Detailed Study and Report on the Current Building Designs and EE Building Applications - Draft

Building Sector Energy Efficiency Program (BSEEP)

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Foreword

This document is produced as part of Component 4, Building Sector Energy Efficiency Program (BSEEP) by CK Tang (ck@gbeet.com) and Nic Chin (nc.environmentology@gmail.com).

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Introduction
Among the deliverables of The Building Sector Energy Efficiency Program (BSEEP), Component 4, Information and Awareness Enhancement, over the next 12 months are the production of a Passive Technical Guidebook and an Active Technical Guidebook. In conjunction with the production of these Guidebooks, a report on the state of current energy efficiency design practice in Malaysian buildings should be produced as soon as possible, to provide a roadmap for the development of the Technical Guidebooks.

The current state of energy efficiency design practices in building in Malaysia is primary influence by the following major items:
1. Malaysian Standard (MS) 1525
2. Demonstration Buildings
3. Malaysia’s Green Building Index (GBI)
4. MASHRAE (Malaysian Chapter of Ashrae)
5. BEIT software (from ACEM)

MS1525
MS1525 is the current standard being referred to by many architects and engineers for energy efficiency in building design in Malaysia. It provides a minimum performance specification for architects and engineers to design their building to meet this standard. Unfortunately, MS 1525 is not a requirement in Malaysia’s Uniform Building by Law (UBBL) and therefore, it is practiced voluntary.

The increased market awareness of Green Building Index (GBI) Malaysia has spurred the use of MS1525 more regularly by Malaysian architects and engineers. However, there is no statistic of the percentages of projects in Malaysia that followed the MS1525 but it is safe to assume that all 200+ projects currently registered for GBI rating would have read and followed the MS1525.

Misconception of MS 1525
The MS1525 is a minimum design standard. In other words, it is the worst building that is allowed to be built in Malaysia. Due to a report made in year 1987 during the initial development of MS1525, it was mentioned in the report that a Building Energy Index (BEI) of 136 kWh/m²/year is achievable by an office building if the MS1525 is implemented. However, in year 1987, the use of small power (computers, printers and other office equipment) is almost non-existence. Since early 1990s, the use of small power has increased significantly, increasing a typical office building energy consumption to the range of 200~300 kWh/m²/year, today. In year 2005, another round of energy simulation was conducted mirroring the study made in 1987, it was found that if all the minimum standard of the MS1525 (2007) is followed today, the BEI of the office building will be approximately between 200 to 220 kWh/m²/year due the increase in small power use and ventilation rates since year 1987.

Demonstration Buildings
The government of Malaysia has built three (3) numbers of energy efficient demonstration office buildings in the last 10 years. These buildings are:
1. Low Energy Office (LEO) belonging to the Ministry of Energy, Water and Green Technology in Putrajaya (measured BEI of 100 kWh/m²/year),
2. Green Energy Office (GEO) belonging to the Malaysian Green Technology Center in Bangi (measured BEI of 35 kWh/m²/year) and
3. Diamond Building belonging to Suruhanjaya Tenaga in Putrajaya (measured BEI of 65 kWh/m²/year).

These demonstration buildings mentioned above served as a proof of concept and also to inspire the building industry to build buildings that are low in energy consumption.

**GBI positive influence for Energy Efficiency in Building**

The GBI rating system is a strong driver in Malaysia for energy efficiency in building. It allocated the highest points for energy efficiency (among other green features) in the GBI commercial buildings’ green rating scheme. In addition, the GBI Facilitator course offered training in the design of energy efficiency in building. Fundamental design of energy efficiency in buildings is taught in these courses.

**MASHRAE**

The Malaysian chapter of ASHRAE conducts regular training for the building industry on the best practices in the design of air-conditioning system, pipe sizing, duct sizing and energy efficiency in building.

