Guidelines to Practice Energy Efficiency in CKE Design

1.0 Introduction

Energy Efficiency (EE) in the JKR context means the efficient utilization of energy during the operational lifespan of a building where the comfort of its occupants is not compromised nor sacrificed. Initially EE can be achieved by wisely taking various energy saving measures during the design stage of the building. In projects designed by JKR, energy in buildings is associated mainly with electricity. Often this is mistakenly taken to imply that EE is the sole responsibility of electrical engineers. In reality, anything that leads to the eventual end-use of electricity is related to EE in buildings.

2.0 Integrated Design Approach

Integrated building design is a process of design in which multiple disciplines and seemingly unrelated aspects of design are integrated in a manner that permits synergistic benefits to be realized. The goal is to achieve high performance and multiple benefits at a lower cost than the total for all the components combined. This process often includes integrating green design strategies into conventional design criteria for building form, function, performance and cost.

To achieve EE in JKR constructed buildings, it can be carried out by applying both passive and active design strategies.

Passive design strategies includes adopting design measures such as building orientation and shape, site planning, selection of building envelope wall and roof materials with low thermal mass conductivity, building shading design, window type and design, type of glazing, daylight harvesting strategy, using natural ventilation and good landscaping design.

While active design strategies refers to selecting energy efficiency equipment, utilities systems, control system and strategy that result in direct reduction in the building energy running costs. This includes using high efficiency HVAC system, such as using Variable Air Volume (VAV) or chilled beam air condition technologies; using high efficiency motors, pumps and fans, Variable Speed Drivers (VSDs) with motor driving pumps and fans with variable loads; use of high efficient lighting system and occupancy sensor and use of effective control system such as Building Automation System (BAS).

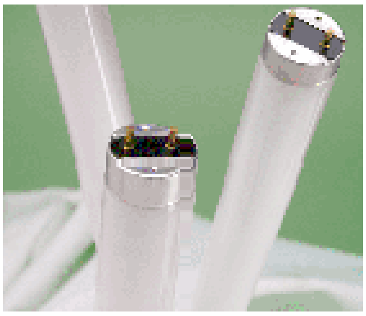
In Cawangan Kejuruteraan Elektrik we are focused on active design strategy one of which is includes Electric Lighting Design. This will be focused in this guideline.

3.0 Lighting Design

3.1.1 Types of Lighting

There are many type of lighting products including light bulbs, lamps, ballast, fluorescent lamps and fluorescent fixtures, troffers, track light, emergency fixtures, batteries, incandescent lighting, high intensity discharge (HID) lamps and fixtures, rope lights, mercury lamps, dimmers and other products for area lighting.

For domestic and industrial use, the selection of lighting, in term of wattage and colour rendering, is important in ensuring the right environment for a working area and the efficient utilization of energy, without jeopardizing any visual elements.



Several Types of Energy Efficient Lights

3.1.2 Electronic Ballast for Fluorescent Lighting

Although electronic ballast saves substantial amount of energy, it is not widely used to replace the relatively energy-inefficient standard electromagnetic ballast because of its higher cost

Electronic ballast gives significant energy savings with fluorescent lighting, typically reducing power consumption by around 25%. Electronic ballast is designed to last 10 to 15 years lifetime with long burning times and low switching frequencies. They are more compact and 60% lighter weight than electromagnetic ballasts.

Using electronic ballasts give freedom from the 50Hz lamp flicker, making lighting much easier on the eyes. There is no audible hum and lower heat generation, contributing to improved working conditions. Lamp starting is instantaneous; these ballasts also prevent stroboscopic effects which can be dangerous where rotating machinery is used.

Several Types of Energy Efficient Electronic Ballasts

3.1.3 Electromagnetic Ballast

The type of electromagnetic ballast must be energy efficiency and energy saving. The Code of Practice has called for fluorescent ballast loss not to exceed 6.0 W in accordance to MS IEC 60929:1995.

3.2 Lighting Design Criteria

3.2.1 Luminous Environment

Good lighting practice for workplace is more than just providing good task visibility. It is essential that tasks are performed easily and in comfort. Thus, the lighting must satisfy the quantitative and qualitative aspects demanded by the environment. In general lighting is to ensure:

i. visual comfort, where the workers have a feeling of well-being
ii. visual performance, where the workers are able to perform their visual tasks, speedily, and accurately, even under difficult circumstances and during long periods
iii. visual safety, to see one's way around the detect hazards.

