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Research Article

Review of Building Energy Efficiency in the Hot and Humid Climate of Malaysia

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Abstract: Globally, environmental concerns and the progressively increasing high cost of energy have resulted in renewed interest in alternative forms of energy conservation and efficiency. The aim of this study is to describe various energy policies that the government of Malaysia has been adopted in order to ensure long-term reliability and security of energy supply for sustainable social economic development in the country. Improved living standards in developing nations have led to higher demand for energy, which requires nations to review their energy efficient strategies. While a significant portion of the total primary energy is consumed by buildings in developed nations, developing nations like Malaysia are proactively addressing the energy consumption issue. This review describes the standards and energy efficient codes for buildings, introduces low-energy building concepts and provides information on energy consumption of buildings in Malaysia. Alternative energy options like biomass, solar, wind and mini-hydro energy to ensure reliable, sustainable and secure supplies of energy in this country are considered.

Keywords: Building energy efficiency, energy demand, Malaysia, policy

INTRODUCTION

With a global demand for energy projected over the next 24 years (Source OECD, 2006), effective energy-efficient policies and programmes need to meet all dimensions of sustainable development, including social, environmental and economic (Komor and Bazilian, 2005). Energy may be considered a catalyst for development but it can also be used as a barometer to measure the level of economic development in a particular country. Awareness of environmental degradation derived from energy production such as air pollution and climate change is leading to not only policy change, but energy audits. Therefore, energy audits are conducted as a useful way of determining how energy efficient the building is and what improvements can be made to enhance its efficiency. Energy efficiency in buildings is defined by the minimisation of energy used for heating, cooling, lighting and operation of appliances within buildings (Mekhilef *et al*., 2014). The rapid growth in population and economic activities in tropical countries leads to an increase in energy consumption, which hastens the depletion of available energy resources (Kwong *et al*., 2014). There are three main government establishments in Malaysia that comply with energy conservation standards: the Green Energy Office (GEO) in Bangi,the Low Energy Office (LEO) and the Malaysia Energy Commission Sustainable Building (Diamond Building), both located in Putrajaya (Xin and Rao, 2013).

Energy efficient Codes exist to provide guidance for commercial, industrial and now, residential buildings and houses. The Leadership in Energy and Environmental Design (LEED) in the United States (US), an internationally recognised green building certification system developed by the US Green Building Council (USGBC), provide a concise framework for identifying and implementing green building design. The United Kingdom (UK) has a similar Code, promoting sustainability of homes (Low Energy House, 2010). While there are few countries in the world that have adopted mandatory requirements on energy conservation for buildings, developed States like the UK, Sweden and Finland, continuously review their renewable energy policy to ensure that their country is moving towards a sustainable energy economy (Ericsson *et al*., 2004; Tsai and Chou, 2006; Wang, 2006; Winkler, 2005). Due to increase in population and vast economic growth, energy consumption for

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developing nations is projected to expand in the years to come (SourceOECD, 2006), with consumption in Malaysia and Singapore's commercial buildings being the highest in the region (Mohamed and Lee, 2006). Therefore, the study establishes that the government of Malaysia have implemented various energy policies successfully due to increase access to affordable modern energy services in order to accomplish the mix energy resources and technologies. Governments like Malaysia will need to commit time, technical expertise and seek financial assistance to evaluate materials used in building performance in developing the necessary energy efficiency programmes (Ossen, 2005; Mohamed and Lee, 2006).

STANDARDS AND ENERGY EFFICIENT CODES OF BUILDINGS IN MALAYSIA

After the oil crisis in 1980, Malaysia considered energy conservation and efficiency of great concern and supported policies developed for the country's long-term energy security and socio-economic development (Mohamed and Lee, 2006; Ramatha, 1994). Three policies address main issues of energy production, distribution and consumption (Wong and Li, 2007): Malaysia's National Energy policy, established in 1979 (Malaysia Minister Department, 2001; National Depletion Policy, 1980; Mohamed and Lee, 2006). The 1979 Policy also emphasised clean utilisation of energy, a progressive goal considering statistics illustrate rapid growth of demand (Ossen, 2005). Long-term country guidance in the form of the Seventh Malaysia Plan (1996–2000) require regulations to include energy management of controlled installations, appointment and duties of energy efficiency officers, approval and labelling of certain energy consuming products and scheduling of products.