**BEIT software (from ACEM)**

The BEIT software, now in version 1.2, is a JAVA based software that can be installed on Windows or Mac computer and is provided free by ACEM (Association of Consulting Engineers Malaysia). The software assumes a shoebox shaped building and with the input of a few key parameters, estimates the annual energy consumption of the building. BEIT was launched by ACEM in 2010, and since then, more than 500 architects and engineers have been trained on it.
Industry Dialog on the Development of Passive and Active Technical Design Guideline for Building Industry

An industry dialog was organized on the 13th June 2012 for feedback on the status of current energy efficiency design practices and to gain an understanding of the information required by the industry in order for energy efficiency to be practiced on all new building design. 21 industry leaders from both private and public sectors attended the dialog session. The output of the industry dialog is presented below.

A. Passive Energy Efficiency Design Practices in Malaysia

1. Building form, core locations and shape selection

Currently there is no available information on the impact of building form, core location and shape selection. Such information when provided will enable architects to consider energy efficiency as part of their concept design development. It will provide architects with a rule of thumb of the impact of energy consumption in building due to the selection of building form, core location and shape. 11 basic building shapes were recommended during the dialog session with the industry.

2. Roof Insulation

The correct application of roof insulation/ventilation is a much debated topic today in the building industry. Its influence on energy saving is not well defined, leading to requirements for roof insulation U-value to be as low as 0.15 W/m²K to score maximum points for GBI residential. In addition to insulation on the roof, there are also other roof solutions being marketed here in Malaysia, such as Cool Roof solution (where the roof attic is ventilated and provided with low-emissivity surfaces and Cool Paint solution (where the solar absorption value is very low but the emissivity value is high). In addition, there is also a current debate on the inclusion of roof attic space (pitch roof design) as part of the U-value computation.

In addition, the hours when air-conditioning is used will have a big impact on the energy consumption and comfort condition of the space below the roof. All these scenarios have to be addressed to enable designers to select the most optimal solution for their building design.

3. Wall Insulation

The benefit of wall insulation is also not well defined. There exists assumption in the building industry that wall insulation can provide significant energy savings in building in this climate. However, the average outdoor air temperature in Malaysia is 27°C, which is only 3°C higher than the recommended indoor air temperature of 24°C.

4. Atrium/Air-Well Ventilation Strategy

It was found that it is a common design practice to provide air-conditioning for atriums in commercial buildings due to comfort expectations in commercial building today. Energy efficient design of air-conditioned atrium has to be addressed. The industry dialog session also revealed that air well for residential towers is normally provided with stack ventilation strategy. It was requested by the industry that a guideline on the optimum design for daylight and ventilation/comfort optimization for air well in residential tower be provided for the industry.
5. Windows to Wall Ratio
Typical windows to wall ratio practiced by the building industry today is 70% and upwards. The building trend is towards increasing more glazing area rather than a reducing glazing area.

6. Glazing Properties
Typical glazing properties used in the building industry today is tinted single glazing. In general there is a lack of understanding of glazing performance with different type of glazing, such as single glazing, single glazing with low-e, double glazing and double glazing with low-e. Due to the reason that cost of single glazing and high performance double glazing is significantly different, there is a need to provide the benefit of using high performance double glazing for the industry to make informed decision on glazing selection.

The OTTV formula in the MS1525 is a good guide to the industry on the selection of glazing properties. However, the strict adherence to design the façade to the OTTV limit sometimes causes missed opportunity to gain further savings with good financial returns. For example, the OTTV limit can be achieved with small windows to wall ratio, however, if the windows is facing east or west (where it received direct solar radiation), provision of high performance glazing may yield good savings and payback, but since the designer has achieved the OTTV limit, a poor glazing properties was selected instead.

7. External Sun Shading
There is a mixed response from the building industry experts on the need of financial justification of external sun shading. JKR strongly voiced that providing financial savings due to external shading has to be addressed so that building are built cost efficiently and not for aesthetic reason alone. Provision of external shading is part of the architectural design, placed by the architect to reduce cooling load and energy for the building. However, there is a trend by building developers and JKR as well to ask the architects for justification of the need to have external sun shading to be provided and have it removed or added due to “value engineering”. In summary, there is a need in the building industry to estimate cooling load reduction and energy reduction due to use of external shading devices using a simple method.