Accordingly, to have a good lighting design, the following criteria should be taken into consideration:

i. Luminous environment
ii. Luminance distribution
iii. Illuminance
iv. Glare
v. Directionality of light
vi. Colour aspects of light and surfaces
vii. Flicker
viii. Daylight
ix. Maintenance

Design values for the quantifiable parameters of illuminance, discomfort, glare and colour rendering are presented in Appendix 1.

3.2.2 Luminance Distribution

The luminance distribution in the field of view controls the adaptation level of the eyes, which affect task visibility. A well-balanced adaptation luminance is needed to increase:

i. visual acuity (sharpness of vision)
ii. contrast sensitivity (discrimination of relatively small luminance differences)
iii. efficiency of the ocular functions (such as accommodation, convergence, papillary contraction, eye movements, etc.)

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

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

The luminance of all surfaces is important and will be determined by the reflectance of and the illuminance of the surfaces. The range of useful reflectance for the major interior surfaces is given in Table 1 below.

No	Interior Surfaces	Range of Useful Reflectance
1	Ceiling	0.6 – 0.9
2	Walls	0.3 – 0.8
3	Working Planes	0.2 – 0.6
4	Floor	0.1 – 0.5

Table 1: Range of useful reflectance for the major interior surfaces

3.2.3 Illuminance

The illuminance and its distribution on the tasks areas and the surrounding area have a major impact on how quickly, safely and comfortably a person perceives and carries out the visual task. For spaces where the specific area is unknown, the area where the task may occur is taken as the task area.

All value of illuminance specified in this guideline are maintained illuminance and will provide for visual safety at work and visual performance needs. The details of this can be referred to Appendix 2

3.2.3.1 Recommended illuminance at the task area

The values given in Appendix 2 are the maintained illuminance over the task area on the reference surface which may be horizontal, vertical or inclined. The average illuminance for each task shall not fall below the value given in Appendix 2 regardless of the age and condition of the installation. The values are valid for normal visual conditions and take into account the following factors:

i. requirement for visual tasks
ii. safety
iii. psycho-physiological aspects such as visual comfort and well-being
iv. economy
v. practical experience.

The value of illuminance may be adjusted, by at least one step on the scale of illuminance, if the visual conditions differ from the normal assumptions. The illuminance should be increased when:

i. unusually low contrasts are present in the task
ii. visual work is critical
iii. errors are costly to rectify
iv. accuracy or higher productivity is of great importance
v. the visual capacity of the worker is below normal.

The required maintained illuminance may be decreased when:

i. the details are of an unusually large size or high contrast
ii. the task is undertaken for an unusually short time.

In area where continuous work is carried out, the maintained illuminance shall not be less than 200 lux.

3.2.3.2 Scale of illuminance

A factor of approximately 1.5 represents the smallest significant difference in subjective effect of illuminance. In normal lighting conditions, approximately 20 lux of horizontal illuminance is required to just discern features of the human face and s the lowest value taken for the scale of illuminance. The recommended scale of illuminance is:

20 – 30 – 50 – 75 – 100 – 200 – 300 – 500 – 750 – 1000 – 1500 – 2000 – 3000 – 5000 lux.

3.2.3.3 Illuminance of immediate surroundings

The illuminance of the immediate surroundings areas shall be related to the illuminance of the tasks area and should provide a well-balanced illuminance distribution in the field of view. Rapid spatial changes in luminance around the tasks area may lead to visual stress and discomfort.

The maintained illuminance of the immediate surroundings areas may be lower than the tasks illuminance but shall not be less than the values given in the table below.

Task illuminance lux	Illuminance of immediate surrounding lux
≥ 750	500
500	300
300	200
≤ 200	Same as task illuminance

Table 2: Illuminance of immediate surroundings and task illuminance

3.2.3.4 Uniformity

The uniformity of the illuminance is the ratio of the minimum to average value. The illuminance should change gradually. The task area should be illuminated as uniformly as possible. The uniformity of the task illuminance shall not be less than 0.7. The uniformity of the illuminance of the immediate surrounding areas shall be not less than 0.5.

3.2.3.5 Colour aspects

The colour qualities of a near-white lamp are characterized by two attributes:

i. The colour appearance of the lamp itself
ii. Its colour rendering capabilities, which affect the colour appearance of objects and persons illuminated by the lamp.

These two attributes must be considered separately.

Colour Appearance

The variation in the amount of colours within a light mixture affects the appearance of the light in terms of its relative ‘warmness’ or ‘coolness’. To describe this ‘warmness’ and ‘coolness’ of the colour of the light sources, the term ‘colour temperature’ is used.