The Green Building Index (GBI), launched in 2008 and similar to the Green Star and Green Mark initiatives of Australia and Singapore, is Malaysia's industry recognised green rating tool for buildings to promote sustainability in the built environment which raises awareness among developers, architects, engineers, planners and the public about environmental issues and the responsibility to future generations. It is developed specifically for the local tropical climate, environment and developmental context, as well as cultural and social needs (Al-Tamimi, 2011). As a rating system which provides a comprehensive framework for building assessment of energy efficiency (EE), indoor environment quality, sustainable site planning and management, materials and resources, water efficiency (Chua and Oh, 2010), the GBI results in successful projects partially funded by global organisations and invested in by the government (Al-Tamimi, 2011). The GBI guideline developed into the Malaysian Standard MS 1525:2001, Code of Practice on Energy Efficiency and Use of Renewable Energy for Non-Residential Buildings (Malaysian Standard 2001) which incorporates almost all of the ideas and principles recommended in the MS 1525:2007 (Ahmed, 2008).

LOW-ENERGY BUILDINGS IN MALAYSIA

The LEO under the Ministry of Energy, Green Technology and Water (MEGTW), Zero Energy Office (ZEO) of Malaysian Green Technology and Water (GTM) and the Diamond building of the Energy Commission (EC) are examples of energy efficient implementation for buildings. PusatTenaga Malaysia (Malaysia Energy Centre), previously known as the ZEO Building as shown in Fig. 1, is officially Malaysia's first GBI-certified building in 2009 (GBI, 2011). The LEO Building in Putrajaya (Fig. 2) is an example of such efforts by MEGTW, being first occupied in 2004 (Al-Tamimi, 2011). A ZEO building requires that the building must not consume more electricity than renewable energy (RE) sources can be produced on site (Chua and Oh, 2010).

The EC is designed as an energy efficient building to house its headquarters. A building located in the commercial district of Putrajaya, it is nominated as the most sustainable building in Malaysia. The diamond-shaped building provides a self-shading form as a passive design strategy (Fig. 3) (Nikpour *et al*., 2013).

Fig. 1: The PTM (ZEO) building in Bangi, Malaysia, GEO (2011)

Fig. 2: The LEO building in Putrajaya, Malaysia, MEGTW (2011)

Fig. 3: The energy commission diamond building, Xin and Rao (2013)

The atrium of the building is exposed to the intense solar radiation across the day. It is designed in such a way that the heat gain and thermal impact are kept at a minimum while ensuring sufficient daylight enters for natural lighting purposes in both the atrium and the office zone around the atrium.

ENERGY CONSUMPTION OF BUILDINGS IN MALAYSIA

Roodman *et al*. (1995) and the United Nations Environment Programme (UNEP) (Al-Tamimi, 2011)highlight that the World watch Institute estimates building consumption to be at least 40% of the world's energy and 16% of the water used annually. The majority of countries in the world have developed with a reliable and adequate supply of electricity generated by fossil fuels. In the Building Energy Efficiency Programme (BEEP), energy efficiency promotes optimal use of energy in heating, cooling and lighting which can be achieved by several strategies that optimise and regulate energy use in the building. Examples of BEEP strategies include windows with glazing to prevent heat gain and controls for regulating energy use (Chua and Oh, 2010). Heating, Ventilation and Air Conditioning (HVAC) accounts for 40-60% of the energy used in commercial and residential buildings in the United States. In the developing world, China for example, t HVAC energy use is lower (Li and Yao, 2009) indicative of the scale of the looming problem.

