2	76.03
CHWP	415	45	0.8	12	14.94	18.68	179.28	8.05
CDP	415	33	0.8	12	10.96	13.7	131.52	5.91
CT	415	14	0.8	12	4.65	5.81	55.8	2.51
AHU	415	42	0.8	12	13.94	17.43	167.28	7.51
Total							2227.08	

5. Table 2 show types of loads in the residential. Investigate the total annual energy consumption, apportioning (in percentage) for each load and saving while replace 20 light bulb in a year. If we replaced all the light bulb from 36 Watt to LED light Bulb 14 Watt and given average tariff is 33.40 cent/kWh.

Types of load	Power (W)	Daily Operation Hours	Annual Energy (kWh)	Load Percentage (%)
4 Air Conditioner	750	7		
1 Iron	1000	5		
1 Kettle	850	0.5		
20 Light Bulb	36	5		
1 Refrigerator	1200	24		
1 Rice Cooker	350	0.3		
2 Television	150	5		
Total				

Answer:

Annual Energy (kWh)

Air Conditioner = 4 x 750 x 7 x 365 days = 7665.00 kWh

Iron = 1 x 1000 x 5 x 365 days = 1825.00 kWh

Kettle = 1 x 850 x 0.5 x 365 days = 155.13 kWh

Light Bulb = 20 x 36 x 5 x 365 days = 1314.00 kWh

Refrigerator = 1 x 1200 x 24 x 365 days = 10512.00 kWh

Rice Cooker = 1 x 350 x 0.3 x 365 days = 38.33 kWh

Television = 2 x 150 x 5 x 365 days = 547.50 kWh

Total annual in kWh = 22056.99 kWh

Load Percentage (%)

Air Conditioner = (7665/22056.96) x 100% = 34.75 %

Iron = (1825/22056.96) x 100% = 8.27 %

Kettle = (155.13/22056.96) x 100% = 0.7 %

Light Bulb = (1314/22056.96) x 100% = 5.96 %

Refrigerator = (10512/22056.96) x 100% = 47.66 %

Rice Cooker = (38.33/22056.96) x 100% = 0.17 %

Television = (547.50/22056.96) x 100% = 2.48 %

Light Bulb Replacement

Light Bulb = 36 Watt to LED light Bulb = 14 Watt

Different between light bulb 36 Watt and LED light bulb = 36 – 14 = 22 Watt

Saving in kWh = 22 Watt x 20 unit = 440 Watt

= 440 x 5 hours = 2.2 kWh

Saving energy charge = 2.2 kWh/day x 365 days = 803 kWh/year

= 803 kWh/year x RM 0.334/kWh = RM 268.20

6. List **SIX (6)** potential ways to reduce the energy consumption in this residential.

Answer:

i. Turn of all unnecessary light
ii. Use the stairs
iii. Switch PC to sleep mode when unused
iv. Use electrical appliance wisely
v. Keep windows shut when the air-condition us switched on
vi. Ensure all electrical appliances are turn off before leaving the house or office

END OF TOPIC 5

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