Sustainability Development; Energy Efficiency Passive Design Practices

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***Abstract*—Recently, environmental performance, especially energy efficiency proposal is the key issue for the sustainability development. This paper studies the importance of energy efficiency in Malaysian building sector. The current building passive energy efficiency design practices in Malaysia are established in three different phases including; literature review based to identify, brain storming session to capture and criticize, and validation by the consultants to verify them. The research shows that financial limitation is the most significant barrier to energy efficiency. So, the awareness of designer plays the important key role to overcome this issue by employing the energy efficiency design practices. Therefore, the number of 14 current building passive energy efficiency design practices is found to be implemented by building sector designers toward development of sustainability in Malaysia. Results clearly indicate that the daylight harvesting, external sun shading, wall and roof insulation, windows to wall ratio are the most prominent common practices.**

Key words: Sustainability, Energy Efficiency (EE), Passive EE design

I. INTRODUCTION

Sustainability presents major challenges and amazing opportunities for industries [1]. Since 2005, a new definition of sustainability is reconciliation between three aspects of environmental protection, social development and economic growth. [2]. Figure 1 illustrates the integration of these three dimensions to redress the balance between them as mutually beneficial factors.

In the triple basic reasons of sustainability, the strategy of 'environmental performance' is essentially needed [1]. Besides, sustainability is progressively more observed as a desired goal of development and environmental management.

With the aim of environmentally managing, the majority of the developed countries are in the center of shifting from crude oil dependent to diversity of mix energy and development of renewable energy sources. Although, converting from the 'old economy' to the 'new economy' with the aspect of reuse, recycle and new energy is a desired goal, but managing of this transition is a challenge due to bringing substantial endangering

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to biodiversity and human safety [2]. Hence, it is essential to running energy efficiency ways that are free of possible risks.

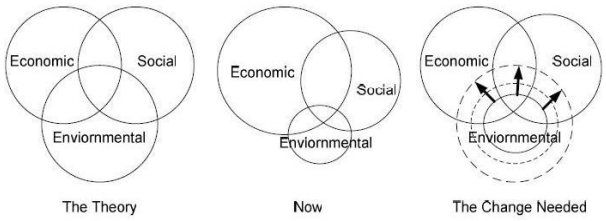


Figure 1: Overlapping circles of Sustainable Development (Adams, 2006)[3].

II. Implementiong of Energy Efficiency Solutions

To have a community environmentally sustainable, going to energy efficiency is a concept that receives attention nowadays. To propose sustainability for construction building industry, "energy efficiency as an environmental strategy" is significantly more prominent [4]. Evidences reveal that energy efficiency program is a necessity for developing societies, especially for Malaysia as a prospective hub in sustainability development. Given below are some of the mentioned evidences;