Energy studies of commercial buildings in Southeast Asia, comprising of Malaysia, Indonesia, Philippines, Singapore and Thailand, were initiated under the ASEAN-USAID Building Energy Conservation project in 1992 (Ossen, 2005). According to the results in Malaysian offices, energy consumption forair-conditioning and fans is approximately 68.8% and electric lighting 23% oftotal electricity use. Compared to other Southeast Asian countries, the energy consumption for air-conditioning is still high in Malaysia, while Singapore reports the highest lighting consumption (Table 1) (Ossen, 2005). Buildings, energy and the environment have become some of the key issues facing the building profession (Ahmed, 2008) with Malaysia requiring strong and efficient strategies in place to lower energy consumption in building.

As Malaysia moves towards becoming a developed country, energy requirements remain very intensive. Energy efficient measures, standards and codes are introduced to determine the baseline mainly in non-residential buildings. These standards underline the minimum requirements to achieve energy savings in buildings (Ossen, 2005) considering that energy demand in Malaysia are estimated to be growing at a rate of about 5-6% annually (UK Trade and Investment, 2003). Table 2 shows that more than 50% of the energy used in commercial buildings is utilised by lighting and air-conditioning. This leads to the assumption that there is an enormous potential in energy savings that may result from energy efficient practices in buildings (Ahmed, 2008).

Electric lighting energy consumption: In Malaysia, there is a growing concern about energy consumption and its climate does not offer sufficient conditions to ensure cooling comfort all year round. Figure 4 shows that electricity generation in 2009 is 99,247 GWh, which represents an increase of 343% from 22,400 GWh in 1990 (Al-Tamimi, 2011).

The commercial and residential sectors in Malaysia consume about 29% and 20% of the total electricity usage for the year 2002, respectively (MECM, 2002). Amounting to approximately one quarter of total usage, increments for both sectors increased from the previous year. The industrial sector reports the highest amount of electricity energy at 51% of total usage. The total electricity consumption in 2001 recorded 63,043 GWh and 66,991.4 GWh in 2002, a 6.3% growth. Annual growth rate for electricity demand increases to 5.8% in 2002 from 4.5% in 2001. The growth in electrical demand is due to the economic recovery in the industrial and commercial sectors. The total final commercial energy demand is 33,290 KTOE (kilotons of oil equivalent) in 2002 compared with 31,515 KTOE in 2001. The total electricity consumed from 1980 to 2009 increases by 9.2%, while the country's gross domestic product (GDP) increases by 6.2% in the same period (Bekhet and Othman, 2011).

Table 1: Electricity consumption percentages by building components for ASEAN countries

	Consumption by component (%)			
Country	Air-conditioning	Fans	Lighting	Miscellaneous
Indonesia	36.6	43.5	11.8	8.10
Malaysia	60.1	8.70	23.1	8.10
Philippines	45.0	16.2	22.5	5.60
Singapore	36.6	13.2	24.2	26.0
ASEAN*	46.0	15.6	22.5	15.5

ASEAN-USAID Building Energy Conservation Project Final Report (Loewen *et al*., 1992)

Table 2: Energy consumption according to building type in Malaysia

Electrical appliances	Residential	Hotels	Shopping complex	Offices
Lighting	25.3	18.0	51.9	42.5
Air conditioning	8.30	38.5	44.9	51.8
Total	33.6	56.5	96.8	94.3

Ahmed (2008)

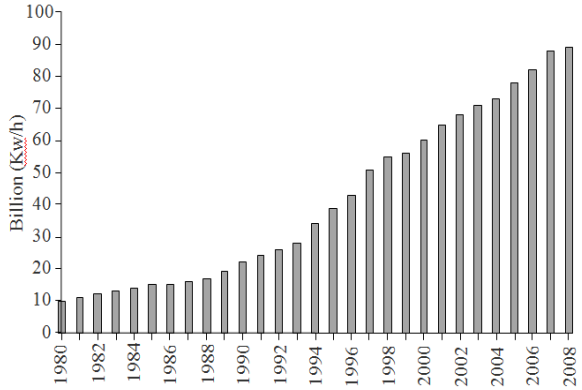

Fig. 4: Electricity Net Consumption in Malaysia EIA (2009)