8. Daylight Harvesting
In general there is a good understanding that daylight harvesting in building reduces building energy consumption. Unfortunately, the industry does not have adequate design tools for daylight harvesting to be used in daily building design. There is a need to provide simpler tools for architects to design daylight harvesting features into buildings as part of the daily design work.

Glare discomfort will defeat any daylight harvested, because building occupants will put up blinds cut out all daylight from the windows to prevent glare in building. Glare-free daylight harvesting design skills need to the imparted to the industry for this design skill to take off. This skill is very important because it is a passive feature with the highest potential of reducing energy in building.

9. Skylight Design
Overenthusiastic design of skylight has caused warm greenhouse spaces in the tropical climate. There is a need to provide a guide on the quantity of skylight to be provided for a space to receive the right amount of daylight without overheating the space.
10. Air-Tightness in Building
There is currently no air-tightness requirement for building construction in Malaysia. There is very little awareness of the energy efficiency potential of air-tight building in this climate. In addition, it is perceived that infiltration does not contribute much to the building energy consumption. One of the reasons that lead to this perception is because buildings in Malaysia are normally positive pressure due to the fresh air drawn in by the mechanical system. It is viewed that improvement to the building air-tightness beyond the fresh air intake requirement will not yield energy saving due to this positive pressure provided. The holistic benefit of building air-tightness has to be presented to the industry.

11. Zoning Requirement
There was a request for a guideline on energy efficient zoning requirement of 24 hours zone, 8 hours zone and naturally ventilated zone.

12. Interior Design Layout
There was also a request for a study on the impact of interior design layout on energy efficiency in building.
B. Active Energy Efficiency Design Practices in Malaysia

1. Lighting Power Density
It was agreed that the lighting power density in MS1525 is the standard of practice by the building industry. It is also relevant to highlight here that at least one public space in Kuala Lumpur is currently using LED lights for general lighting. These LED lamps have a typical light efficacy of 55 lumens per watt as compared to a typical T5 fluorescent tube with a light efficacy of 90 lumens per watt. Moreover, LED lights tend to be focused and do not dispersed as wide as the use of fluorescent lights fitted with good light reflectors as provided by the luminaire fittings. T5 fluorescent lights with good luminaire fitting can provide efficient lighting with lighting power density below 10 W/m². It is estimated that energy consumption of the LED lights for general lighting in this public space is approximately 100% higher than using a regular T5 fluorescent lamp with good reflector. There is a need to provide the building industry the correct information on the choice of light fittings and its relationship to energy efficiency.

2. Lighting Control
Almost all new buildings lighting system are equipped with scheduled building management system with manual switch overriding function where necessary. Common area lighting circuit is normally circuited on alternate light fittings for ability to switch off 50% of the lights during nonstandard office hours in multi-tenanted buildings. This will allows 50% of the lights in the common area to be switched off during nonstandard office hours and 50% of the lights will be left switched on all night, in case there is still one or more persons working late in the building.

During the industry dialog, it was suggested for a study to show the saving potential in common area by providing a minimum lighting level (approximately 20% or 1 out of every 5 light fittings in common area are used to provide minimum night lighting level) and then provide occupancy sensor or time-delay switch to turn on all the lights when the common space is used. The same suggestion is made for fire escape staircases as well. It was also found that it is common for fire escape staircase lights to be switched on 24 hours daily in many buildings. A few existing buildings has practiced switching off the fire escape staircase during non-office operating hours and this has raised safety concern for building occupants working late in the building. There is a need to provide a guideline on optimizing electrical lights in fire escape staircases with different options of efficiency.

3. HVAC Sizing Design Practices
Most building HVAC system is properly designed using building heat load calculation software tools from Carrier, Trane and etc. However, it is also known that there are instances where the air-conditioning system sizing is done based on the rule-of-thumb heat load in W/m² or Btu/ft².h. In these cases, the HVAC system will be oversized wasting client initial capital cost. Moreover the system will also be running non-efficiently at low part load during operation. During the industry dialog session, it was provided with anecdotal evidence that there exist many buildings that was designed and installed with 3 chillers to operate at peak load but in actual operation, only one chiller needs to be operated for the entire year. Therefore, there is a need to address how HVAC system is sized and the assumptions that are used in the sizing of HVAC system.