Colour Temperature or Correlated Colour Temperature (CCT) due to its theoretical basis in the study of ‘black body’ radiation should apply only to source with a continuous spectrum (such as incandescent lamps and natural light). However, for light sources with non continuous spectral distribution (such as fluorescent lamps where the spectrum consists of peaks of energy), CCT is used mainly on an empirical sense (i.e. in a very ‘near approximate’ sense).

Colour Rendering

A more common method of characterizing light sources by its colour is the Colour Rendering Index (CRI). The CRI compares the spectral energy content of a light source to that of a standard reference source with full spectrum. The CRI value is the numerical value and is 100 for full-spectrum natural white-light. Incandescent lights are considered nearly white and have CRI close to 100. Most lights have CRI typically in the range of 20 – 80.

The CRI model is not a perfect model and should only be used to compare light source with the same colour temperature. For example, (about) 6000K daylight fluorescent and clear mercury has CRI of 76 and 22 respectively. The daylight fluorescent will therefore render colours better than clear mercury. The difference between a 3400K tungsten halogen with CRI 99 and an ordinary 2800K incandescent with CRI 92 can usually also be differentiated by most observers. Despite the small difference in CRI values, the tungsten halogen will render colours more vividly compared to the ordinary incandescent. Colour rendering is important especially in the case of (building) façade and monument building.

3.2.4 Daylight

Daylight may provide all or part of the lighting for visual tasks. Daylight may create a specific modeling and luminance distribution due to its nearly horizontal flow from side windows. Daylight can also be provided by roof lights and other fenestration elements. An automatic or manual switching or dimming of the lamps is required during day time depending on the visual acceptance limit.

3.2.5 General Principles of Efficient Lighting Practice

Lighting must provide a suitable visual environment within a particular space, i.e. sufficient and suitable lighting for the performance of a range of tasks and provision of a desired appearance.

The maintained illuminance levels and maximum allowable power for illumination systems for general building areas are as given in Table 3.

For a building comprises one or more discrete spaces, the lighting power density of each space should not exceed the corresponding maximum allowable value as listed in Table 3.

Building Types / Space	**Recommended average Illuminance levels (Lux)**	**Max. lighting power (W / m²)**
Food Service	200	14
Cafeteria	200	14
Leisure Dining / Bar	150	14
Fast food	200	20
Office	300 – 400	20
Supermarket / Department Store	200 – 750	30
Retail Shop	200 – 750	20
Main Concourse at multi – store shopping centre	200 – 750	15
Basement Car Park	50	5
Hotel / Motel:		
Guest room & Corridor	100	17
Public Area	100	20
Banquet & Exhibit	300	20
Store / Stairs / Lavatory	100	10
Classroom	300 – 500	18
Lecture Theatre / Auditorium	300 - 400	25

Table 3: Recommendation average illuminance levels and maximum allowable values of Lighting Power Density

3.3 Efficiency of Luminance

The efficiency of a light source depends to large extent on how efficient (L.O.R) and performance of the lighting fixtures.

A lamp that produces 20 lumens / watt, when installed, may actually distribute only 10 lumens when covered by dust.

3.4 Lighting Zone Control

All spaces enclosed by wall and ceiling height partitions shall be provided with at least one operated on-off lighting control for each room.

Switch to compacts fluorescent light bulbs, in areas where lights are left on for long periods of time, or in difficult to reach places.

One switch is provided for each task or group of task within an area of 30 m² or less. Lighting switch must possibly next to exit door.

The total number of switches shall be at least one switch for each 1kW of connected load.

Used of a separate circuit where day light can be use and alternate switching to optimize the use of lighting. In typical side lighting design with window along one wall it is best to place the luminaries in rows parallel to the window wall and circuited so that the row nearest the windows will be the first to dim or switch off followed by successive rows.

Automatic ‘on’ / ‘off’ control switches are required for areas of infrequent use by using lighting sensors.

For commercial building and offices, lighting in low occupancy area, i.e. M & E plant rooms, store rooms, meeting rooms, and any other identified areas, an automatic control system equipped with sensor shall be placed in order to reduce the energy consumption at that particular area.

For landscaping area in condominiums and apartments, lighting shall be switched of 30% after 12:00 am due to low occupancy in these areas.

Street lights at urban area (especially major highway and federal routes) shall be dimmed to 50% after 1:00 am in view of the low traffic. However, this is not applicable in rural area where only a few streets lights are installed.

3.5 Electrical Energy Meter

Electrical Energy Meters should be installed at strategic load centers to identify consumption by functional use of the lighting, air conditioning or plug loads. This energy meter can be placing near to the each distribution board for enable us to systematically monitor the energy consumption.