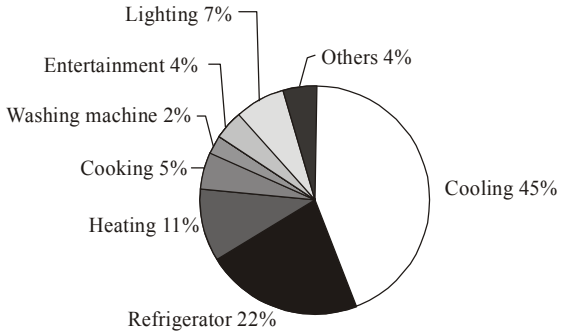

Fig. 5: Average Home Electricity Consumption, CETDEM (2006)

Cooling energy consumption: In tropical countries, cooling contributes to a significant share of residential energy consumption. The Centre of Environment, Technology and Development, Malaysia (CETDEM) in cooperation with MajlisBandarayaPetaling Jaya emphasises these realities with a study of household energy use (Sabouri, 2012). According to Rahman *et al*. (2008) Malaysian buildings are consuming approximately 70% of energy for cooling indoor environments. National energy demand has increased fivefold over the last two decades, while the total population has doubled in the past 30 years from 10.4 million in 1970 to 22.2 million in 2000. Since most of the cities in this region experience a hot and humid climate all year round, it is particularly important to develop passive cooling techniques in order to reduce energy consumption caused by the growing use of air-conditioners. The total number of households with air-conditioners in Malaysia has dramatically increased from 13,000 in 1970 to 229,000 in 1990 and 775,000 in 2000, mainly due to the increase in household income (Kubota *et al*., 2009). Improved living standards means people tend to be more accustomed to air-conditioned environments. The more affluent, the more popular air-conditioning systems become to achieve a comfortable internal environment (Byrd, 2008). Based on a United Nations Development Report, Malaysia is the 26th largest contributor of greenhouse gases globally (Sadrzadehrafiei, 2013). A CETDEM study of household energy use shown in Fig. 5 finds that air conditioning consumes the most electricity in the home, accounting for nearly 45% of the average household consumption (CETDEM, 2006). The number of air conditioners has increased from 57,340 units in 1980 to 860,462 in 2008 (Al-Tamimi, 2011).

The study of Kongkiatumpai (1999) finds that the mean energy consumption reduction corresponding to a 1°C increase of the set point is about 6.14%. This is also confirmed by the study of Atthajariyakul and Leephakpreeda (2004) which shows that energy is saved by 17.5% when the temperature set point changes from 25 to 28°C. This amounts to approximately 6% savings for every 1°C increase (Atthajariyakul and Leephakpreeda, 2004; Kongkiatumpai, 1999). Energy use is especially sensitive to temperature in the hot summer months and in southern regions. Ahmed (2008) reports that more than 40% of the energy consumed by Malaysian buildings can be reduced if energy efficiency is practiced and sustainable technologies are applied to buildings. The increase in electricity use by the residential sector, particularly in hot and humid periods, is caused by the growing demand for air-conditioners to provide thermal comfort for the occupants (Wong and Li, 2007).

CONCLUSION

Previous works relevant to energy issues in the Malaysian context are reviewed (in general the South East Asian region) to attain an overview on the energy consumption in office buildings. Review of energy consumption patterns in Malaysia reveals that energy demand in general has increased almost thrice in 2002 compared to 1990. As a conclusion, Malaysia is aware of its role in formulating its national energy development policies, being sensitive to the country's development needs, the environment and utilisation of energy resources. They are conscientious and responsive towards the call for sustainable development in promoting renewable energy and energy efficiency. Thus, it is important to promote energy conservation and efficiency in every sector within the country in order to reduce the energy demand in the future.

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