# Building Energy Efficiency Labelling Programme in Singapore

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## ABSTRACT

The use of electricity in buildings constitutes around 16% of Singapore's energy demand. To incorporate energy efficiency measures is one of the key mission to ensure that the economy is sustainable. The recently launched building energy efficiency labelling programme is such an initiative. Buildings whose energy performance are among the nation's top 25% and maintain a healthy and productive indoor environment as well as uphold a minimum performance for different systems can qualify to attain the Label. Detailed methodologies of the labelling process as well as the performance standards are elaborated in this paper. The main strengths of this system namely a rigorous benchmarking database and an independent audit conducted by a private accredited Energy Service Company (ESCO) are highlighted. A few buildings are already awarded the Energy Smart Office Label during the launch of the programme in December 2005. The labeling of other types of buildings like hotels, schools, hospitals etc is ongoing.

## KEYWORDS

Labeling, energy, efficiency, air conditioning, indoor environmental quality

## 1 AN OVERVIEW OF ENERGY LABELLING

The importance of Labelling a building in terms of energy performance is well recognized worldwide. A labelled building can get special recognition which helps to increase its resale value and rental income. Labelling can also help to identify poorly performing buildings and opportunities for energy saving. Highlighting the buildings with Labels in the portfolio sends a positive message to lenders, appraisers, owners, investors, and potential tenants or customers. It can assist in tracking the building's progress over time. It enables facility managers to set target and work towards improving energy efficiency in the long run by effectively employing the resources;

Most rating programs have been rather small, penetrating less than one percent of the building stock. However, the US Environmental Protection Agency's (EPA) Energy Star program is much larger scale involving more than a thousand buildings (Olofsson, Meier and Lamberts, 2004). As demonstrated by ENERGY STAR programme of US EPA, the Labelling helps to achieve tremendous energy savings at the national level. The European Union has recently come up with a directive for the energy performance of buildings requiring each Member State to create a clear legislative framework which will deliver the energy saving potential (www.eplabel.org).

## 2 SINGAPORE'S LABELLING PROGRAMME

Singapore is an equatorial country with relatively uniform temperature and high humidity. The average daily temperature is about 26.8 deg C and the average daily relative humidity is about 84.3 percent. Most of the 2.07 million employees are working in air-conditioned spaces that are cooled and de-humidified so as to achieve higher work productivity. The use of electricity in buildings made up 16% of Singapore's energy demand in 2004 and that was 5,307 GWh or about S$1 billion. Given Singapore's hot and humid climate, it is not surprising that demand for cooling forms a large part of the electrical demand. Indeed, most commercial and institutional energy usage comes from air-conditioning and lighting; government buildings are no exception. Typical office buildings can easily attribute 40 percent of their electrical demand to air-conditioning use and 15 percent to lighting use. There is a great potential for energy saving as many of the buildings are wasting energy because of inefficient design and neglected operation.

The Building Energy Efficiency Labelling Programme is developed by the Energy Sustainability Unit (ESU) of the National University of Singapore (NUS) and is implemented jointly with the National Environmental Agency (NEA) and ESU. The main objective of this programme is to grant recognition for building energy efficiency best practices and thereby motivate building owners and professionals to accord priority to building energy efficiency during the design, development and management of a building. It also helps to create role models and thereby spread the best practices relating to building energy management. It enables facility managers to set target and work towards improving energy efficiency by effectively employing the resources. The first product of the programme namely the Energy Smart Office Label was launched on 16 Dec 2005. 8 office buildings were certified as Energy Smart Office during the event.

### 2.1 Labelling Methodology

The Label will be granted on a scientific and objective basis. Buildings whose energy performance are among the nation's top 25% and maintain a healthy and productive indoor environment can qualify to attain the Label. However, the Labelling scheme also serves to work as a benchmark and checking scheme for buildings which may not completely fulfill the criteria. These buildings can apply for an energy certificate in which a detailed systems' level energy performance and benchmarking will be shown and the saving potential will be estimated. This can help the building owners to set target for the future and work towards achieving the Label award. Once awarded, the Label will be reviewed and assessed every three years. An applicant commences by engaging the services of an accredited energy services company (ESCO) from the ESU website to evaluate and certify the building's physical and operating characteristics, energy consumption and conformance to current indoor environmental standards.