3.6 Guideline for Best Practice

i. Maintenance

Maintained illuminance depends on the maintenance characteristic of the lamp, the luminaire, the environment and maintenance programme. The lighting scheme should be designed with overall maintenance factor calculated for the selected lighting equipment, space environment and specified maintenance schedule. The calculated maintenance factor should not be less than 0.70.

Best practice guideline is established for periodical maintenance and appropriate selection and usage of lighting equipment.

ii. Determination of Lighting Efficiency

Lighting power consumption in term of kWh is determined as follows:

$$\boxed{\text{Consumption power per lighting (kW)}} \times \left(\frac{\boxed{\text{Average luminance on working place, } E \text{ (lx)}} \times \boxed{\text{Area, } A \text{ (m}^2\text{)}}}{\boxed{\text{Luminance flux per one lamp, } \Phi \text{ (m)}} \times \boxed{\text{Criteria for rational use of energy}} \times \boxed{\text{Maintenance rate, } M}} \right) \times \boxed{\text{Operating Hour, } T \text{ (h)}}$$

4.0 Transformers Design

The Electrical Supply Industry (ESI) uses transformers in the generation, transmission and distribution sectors. Decision to purchase what type of transformers is more of economics where one must compare the higher initial capital cost to purchase higher energy efficient transformers with the cost of the losses of lower efficient transformers over time.

Increased cost of energy results in energy conservation and usage of energy-efficient equipment. Improvement of transformer efficiency results in savings from reduction in losses, which will lead to reduction in the consumption of fossil fuels to produce the electrical energy, thereby resulting in improved conservation of natural resources towards sustainable development.

This guideline sets out the minimum requirements for achieving energy efficient design and installation of power transformer without sacrificing safety, reliability and quality. The guideline provides guidance on specification, selection, efficiencies and efficient utilization of liquid-filled transformers. It also provides guidance on best practice in the design, operation and maintenance of power transformers.

4.1 Types of Transformer

A Power Transformer is a static piece of apparatus with two or more windings which, by electromagnetic induction, transforms a system of alternating voltage and current into another system of voltage and current usually of different values and at the same frequency for the purpose of transmitting electrical power.

Transformers are generally classified into two categories as follows:

a) Liquid (Oil) Filled Transformer

A transformer of which the magnetic circuit and windings are immersed in an insulating liquid (for this guideline, it may be any insulating liquid, mineral oil or other product) is regarded as oil-filled transformer.

b) Dry Type Transformer:

A transformer of which the magnetic circuit and windings are not immersed in an insulating liquid is regarded as dry type transformer.

4.2 Parts of Transformer

The transformer essentially consists of the following parts:

a) Magnetic core
b) Windings
c) Insulation
d) Tank
e) Cooling system
f) Bushings
g) Tap-changers

4.3 Types of Transformers Losses

Transformers can be broadly classified into 2 categories as follows:

a) No-load losses consists of the following components:

i) Hysteresis losses in core laminations
ii) Eddy current losses
iii) I^2R losses due to no load currents
iv) Stray losses
v) Dielectric losses

b) Load losses consists of the following components:

i) Losses in windings due to load current flow
ii) Conductor eddy current losses
iii) Losses at auxiliaries

4.4 Guidelines on Selection of Transformers

The following are the selection criteria:

a) The type of transformer
b) Voltage transformation ratio
c) The winding connection and vector group
d) The impulse withstand voltage
e) The impedance voltage
f) Flux density
g) The transformer losses and transformer efficiency
h) The tapping range
i) Limits of temperature rise
j) Class of winding insulation
k) Noise
l) Design and construction

4.5 Guideline on Efficient Utilization of Transformer

The following are the engineering considerations for the efficient utilization of transformers:

a) Sizing of capacity
b) Balanced loading of transformers operating in parallel
c) Load factor
d) Transformer impedance
e) Design and construction
f) Effects of power quality and harmonics
g) Choices of transformer core materials
h) Techno-Economic Life Cycle Costs

4.6 Location of Distribution Transformers

Location of distribution transformers should comply with table below:

Load fed by Transformers	Distance of Transformer from Load Centres
> 600 A	Not more than 20 meters
300 A to 600 A	Not more than 100 meters

4.7 JKR Specification in Transformers Design

4.7.1 The 33/11kV transformers shall be suitable for conditions operation on a three phase 50 Hz high voltage transmission system at the voltage specified and, unless specifically stated otherwise, the neutral earthing conditions for these systems will be as follows:

0.415kV	Solidly earthed
11kV	Solid or resistance earthed
33kV	Solid or resistance earthed

4.7.2 The transformers shall be of low iron loss and low copper loss cast resin dry type complying with the relevant British Standard or IEC recommendations.