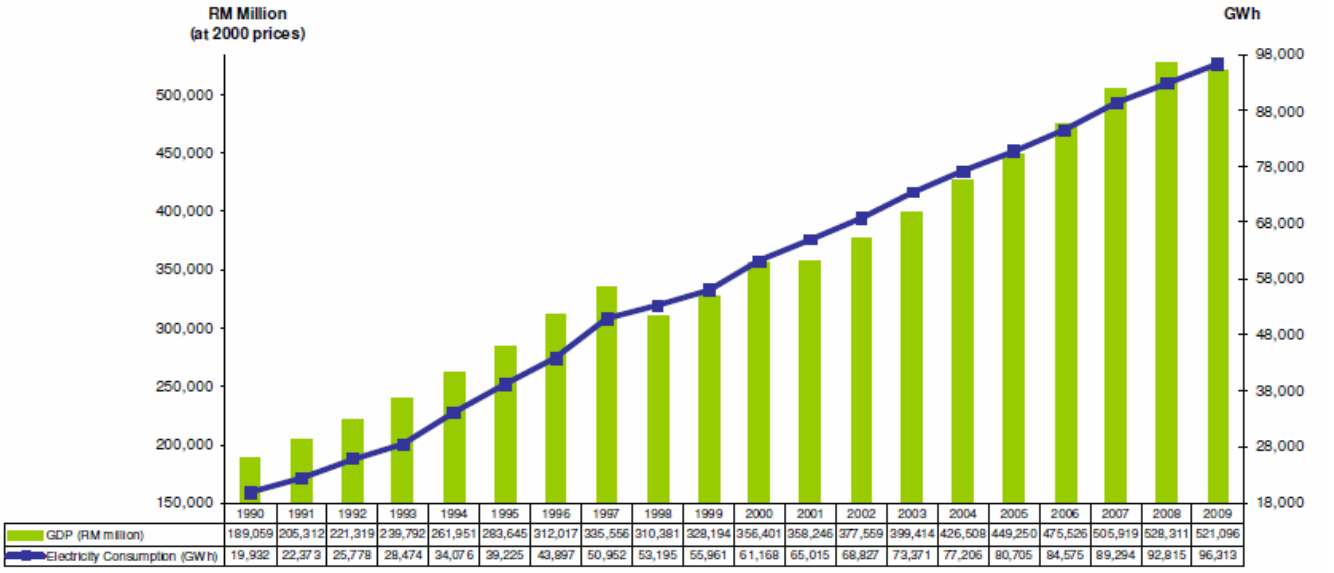
A. Energy usage and demand

The climate change, energy security and instability of petroleum price are concerns that encourage significantly thinking about generation, transition and consumption of energy and electricity specifically in Malaysia [5]. Based on Shafiea et al. 2011 [5] a primary increase by 1.6% per annum or 45% in total of global energy consumption is predicted between now and 2030 in the next 18 years. In addition, Malaysia is dependent on fossil fuel for industrial sections such as building construction. That is while in 2009, 94.5% of electricity is generated by using fossil fuel [5]. Energy demand is important evidence regarding to this issue. Figure 2 shows that electricity demand in Malaysia is expected to reach 18,947 MW in 2020 and 23,092 MW in 2030. This shows a raise of approximately 35% from the 14,007 MW in 2008 [5]. In Malaysia, Overall electricity demand is estimated to grow up continuously between 7 to 8 percent per year until 2020.

Going forward to sustainability needs to reduce consumption flow. Regarding to increasing in the word demographic population, more especially in Malaysia predominately the role of efficiency in each aspect of our community, particularly in energy is vital.

B. Gross domestic product

Gross domestic product (GDP) is a measurement for economic growth assessment. In Malaysia, GDP has correlation nearly exactly with the energy consumption of the nation [5]. Figure 3 illustrates the trends in GDP and electricity consumption in Malaysia from 1990 until 2009. It is observed that GDP is accurately followed by energy consumption during 19 continuous years.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
GDP (RM million)	189,059	205,312	221,319	239,792	261,951	283,645	312,017	335,556	310,381	328,194	356,401	358,246	377,559	399,414	426,508	449,250	475,526	505,919	528,311	521,096
Electricity Consumption (GWh)	19,932	22,373	25,778	28,474	34,076	39,225	43,897	50,952	53,195	55,961	61,168	65,015	68,827	73,371	77,206	80,705	84,575	89,294	92,815	96,313

Fig. 3. Trends in GDP and electricity consumption in Malaysia, 1990–2009, Source: National Energy Balance 2009, Ministry of Energy, Green Technology and Water [6].

C. Developing in human quality of life

In addition, Government in the direction of country development is required to increase the level of people income intending to increase in quality of life. On the other hand, enhancing human quality of life causes the higher energy usage, and it leads to increase in carbon footprint.

This acknowledges that Malaysia needs to improve the efficiency of energy consumption and carbon foot print in sustainable building construction to make improvement in human quality of life [7]. Figure 4 highlights correlation between human develop index (HDI) and energy consumption within different countries and shows the critical situation of Malaysia.