## 3 BENCHMARKING

Building energy performance benchmarking can help to review consumption pattern within a building and compare them with the industry norms. This provides representative values for common building types, against which a building's actual performance can be compared. Simple benchmark of whole building annual energy use per unit floor area will permit the assessment of standard or class of energy efficiency. More detailed benchmarks can help to identify problematic areas within a building, predict building energy and cost saving potential and give recommendations of actions to be taken.

The benchmarking system developed here was based on a comprehensive database derived from the surveys of overall 104 commercial office buildings and a detailed study of 16 buildings in Singapore. The buildings were from both public and private sectors among which 81 buildings are defined as general office and 23 buildings are defined as office cum retail. In Singapore, electricity is the most commonly used energy source and accounts for the majority of energy use in commercial buildings. Usage of other sources such as diesel that often used for stand-by power, natural gas and renewable energy is negligible. Therefore, only site electricity energy consumption is measured and used for energy benchmarking. The total building energy consumption was normalized for the effects of primary factors (e.g. Gross floor area or Air conditioned area) and secondary factors (e.g. Building usage, occupancy, ownership, floor area occupancy rate etc.). This can make the benchmarking among buildings more fair and accurate. The sampling error has been determined as 5%. The input data for the whole building energy consumption include, GFA, car park area, monthly energy consumption for 1 year, number of occupants, operating hours etc. In order to be within the top 25%, the normalized EUI for an office building should be less than 178 kWh/m$^2$/year. The benchmarking system can also be applied to major energy consuming systems such as air-conditioning, lighting as well as mechanical ventilation.

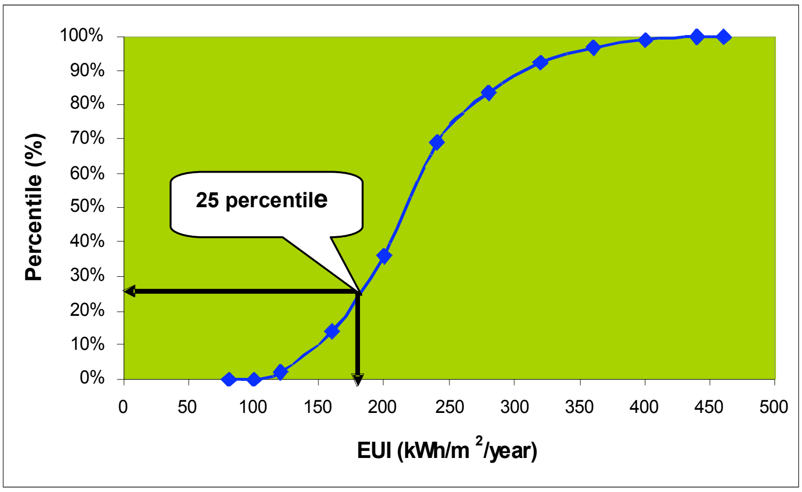


Figure 1 Benchmark curve developed for the Singapore office buildings

## 4 ELIGIBILITY CRITERIA AND PERFORMANCE STANDARDS

To be eligible for the Energy Smart Office Label, the buildings should be able to meet the physical, occupancy and energy criteria. The performance standards set are as given below.

### 4.1 Systems' performance

Building systems' design and operating efficiency are fundamental to the overall energy efficiency of a building. Air conditioning, the biggest consumer of electricity is recognized to have the most critical effect in Singapore. The air conditioning system energy performance indicator serves as a benchmark to the total building energy efficiency classification. Hence, in order to minimize the total energy consumption, it is necessary to ensure that such essential building system perform as efficiently as possible. The next larger energy consuming systems are lighting and mechanical ventilation systems. Taking into consideration the existing buildings which have been equipped for a period of time, the range of acceptable performance efficiency for the various systems are as given in Table 1. Building owners and their management are encouraged to optimise systems' efficiency. Where appropriate, actions should be taken to retrofit systems and upgrade their efficiency to a suitable standard.