4.7.3 The air conditioning plus the other mechanical system shall be supplied by its own transformer.

4.7.4 The no load and full load losses for cast resin dry type shall not exceed the following values:

Rated Power (kVA)	No Load Loss (Watt)	Load Loss (Watt)
500	820	5300
800	1450	5000
1000	1600	6100
1250	1900	7500
1600	2300	8800
2000	2850	12000
2500	3350	13900

4.7.5 Power transformer loadings shall not exceed 70% of rated capacity under normal conditions. The choice of power transformer sizes shall take into consideration harmonics as well as current and future fault levels. There shall be provision for forced cooling of the transformer.

4.7.6 The transformer Test to be carried out shall cover but not limited to the following:-

<u>1. Routine Tests</u>

a) Induced voltage dielectric test

b) Applied voltage dielectric test

c) Measurement of no-load losses and the no-load current

d) Measurement of the resistance of MV and LV windings

e) Measurement of the impedance voltage and load losses

f) Measurement of the transformation ratio and verification of the vector group

2. Type Tests

a) The temperature rise test

b) The lightning impulse test

3. Special Tests

a) Measurement of the partial discharge level

b) Measurement of the noise level

4.7.7 Adequate ventilation system shall be provided for the Transformer Room.

5.0 Motor Design

In Malaysia, electric motors typically account for 70% of the electricity usage among industries. The motors in the industrial sector in Malaysia consume as much as RM6 billion worth of electrical energy annually. It, therefore, makes sense that higher efficiency in motors will result in substantial savings in energy and electricity costs.

5.1 Motor Selection

5.1.1 High Efficiency Motor

Motors convert electrical energy into mechanical energy to drive machinery. During this conversion, some energy is lost. Current motors feature improved designs and incorporate the latest developments in materials technology. The most efficient of these motors are termed High Efficiency Motors (HEMs) – classified as Eff1 under the European Committee of Manufactures of Electrical Machines and Power Electronics (CEMEP), or their equivalent.

The CEMEP classification standard has been adopted by Malaysia to classify motor efficiencies. Below HEMs or Eff1 are Eff2 and Eff3 motors, which have descending an order of efficiencies. Key design features of HEMs include:

- Improved fan design - Reduces wind age losses and improves air flow
- Better slot design - Improves both efficiency and power factor
- Improved core design - Lowers flux density and increases cooling capacity, reducing magnetic and load losses
- Optimized air gap - Reduces current requirements and stray load losses

These features result in other advantages besides energy savings, as HEMs:

- Have higher power factor
- Have longer lifespan and fewer breakdowns
- Run cooler and less susceptible to voltage and load fluctuations, and
- Produce less waste, heat and noise.

Motor efficiency classification labels are labeled as EFF1 (the highest), EFF2 and EFF3 (the lowest) on rating plates and technical data tables in manufactures' catalogues.

5.1.2 Efficiency Classification

Motors are classified according to CEMEP in three efficiency classes:

EFF1 (high-efficiency motors) **EFF 1**

EFF2 (improved-efficiency motors) **EFF 2**

EFF3 (standard motors) **EFF 3**

5.1.3 Efficiency Testing Requirements

Motor energy efficiencies are to be tested according to MS IEC60034-2:2005 or its latest edition. The qualifying motors for Energy Efficiency Classification under CEMEP are as follows:

- Totally Enclosed Fan Cooled (TEFC), IP 54 or IP 55
- 3 – phase, squirrel cage induction motors, of 2 - & 4 – pole construction with outputs 1.1 to 90kW.
- Rated for 400 volts, 50 Hz, S1 Duty (Continuous Duty). For motors rated at 380 – 420 volts, the declared efficiency values are tests at 400V.
- Standard design (Design N), given in IEC60034-12 and Harmonization
- Document (HD) 231.

5.2 Energy and Costs – Saving Potential

5.2.1 Costs premium for High Efficiency Motors

The cost premium for HEM is about 50 to 150 percent above the cost of an average motor. An HEM comes with higher capital cost but there will be a significant amount of energy savings during its lifespan. The Malaysian Government has made it even more attractive to buy HEMs by offering:

- Exemption on import duty and sales tax, and
- Investment tax allowance for energy efficient equipment

On average, the initial purchase cost of a motor only makes up 2% of the total cost of ownership. The total electricity consumed to operate the motor over its lifetime of 15 years makes up 97% of its total lost.