Small power assumption of 15 W/m² is commonly practiced today. However, figure up to 30 W/m² was quoted during the industry dialog session. It was requested that a guideline should be provided for small power based on area (m²) and no of persons.
Lighting power of 15 W/m² is also commonly practiced today as the assumption for multi-tenanted building. Most consultants will coordinate the air-conditioning sizing with the design of the lighting system if it is an owner occupied building. However, there are consultants that do not follow such practices and use the lighting power density of 15 W/m² regardless of the actual design of the lighting system.

Fresh air ventilation rate usually follows the requirement of Ashrae 62.1. Consultants that do not use Ashrae 62.1 would typically assume 15 cfm/person (7.1 l/s per person). It is also understood that some consultants may not be using the latest version of Ashrae 62.1 and may be using an older version that asked for a much higher fresh air ventilation rate.

Design population density was stated by Economic Planning Unit (EPU) to be 16 m²/person for public buildings, while in the private sector, the standard of practice is 10 m²/person as mentioned in the UBBL (Malaysian Uniform Building by Law) and Bomba requirement. It is also common for the air-conditioning system sizing design to follows the default occupancy density provided by Ashrae 62.1 when no other information is available. The actual population density in existing Malaysian buildings varies significantly from building to building and is difficult to fix a number to it.

It is typical to assume a fan static pressure of 2 inch w.g. (500 Pa) during the sizing stage, but it was also agreed that some consultants do not provide this input at all while sizing the air-conditioning system. It was also commented during the industry dialog that consultants will use the efficiency of the fan as per selection of fan made during sizing stage. However, during sizing stage, the fan is not selected yet; therefore an assumption has to be made. It seems that the heat generated by AHU fan and motor is normally not accounted for but may be unknowingly allocated as part of the small power or lighting load during the design stage.

Lately, it has become common for engineers to request for glazing, wall and roof properties from architects to size their air-conditioning system.

Infiltration is normally not included in the sizing of air-conditioning system because the fresh air intake is assumed to have provided adequate positive pressure to the building enough to keep infiltration out of the building. However due to the lower fresh air ventilation rate of the latest Ashrae 62.1 coupled with exhaust air from toilets and lack of building air-tightness, buildings may not have adequate positive pressure to keep all the infiltration out. There is a risk that building air-conditioning system could be undersized due to the misunderstanding of all these factors that may cause excessive fresh air intake for the air-conditioning system.

It is important for air-conditioning sizing engineers to understand all the factors that contribute to the building heat load carefully to be able to size the system correctly for optimal energy efficiency.

4. **CAV, VAV and FCU**

The industry dialog session revealed that VAV are commonly designed for owner occupied building, while CAV is common for multi-tenanted building. However, there is a trend towards not providing any air-conditioning system at all, for multi-tenanted building. In these buildings, each individual owner is expected to put their own split-unit air-cooled air-conditioning unit themselves. Due to the reason that the efficiency of split-unit air-cooled air-conditioning unit is significantly lower than typical water cooled chilled water system, this trend is worrisome.
It was also revealed that it is not common practice to use FCU for an entire building. However, in certain situations, where the building is only partially occupied most of the time, the use of FCU may be the more energy efficient option to be considered because it allows fan power to be totally switched off at unoccupied spaces.

5. AHU Efficiency
The MS1525 provided a fan power limit on AHU. However, it was found during the industry dialog session that hardly anyone practiced this fan power limit in the industry. It was also found that it is not common to compute or to specify the fan power limit on AHU.

The current design practice on AHU design is to size the duct to a static pressure loss of 2 inch w.g. (500 Pa). Thereafter, there is no control on the fan efficiency or fan type to be used and also no control of the pressure loss across the cooling coil and air filters.

It was also found out from the industry dialog that most AHU are not fitted with pressure differential gauge on the air filters. Only a few owner occupied buildings may have this feature installed.

JKR indicated that their specification has requested for air foil fan since a couple of years back.

At the end of fan selection discussion, it was also indicated that forward curve fans are often used by the industry due to its low initial cost.

