UNIT INSPEKTORAT DAN PENGURUSAN TENAGA
CAWANGAN KEJURUTERAAN ELEKTRIK
IBU PEJABAT JKR MALAYSIA

ENERGY EFFICIENCY GUIDELINES FOR CKE DESIGN

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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.

1.1 Scope

The guidelines apply to electrical installations for non-residential buildings either it is a conventional design or design and build such as the peak design rate of electrical energy usage for all purposes is greater than 10W/m^2 of gross floor area.

1.2 Objective

The objective of these guidelines is to ensure that electrical system design comply with the minimum requirements of MS 1525:2007- Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (First Revision).

1.3 Responsibility

Head of Design Team (HODT) is responsible for ensuring adherence to these guidelines.

1.4 Method of Compliance

HODT shall use the EE checklist as in Appendix 3 together with these guidelines. This checklist shall be submitted during Design Verification and attached with JKR.PK Form(O).02-2 (Form Review / Verification / Validation).

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.

EE in JKR constructed building can be achieved 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 Air Conditioning and Mechanical Ventilation (ACMV) 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).

Cawangan Kejuruteraan Elektrik focuses mainly on active design strategy which includes electric lighting design. Hence, this guideline is developed to accommodate the strategy.

3.0 Lighting Design

3.1 Types of Lighting

There are many types 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 Light

3.2 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 ballasts are 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

3.3 Electromagnetic Ballast

The type of electromagnetic ballast must be energy efficient 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.

3.4 Design Criteria

3.4.1 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.

3.4.2 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

3.4.3 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

3.4.3.1 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.

3.4.3.2 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.

3.4.3.3 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

3.4.3.4 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.

3.4.3.5 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.

3.4.4 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.

3.4.5 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 for general building areas are as given in Appendix 2.

Lighting load shall not exceed the corresponding maximum value as listed in Table 3.

Building Types / Space	**Max. lighting power (W / m^2)**
Restaurants	15
Offices	15
Classrooms / Lecture Theatres	15
Auditoriums / Concrete Halls	15
Hotel / Motel Guest Rooms	15
Lobbies / Atriums / Concourse	20
Supermarkets / Department Stores / Shops	25
Stores / Warehouses / Stairs / Corridors / Lavatories	10
Car Park	5

Table 3: Maximum allowable power (including ballast loss) for illuminance systems

3.5 Efficiency & Efficacy 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.

3.6 Lighting Controls

All lighting systems except those required for emergency or exit lighting should be provided with manual, automatic or programmable controls. For lighting loads exceeding 100 kW automatic controls should be provided.

3.7 Lighting Zones 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 m^2 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.

3.8 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:

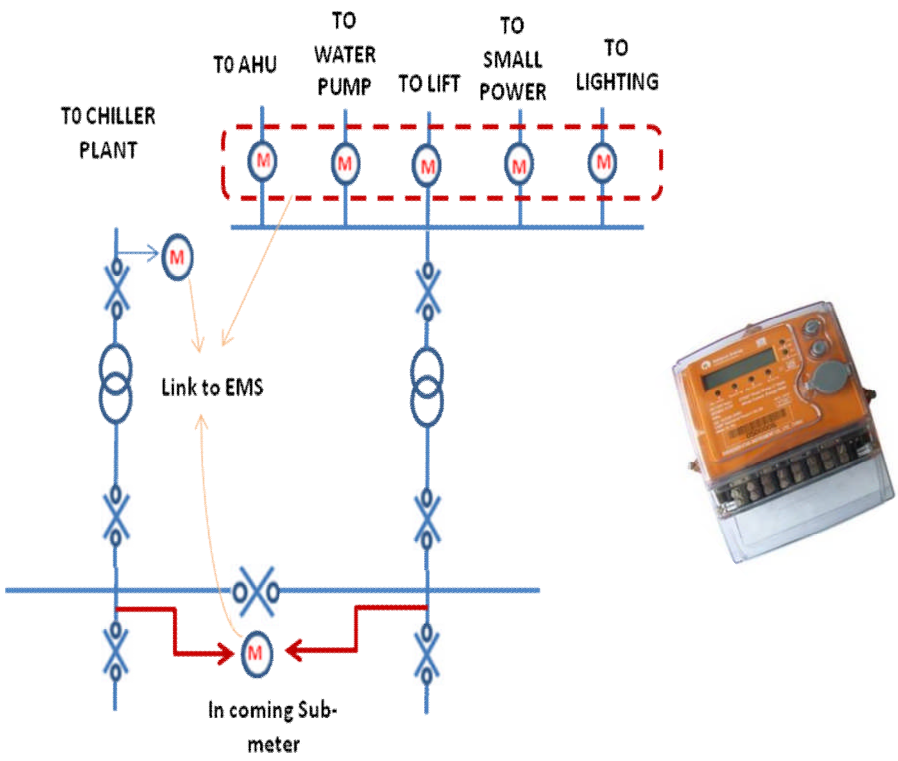
$$\boxed{\text{Consumption power per lighting (kW)}} \times \left(\frac{\boxed{\text{Average luminance on working place, E}} \times \boxed{\text{Area, A } (\text{m}^2)}}{\boxed{\text{Luminance flux per one lamp, } \Phi \text{ (m)}} \times \boxed{\text{Criteria for rational use of energy}} \times \boxed{\text{Maintenance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