5.2.2 Savings in Running Cost

The energy costs of a motor can be quite high over its lifetime. The longer the operating hours, the higher energy costs. Therefore, the lifetime cost calculations should be performed to determine whether repair or replacement of an existing standard motor with a high efficient motor is more economical.

What to Consider When Selecting a Motor

When changing to a smaller or high efficiency motor, it is important to consider the following:

a) Running Temperature – High efficiency motors operate within the same Class B temperature limits as standard motors but will not dissipate as much heat.
b) Maximum power capability – Before changing to a smaller, lower rated motor, it is important to check that no load will arise which will exceed this new rating.
c) Starting torque – The starting torque developed in the new, lower rated motor is likely to be less than that of the existing motor. Thus, the starting duty in the application will have to be checked. In cases, where the existing drive is a star / delta starter, a change to direct on - line - start can be considered except when starting torque or current must be limited. Soft starter may be considered.
d) Special loads – Many drives provide starting and acceleration torque to the load as their main function, e.g. centrifuges or flywheels on presses. The running current of these machines, e.g. when full speed achieved, is quite low and may give the

impression that downsizing is possible. Such cases are unsuitable for application of this energy saving opportunity, but this could be easily established measuring the starting current.

6.0 Suggested Methods for Energy Efficiency by Others in JKR

6.1 Building Design Specification

The nature of the building environment is an important factor in the design of the lighting system. If dark colours are used on walls, floors and ceilings, the result is decreased light level as more light is absorbed by the dark surfaces. Using light colours instead can allow the removal of lamps in some cases.

6.2 Maximise Daylighting / Natural Lighting Used

In this stage, the electrical designers should coordinate the electrical lighting system with the day lighting design proposed by the architect.

For a place that is opened to the sunlight, there should enclose a lux sensor / light control system to limit the glare entering the workstation to avoid errors, fatigue and accidents.

Wherever possible, use "natural lighting". Choose transparent roof material, which is easy to clean and will not darken under the action of sunlight.

Clean the "reflector" portion of the fluorescent light fittings to maintain the available light output

Task or area lighting may be used in some cases where only a small area of a building needs higher lighting levels. Therefore, an efficient use of lighting is applicable; however it neither must nor compromise the visual aspects of a lighting installation simply to reduce the energy consumption.

Factors such as glare or stray reflections should also be taken into account. They can have an impact on productivity as well as on the energy efficiency of the system.

6.3 Energy Efficient Office Equipment and Plug Loads

Except in Design & Build contracts, the purchase of office equipments and other plug loads are not normally included under JKR 203 contracts. However we should be proactive in advising our clients that they should only purchase energy efficient office equipment in line with our integrated design approach.

Office equipment includes computers, printers, faxes, copying machines and other equipment. Energy consumption of such equipment can represent large portion of the building energy consumption. Using readily available energy efficient and reasonably priced office equipment such as computers with power management functions, laptop, liquid crystal display (LCDs) monitors, multifunction office equipment and others can offer substantial reduction in office equipment energy consumptions.

6.4 Energy Efficient HVAC Systems

HVAC systems are intended to provide adequate cooling comfort, dehumidification and ventilation to occupied spaces at reasonable costs. Some of effective and energy efficient system include:

- Efficient multi zoning air distribution with Variable Air Volume (VAV) and Variable Speed Drives (VSD) to ensure the air conditioning areas are all within the specified comfort zones and to control cooling comfort where you want it.
- Using the motion sensors and occupancy sensors to control the temperature in unoccupied rooms.
- Using effective air infiltration control to prevent the egress of external untreated air.
- Using of High Efficiency Motor (HEM) for bigger horse power motor with longer running hours.
- Using of Energy Recovery Wheel to recover energy from exhaust air.
- Better ductworks and pipes insulation to prevent heat loss through condensation.
- Using of high accuracy thermostats for accurate temperature control.

6.5 Comprehensive Energy Management System (EMS)

Having an effective building monitoring, control, operation energy management and reporting system can play a critical role in operating and maintaining energy efficient building. This system will ensure that the building operates as efficiently as possible while meeting the occupants' comfort and functional needs not only during testing and commissioning but throughout the life of the building.

6.6 Awareness

An intensive programme of electricity saving awareness for all employees for their cooperation in lighting control.