6. CO₂ Control of Fresh Air Intake
It was found out that although cost of CO₂ control of fresh air intake is fairly reasonable, it is hardly specified to be used in the private sector. The energy efficiency gain of using such control system is not appreciated by the building industry. Compounding to this problem is the revelation that there exist a few new buildings that are designed without any mechanical fresh air intake at all. It was revealed during the industry dialog that the Malaysian Uniform Building by Law (UBBL) has a minimum requirement of 1 air change per hour; however, it is not clearly specified if this requirement is for fresh air change or recirculated air change.

7. Heat Recovery
With the exception of operating theaters in hospital where specification up to 100% fresh air is required, heat recovery is not used by buildings in Malaysia.

8. Chiller Efficiency
In general almost all chillers installed in Malaysian building today exceed the minimum efficiency requirement of MS 1525. This indicates that there is good awareness in the building industry to specify efficient chillers to be installed.

9. Multiple Chillers
It is a common practice by the industry for multiple chillers installation in Malaysia to be designed for it to cater for various part load of the building. For example, a 3 chillers installation will have the following capacity: 1st chiller 50% capacity of building peak load, 2nd chiller 50% capacity of building peak load and 3rd capacity of chiller 25% of building peak load. This allows most of the chillers to be running close to the peak load for optimum efficiency even when the building is operating at part load condition.
Recent Ashrae journal publication has shown that the use of multiple chillers installed in series has significantly better overall system efficiency. However, all multiple chillers installation in Malaysia is installed in parallel.

**VRF Chiller**
Variable Refrigerant Flow (VRF) chiller that has good part-load efficiency is not commonly known by the building industry.

10. **Chill Water Flow System**
The industry dialog session revealed that most chill water flow system installed today is of variable primary flow type. A minimum chilled water flow rate of 70% of design peak load condition need to be maintained to prevent damages to chiller.

Older buildings are commonly installed with constant primary flow chill water. It is also fairly common to find primary/secondary variable flow chill water system in new buildings today.

This indicates that the building industry generally understood the energy efficiency benefit of variable flow chill water system. It was also mentioned during the dialog session that most engineers in Malaysia understood affinity pump/fan laws very well. This leads to more system being installed with high ΔT chilled water design in the industry to reduce chill water pump power use.

However, tender specification in the building industry rarely indicates the minimum efficiency of pump to be provided for both chill water and condenser water system.

In addition, there seems to be limited knowledge by the Malaysian building industry of the maximum flow rate allowable in pipes provided by Ashrae 90.1 (2007) Table 6.5.4.5, that is based on lifecycle analysis.

Finally, there is no pump power limit practiced by the industry.

11. **Condenser Flow Rate**
Although Ashrae has been publishing on the energy efficiency benefit of lower condenser flow rate, there is no known installation in Malaysia that has reduced condenser flow rate less than the standard rated condition of 3 gpm/ton.

12. **Cooling Tower Efficiency**
It is common to have multi-cells cooling tower installed where fans of each cells can be switched on and off individually. Due to the use of multi-cells cooling tower, it is uncommon to find the use VSD on cooling tower. It is also uncommon practice to specify cooling tower fan power limit for the amount of heat rejection from the cooling tower.

13. **Commissioning**
Commissioning in Malaysia was summarized in the industry dialog session as “as long as the system can be switched on & off and provided cooling to the building”. Air conditioning system is typically not tested to peak load and part load condition during commissioning. Recorded performance data during commissioning are not analyzed for potential further improvement of energy efficiency optimization. The industry dialog session recommended that a commissioning review and report should be implemented on all commissioning conducted in building.
14. Energy Management

Energy management is currently practiced in large factories due to the new mandatory requirement by Suruhanjaya Tenaga (Energy Commission). This mandatory requirement by the Suruhanjaya Tenaga is only for large energy users. Unfortunately most buildings are below the energy consumption limit set by Suruhanjaya Tenaga for mandatory energy management to be implemented for buildings. Energy management in buildings is typically conducted by the facility manager of the building which may not have in-depth engineering knowledge of the air-conditioning system installed at the facility and will not be able to fine-tune the system efficiently.