TABLE 1
Recommended Ranges for The Building Systems' Energy Consumption

| Systems | ⁺Eligibility Requirements | Remarks |
|---|---|---|
| Air Conditioning | Plant room Efficiency < 1.0 kW/RT | Primary and secondary pumps' kW consumption should not be included in the calculation. |
| Lighting | Lighting power density < 9.0 W/m$^2$ | |
| Mechanical Ventilation | Mechanical ventilation density < 3.2 W/m$^2$ | |

⁺ All the ranges given are based on existing data, therefore are subjected to change

Many Singapore office buildings use a central air conditioning system as shown in Figure 6. The system consists of cooling towers (CT), condenser water pumps (CWP), chillers, chilled water pumps (CHWP) and air handling units (AHU) in a closed loop configuration. To compare a building with another building with different number of chillers and AHUs, an indicator KW/RT, which is a measure of energy efficiency for producing chilled water can be used to compare the CTs, CWPs and chillers. But for CHWPs and AHUs, KW/RT may not be suitable as the function of the CHWP (whether Primary and or Secondary) is to provide sufficient pressure head for chilled water to flow and piping configuration is a factor in pressure head requirement. At present, any suitable indicator that takes into consideration of piping configuration to compare two buildings of different piping configurations is not known. Therefore, Energy Smart Office scheme does not consider primary and secondary chilled water pumps for the calculations of air conditioning system's performance. The current standard set for the air condition system is 1 kW/RT. Building owners are encouraged to work towards a higher performance standard within the given range. The revision of this standard to 0.7 kW/RT with effect from 1 Jan 2007 is presently being studied.

## 4.2 Environmental performance

The four environmental parameters namely thermal comfort, illumination, fresh air ventilation and indoor air quality should be according to the code of practice. All the measurements have to be conducted during the occupied hours at representative sample spaces. The sampling locations should be representative of all the floors. Here, the main objective is to make sure that the occupants' needs are not compromised with stringent requirements as shown in the tables. Also an occupant survey should be conducted to see their level of satisfaction in the indoor environment and the survey results should indicate an acceptance rate of at least 80% by the occupants. Table 2 shows the permissible level of Indoor air pollutants based on the guidelines for good indoor air quality in office premises,

Table 2
Acceptable Levels for Various Indoor Air Pollutants

| Parameter | Maximum concentration for specific indoor air pollutants* | Averaging Time* |
|---|---|---|
| Carbon dioxide | 1000 ppm (1800 mg/$m^3$) | 8 hours |
| Carbon monoxide | 9 ppm (10 mg/$m^3$) | Spot measurements |
| Formaldehyde | 0.1 ppm (120 μg/$m^3$) | Spot measurements |
| Ozone | 0.05 ppm (100 μg/$m^3$) | Spot measurements |
| Suspended Particulate matter | 150 μg/$m^3$ | Spot measurements |
| Volatile Organic Compounds | 3 ppm | Spot measurements |
| Bacteria | 500 CFU/ $m^3$ | Spot measurements |
| Fungi | 500 CFU/ $m^3$ | Spot measurements (2 cycles) |

- based on Guidelines for Good Indoor Air Quality in Office Premises, 1st Edition (1996) and CP: 13 1999, Clause 7.6

Besides granting recognition to buildings that are energy efficient and of good indoor environmental quality; it also gives clear targets for buildings that are not energy efficient and or of poor indoor environmental quality, to improve energy efficiency and indoor environmental quality so as to achieve higher work productivity and to reduce energy costs. With clear targets and gap analysis, government organisations can explore exact measures to reduce energy costs.

# 5 CONCLUSIONS

The energy efficiency label can showcase that Energy Efficient Buildings are also performing buildings. This will encourage developers, building owners, Architects and Engineers to adopt best practices in the conceptualization, design and construction as well as in the operations and management of buildings. It helps to reduce $CO_2$ emission and consumption of fossil fuels within the building sector through improved energy efficiency. This also results in lower pressure on infra-structural demand and cost. It is expected that the label will progress with time and contribute quantifiably to the energy efficiency and security targets of Singapore and helps to achieve tremendous energy savings at the national level. The benchmarking and labeling of other types of buildings like hotels and hospitals is ongoing.

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