Appendix 1

Minimum Allowable Values of Luminous Efficacy for Various Types of Lamp

Factor	Incandescent	Fluorescent	MH	HPS	LPS
Wattage	25 – 150	18 – 400	50 – 400	50 – 400	18 – 180
Output (lumens)	210 -2,700	1,000 -7,500	1,900 -30,000	3,600 -4,600	1,800 -33,000
Efficiency (lumens / watt)	8 – 18	55 – 79	38 – 75	72 – 115	100 – 183
Lumen Maintenance	90 (85)	85 (80)	75 (65)	90 (70)	100 (100)
Lamp Life (hours)	750 – 2,000	10,000 – 20, 000	10,000 – 20,000	18,000 – 24,000	16,000
CRI	90 – 95	30 – 90	80 – 90	20 – 39	<20

Notes: **Wattage** and **output** refers to the commonly available lamp rating for outdoor lightings.

Efficiency refers to luminous efficiency taken at 50% mean lifetime and do not include ballast loss.

Lumen Maintenance refers to percent of initial lamp output at 50% of mean lifetime and at end of lifetime (parenthesis).

Lamp Life refers to the approximate mean lifetime of lamp.

Appendix 2

Schedule of interior (areas) tasks and activities with specification of illuminance, glare limitation and colour quality

Type of interior, task or activity	$\bar{E}_m$ lux	UGR_L	R_a	Remarks
1. General Building				
Entrance halls	100	22	60	
Lounges	200	22	80	
Circulation areas and corridors	100	28	40	At exits and entrances provide a transition zone and avoid sudden changes
Stairs, escalators and travelators	150	25	40	
Loading ramps/bays	150	25	40	
Canteens	200	22	80	
Restrooms	100	22	80	
Rooms for physical exercise	300	22	80	
Cloakrooms, washrooms, bathrooms and toilets.	200	25	80	
Sick bay	500	18	90	
Rooms for medical attention	500	16	90	T_{cp} at least 4,000 K
Plant rooms, switch gear rooms	200	25	60	
Post room, switchboard	500	19	80	
Store, stockrooms, cold store	100	25	60	200 lux if continuously occupied
Dispatch packing handling areas	300	25	60	
Control Station	150	22	60	200 lux if continuously occupied
2. Cement, concrete & bricks industry				
Drying				
Preparation of materials, work on kilns and mixers	200	28	20	Safety colours shall be recognizable
General machine work	300	25	80	
Rough forms	300	25	80	
3. Ceramic & glass industry				
Drying	50	28	20	
Preparation, general machine work	300	25	80	
Enameling, rolling, pressing, shaping simple parts, glazing, glass blowing	300	25	80	
Grinding, engraving, glass polishing, shaping precision parts, manufacture of glass instruments	750	19	80	
Decorative work	500	19	80	
Grinding of optical glass, crystal hand grinding and engraving, work on average goods	750	16	80	

Appendix 2 (continue)

Type of interior, task or activity	$\bar{E}_m$ lux	UGR_L	R_a	Remarks
Precision work, e.g. decorative grinding, hand painting	1,000	16	90	T_{cp} at least 4,000 K
4. Chemicals, plastic and rubber industry				
Remote operated processing installations	50		20	Safety colours shall be recognizable
Processing installations with limited manual intervention	150	28	40	
Constantly manned workplaces in processing installations	300	25	80	
Precision measuring rooms, laboratories	500	19	80	
Pharmaceutical production	500	22	80	
Type production	500	22	80	
Colour inspection	1,000	16	90	
Cutting, finishing, inspection	750	19	80	
5. Electrical industry				
Cable and wire manufacture	300	25	80	
Winding:				
- large coils	300	25	80	
- medium – sized coils	500	22	80	
- small coils	750	19	80	
Coil impregnating	300	25	80	
Galvanising	300	25	80	
Assembly work:				
- rough, e.g. large transformers	300	25	80	
- medium, e.g. switchboards	500	22	80	
- fine, e.g. telephones	750	19	80	
- precision, e.g. measuring equipment	1,000	16	80	
Electronic workshops, testing, adjusting	1,500	16	80	
6. Food industry				
Workplaces and zones in breweries, malting floor, for washing, barrel filling, cleaning, sieving, peeling, cooking in preserve and chocolate factories, workplaces and zones in sugar factories, for drying and fermenting tobacco, fermentation cellar	200	25	80	
Sorting and washing of products, Milling, mixing and packing	300	25	80	
Workplaces and zones in slaughter houses, butchers, dairies mills, on filtering floor, in sugar refineries	500	25	80	
Cutting and sorting fruits and vegetables	300	25	80	

Appendix 2 (continue)