4.0 Sub Metering

Electrical energy meters shall be provided for all energy uses of ≥ 100kVA and shall be installed at strategic load centres to monitor energy consumption of key building services such as the outgoing sub-circuits serving, but not limited to the following:

a) Central air-conditioning system
b) Lifts
c) Major water pumping system
d) Plug loads
e) Lightings

These sub-meters shall be linked to the Energy Management System (EMS) for monitoring and recording, and control where appropriate, and refer also to Content 8.5.



Example of Sub Metering Schematic Diagram

5.0 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.

5.1 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.

5.2 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

5.3 Types of Transformers Losses

Transformers losses 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

5.4 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

5.5 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

5.6 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

5.7 JKR Specification in Transformers Design

5.7.1 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

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

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

5.7.4 The no-load loss, load loss and total losses shall not exceed the values specified in table below. The tolerance shall be in accordance with MS IEC 60076-1, which allows +10% on total losses, and +15% on no-load and load losses, provided that the tolerance for total losses is not exceeded.

Dry-type

Rated Power (kVA)	No Load Loss (W)*	On-Load Loss (W)*	Total Losses (W)*
400	810	4520	5330
500	840	5350	6190
630	1140	5910	7050
800	1420	5500	6920
1000	1580	6650	8230
1250	1880	8170	10050
1600	2290	9650	11940
2000	2860	12940	15800
2500	3330	14990	18320

(at 120°C)

Oil-Filled

Rated Power (kVA)	No-Load Loss (W)*	On-Load Loss (W)*	Total Losses (W)*
100	300	1500	1800
300	600	2800	3400
500	1000	4100	5100
750	1200	6000	7200
1000	1400	7000	8400

5.7.5 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.

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

1. Routine Tests

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

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

6.0 Renewable Energy

Cawangan Kejuruteraan Elektrik shall drive the adoption of renewable energy (RE) in the built environment as an effort to support RE policy in Malaysia and to offer an alternative way to produce energy which is sustainable.

Potential RE project shall be assessed by the availability and reliability of the resources i.e solar, wind, geothermal, low-impact hydro, biomass and others. Generation of renewable electricity using photovoltaic (PV) system is highly

recommended in the Malaysian climate. It can be either grid connected or off-grid system. Solar PV panels can be attached to pitched roofs or flat roofs, fixed vertically onto external walls or located on the ground. They should work efficiently in most locations as long as no part of the panel is shaded from the sun.

If PV system is to consider in the design, as of minimum requirement, it is suggested to estimate the installed power capacity (kWp) where 0.5 % (of total) or 5 kWp (of PV) whichever is the greater, of the total electricity consumption is generated by renewable energy. However, the designers are encouraged to design and install a bigger PV system capacity if it does not cause cost overruns for the whole project.

7.0 Suggested Methods for Energy Efficiency by Others in JKR

7.1 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.

7.2 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 must not 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.

7.3 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.

7.4 Energy Efficient ACMV Systems

ACMV 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.