Type of interior, task or activity	$\overline{E}_m$ lux	UGR_L	R_a	Remarks
Manufacture work of cigars and cigarettes	500	22	80	
Inspection of glasses and bottles, product control, trimming, sorting decoration	500	22	80	
Laboratories	500	19	80	
Colour inspection	1,000	16	90	T_{cp} at least 4,000 K
7. Paper industry				
Pulp mills, edge runners	200	25	80	
Paper manufacture and processing, paper and corrugating machines, cardboard manufacture	300	25	80	
8. Textile industry				
Workplaces and zones in baths, bale opening	200	25	60	
Carding, washing, ironing, drawing, combing, sizing, card-cutting, pre-sinning, jute and hemp spinning	300	22	80	
Spinning, plying, reeling, winding, warping, weaving, braiding, knitting	500	22	80	Prevent stroboscopic effects
Sewing, fine knitting, taking up stitches	750	22	90	
Manual design, drawing patterns	750	22	90	T_{cp} at least 4,000 K
Finishing, dyeing	500	22	80	
Drying room	100	28	60	
Automatic fabric printing	500	25	80	
Burling, picking, trimming	1,000	16	90	
Colour inspection, fabric control	1,000	16	90	T_{cp} at least 4,000 K
Invisible mending	1,500	19	90	T_{cp} at least 4,000 K
Hat manufacturing	500	22	80	
9. Wood working & furniture industry				
Automatic processing, e.g. drying Plywood manufacturing	50	28	40	
Steam pits	150	28	40	
Saw frame	300	25	60	
Work at joiner's bench, gluing, assembly	300	25	80	
Polishing, painting, fancy joinery	750	22	80	
Work on wood-working machines, e.g. turning, fluting, dressing, rebating, grooving, cutting, sawing, sinking	500	19	80	
Selection of veneer woods, marquetry, inlay work	750	22	90	T_{cp} at least 4,000 K
Quality control	1,000	19	90	T_{cp} at least 4,000 K

Appendix 3

Energy Efficiency Checklist (Electrical Aspects Only)

No	Descriptions	YES	NO	Deviation/Justification
1	**Lighting**			
1.1	Use Energy Efficient Lights			
1.2	Use Energy Efficient Electronic Ballasts			
1.3	Use Energy Efficient Electromagnetic Ballast (loss not exceeding than 6.0W)			
1.4	Illuminance designed according to MS1525 Refer Table of lighting wattage/m2			
1.5	Lighting zone control for spaces enclosed by wall and ceiling height partitions by providing more than one on-off operated switch			
1.6	Lighting switch next to exit door			
1.7	Light circuit parallel to day light			
1.8	Separate circuit for day light use			
1.9	Day light sensor near to window			
1.10	Occupancy sensor for intermittently occupied areas			
1.12	Dual timer switches for external corridor lightings to allow partial / reduced illumination levels			
1.13	Dual timer switches for covered walk way lightings to allow partial / reduced illumination levels			
1.14	Dual timer switches for compound lighting to allow reduced illumination levels			
1.15	Two way light switching			
1.16	Increase number of switches for each zone to allow consumers choices to switch off			

	lights			
2	**Transformer**			
2.1	Select a transformer with a rating close to but exceeding the peak demand			
2.2	Design voltage is recommended not to exceed 5% of the rated value			
2.3	Design shall target to achieve power factor at least 0.9 lagging at the incoming			

o	Descriptions	YES	NO	Deviation/Justification
2.4	Design to maintain electric frequency to 50Hz with variations not exceeding +/- 1%			
2.5	Design the locations of power transformers and main switchboards sited at their load centre.			
2.6	Distance of Transformer from load centre: a. Load fed by Transformers: > 600A - not more than 20 meters b. Load fed by Transformers: 300A to 600A - not more than 100 meters			
2.7	The cast resin dry type transformers are of low iron and low copper loss			
3	**Monitoring System**			
3.1	Separate DB for lighting, 13A sockets outlets and small air con / mechanical loads			
3.2	Electrical Energy Meters near to each distribution boards			
3.3	Energy Management System (EMS)			
3.4	Building Automation System (BAS)			
4	**Other items (if any please itemize)**			

4.1				
4.2				
4.3				

Contractors Signature:
Official stamp:
Date:

References

1. Energy Efficiency and Conservation Guidelines for Malaysian Industries. (Published by Pusat Tenaga Malaysia, July 2007)

2. JKR'S Approach Towards Energy Efficiency in Buildings (Articles by Ir Hjh Azura Mahayudin & Ir Gopal Narian Kutty)

3. Malaysia Standard MS 1525:2001

4. Malaysia Standard MS 1525:2007