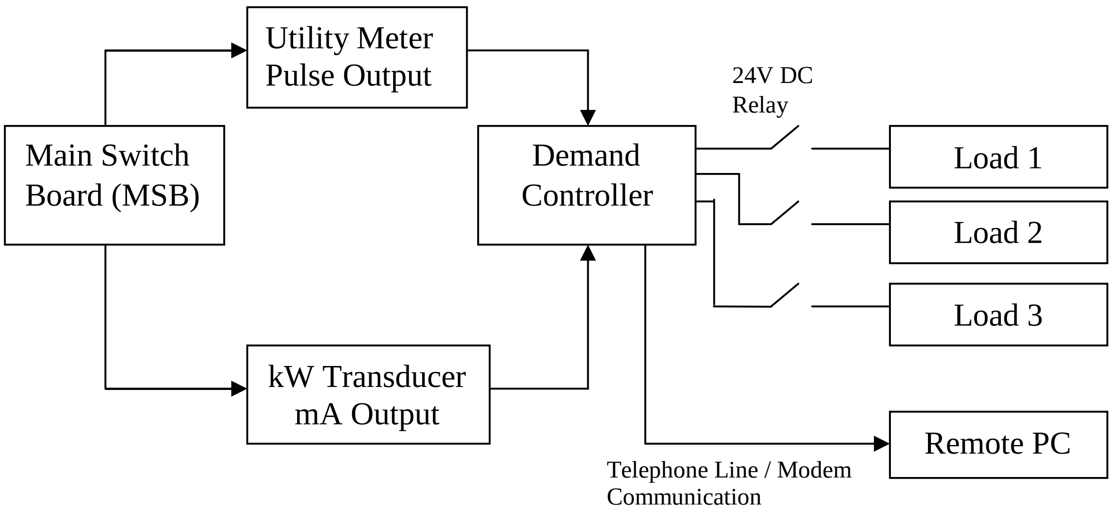
- Using of High Efficiency Motor (HEM) for bigger horse power motor with longer running hours.
- Using of Energy Recovery Wheel to recover energy from exhaust air.
- Better ductworks and pipes insulation to prevent heat loss through condensation.
- Using of high accuracy thermostats for accurate temperature control.

7.5 Energy Management System (EMS)

According to MS 1525, the EMS shall be considered for buildings having area greater than 4000 m² of air-conditioned space where it is a subset of the building automation system function.

For the installations taking supply at 11kV and above from TNB, it is recommended to install the EMS complete with maximum demand (MD) limiting controller for controlling and reducing MD in TNB bill.

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.



Example of Maximum Demand Controller Schematic

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

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

Efficacy refers to the ratio of the measured light output of a luminaire to its active power, express in lumens per watt.

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

Item	Area	Illumination Level (Lux)
1	Ruang Laluan (Luar)	50
2	Tempat Letak Kereta	50
3	Bilik Tidur Hotel	100
4	Lif	100
5	Koridor	100
6	Tangga	100
7	Eskalator	150
8	Bilik Persalinan	100
9	Bilik Pencuci	100
10	Pintu keluar & Masuk	100
11	Dewan Masuk	100
12	Lobi	100
13	Bilik Menunggu	100
14	Kaunter Pertanyaan	300
15	Pejabat	300
16	Pejabat Lukisan	300
17	Restoran	150
18	Kantin	200
19	Kafeteria	200
20	Dapur	150
21	Bilik Mandi	150
22	Tandas	100
23	Bilik Darjah	300
24	Perpustakaan	500
26	Muzium	300
27	Bilik Komputer	500
28	Bilik Mesyuarat	300
29	Bilik Pengarah	300
30	Bilik Pegawai	300
31	Bilik Perbincangan	300
32	Stor	100
33	Bilik Cetak	300
34	Bilik Fail	300
35	Bilik Kuliah	300
36	Bilik Makmal	300
37	Bilik Utiliti	100
38	Dewan Serbaguna	300
39	Surau	300
40	Bilik Solat	300
41	Ruang Wuduk	150
42	Bilik Seminar	300
43	Bilik Tukar Lampin	200

Item	Area	Illumination Level (Lux)
44	Bilik Penyusuan	300
45	Bilik Rawatan	300
46	Bilik Pemeriksaan	300
47	Bilik Analisa	300
48	Farmasi	300
49	Bilik Kebal	300
50	Bilik Pergigian	300
51	Bilik Sterlisasi	300
52	Bilik Pembedahan	500
53	Bengkel	500
54	Ruang Laluan (Dalam)	300
55	Auditorium	150
56	Gimnasium	300
57	Garaj	300
58	Bilik Demontrasi Memasak	100
59	Pantri	100
60	Bilik Penyediaan Makanan	300
61	Bilik Suis/Riser	150
62	Bilik Set Janakuasa	150
63	Bilik Server	300
64	Bilik Mesin	300
65	Bilik AHU	150
66	Bilik MDF	150
67	Rumah Pam	150
68	Bilik Motor Lif	150
69	Bilik Tangki / Mekanikal	150
70	Bilik Tayangan	300
71	Bilik Studio Rakaman	300
72	Bilik Prosedur	300
73	Bilik Gelap	300
74	Bilik Cuci/Dobi	200
75	Hangar	500

Reference: CKE Lux Bulletin dated 23/11/2009

Appendix 3

Energy Efficiency Checklist (Electrical Aspects Only)

Nama Projek:	
Kos Projek (Keseluruhan):	
Kos Projek (Elektrik):	

Kaedah Pelaksanaan:	Konvensional Perunding	
	Konvensional Dalaman	
	Reka & Bina	

Kumpulan BPR	
Nama PRB	

No	Descriptions	√ if Yes x if No N/A	Deviation/Justification
1	**Lighting System and Control**		
1.1	Use of Energy Efficient Lights (Example: Compact Flourescent Lamp / T5 / LED) Total of Lamps Fitting: ______________nos Total of EE Lamps Fitting: ______________ nos		
1.2	Use of Energy Efficient Electronic Ballast Total of Ballast: ______________nos Total of EE Ballast: ______________ nos		
1.3	Use of Low Loss Electromagnetic Ballast (loss not exceeding than 6.0W) Total of Ballast: ______________nos Total of Low Loss Electromagnetic Ballast: ______________nos		
1.4	All spaces enclosed by wall or ceiling height partitions should be provided at least one operated-on-off lighting control for each room		
1.5	Provided one switch for each task or group of tasks within an area of 30 m^2 or less		

Appendix 3 (continue)

No	Descriptions	√ if Yes x if No N/A	Deviation/Justification
1.6	The total number of switches should be at least one switch for each 1 kW of connected load		
1.7	Lighting switch next to exit door		
1.8	One light circuit parallel to day light (alternate switching)		
1.9	Day light sensor near to window		
1.10	Occupancy sensor for intermittently occupied areas		
1.11	Alternate switching for corridor lighting		
1.12	Use of automatic control for lighting loads exceeding 100 kW (Example: use of sensor or programmable controls (BAS or EMS)) Total Lighting Loads: ____________ kW		
1.13	Dual timer switches for external corridor / 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 for internal corridor or other suitable places		
1.16	Illuminance designed according to MS 1525		

Building Types / Space	Max. lighting power (W/m²)
Restaurants	15
Offices	15
Classrooms / Lecture Theatres	15
Auditoriums / Concrete Halls	15
Hotel / Motel Guest Rooms	15

Appendix 3 (continue)

<table>
<tr><th>No</th><th>Descriptions</th><th>√ if Yes
x if No
N/A</th><th>Deviation/Justification</th></tr>
<tr><td></td><td>
<table>
<tr><th>Building Types / Space</th><th>Max. lighting power (W/m²)</th></tr>
<tr><td>Lobbies / Atriums / Concourse</td><td>20</td></tr>
<tr><td>Department Stores / Shops</td><td>25</td></tr>
<tr><td>Stores / Warehouses / Stairs /</td><td>10</td></tr>
<tr><td>Car Park</td><td>5</td></tr>
</table>
</td><td></td><td></td></tr>
<tr><td>2</td><td>Transformer</td><td></td><td></td></tr>
<tr><td>2.1</td><td>Efficiency of Transformer:
a. Transformer size : < 1000kVA at full load condition
- not lower than 98%
b. Transformer size : > 1000kVA at full load condition
- not lower than 99%</td><td></td><td></td></tr>
<tr><td>2.2</td><td>The locations of power transformers and main switchboards sited at their load centre.</td><td></td><td></td></tr>
<tr><td>2.3</td><td>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</td><td></td><td></td></tr>
<tr><td>3</td><td>Monitoring System</td><td></td><td></td></tr>
<tr><td>3.1</td><td>Energy Management System (EMS) For Building Having Air-Conditioned Area > 4000m²

(To monitor and analyse energy consumption including reading of sub-meter complete with maximum demand limitting programe within 12 month)</td><td></td><td></td></tr>
<tr><td>3.2</td><td>Building Automation System (BAS)
(For M&E control system)</td><td></td><td></td></tr>
<tr><td>3.3</td><td>Digital Electrical Energy Meters shall be provided for all energy uses of ≥ 100kVA and shall be installed at sub-switch board serving, but not limited to the following:
a. central air-conditioning system
b. lift and escalator system
c. major water pumping syatem
d. general power supply
e. lighting supply</td><td></td><td></td></tr>
</table>

* N/A = Not Applicable

References

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

2. Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (First Revision) - MS 1525:2007

3. Surat Edaran Dalaman CKE “11kV Dry-Type dan Oil-Filled Transformer” rujukan (29)JKR(L)5/1/4-43 bertarikh 7 Mac 2008