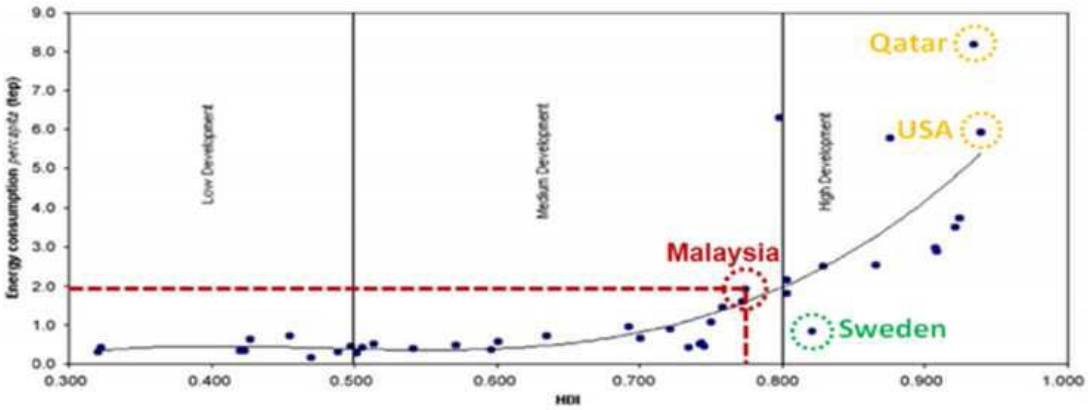


Figure 4: HDI versus Energy consumption within various countries (Adopted from R.A. Dias et al. 2006) [7].

D. Current malaysian plan

Since 7th Malaysia Plan (1996- 2000), an important identified criteria to guarantee sustainability of energy supply is energy efficiency [2]. The key emphasis was to promote the use of new and alternative energy sources and also efficient consumption of energy. Recently, in the 10th Malaysia Plan (2011-2015), the highlighted key vested in National Green Technology Policy (2009) is on following short term aims;

- Promotion and encouragement of EE
- Establishment of EE targets and standards

Consequently, EE plays the key function as an environmental control approach in recently Malaysian plans. Considering of EE in sustainable approach is able to aid reducing material consumption as well as decreasing air pollution [1]. The current increase in annum building energy consumption is estimated continuously to contribute considerably to the country's Green House Gases (GHG) emissions unless actions are done to improve energy efficiency.

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III. BARRIERS TO ENERGY EFFICIENCY

Based on previous effort by Tan Ching Sin et al. 2011 [2] in identifying the main barriers to implement energy efficiency in Malaysia, it can be categorized in two sets:

- Limitation in knowledge or awareness of EE
- Limitation in finance of EE

Accordingly, EE barriers come from government related issues or public related issues. At government's related issues, there are some solutions in accordance with each barrier. Some types of solutions need long-term planning and immense budgets. But another type of solutions, while mostly is free, just needs the awareness about EE behavior capability to use.

At government section, a number of action plans and measures have been taken by the Government of Malaysia to enhance and improve energy efficiency at the supply side and demand side.

IV. ENERGY EFFICIENCY AT DEMAND SIDE IN COMMERCIAL SECTION

The government of Malaysia has taken a number of pro-active actions in promoting Energy Efficiency by the demonstration of Low Energy Office (LEO) building of the Ministry of Energy, Green Technology and Water in 2004, the Green Energy Office (GEO) of Malaysia Green Technology Corporation (MGTC) previously known as Pusat Tenaga Nasional (PTM) in 2008, and also Diamond building as the first one in Malaysia to be awarded the Green-Building Index Platinum Rating in 2011, the highest level of certification for a green building .

These demonstration buildings will hope to promote private building sector to design and construct low energy buildings. The buildings depending on the scores achieved will be given an award depended upon four types of ratings consist of certified, silver, gold and platinum. Non residential and residential properties been assessed under the Green Building Index rating system (GBI). GBI is designed based on six (6) main key criteria as structured in table I.

TABLE I. GBI CRITERIA, SOURCES: SHING CHYI CHUA AND TICK HUI OH, 2011[8],GBI [9], AND TAN CHING SIN ET AL, 2011[2]

	GBI Criteria	GBI for Township Rating tool
1	Energy efficiency (EE)	Climate, Energy and Water
2	indoor environment quality (EQ)	Ecology & Environment
3	sustainable site and management (SM)	Community Planning & Design
4	materials and resources (MR)	Transportation & Connectivity
5	water efficiency (WE)	Building & Resources
6	Innovation (IN)	Business & Innovation

The Green Building Index rating system in Malaysia is a strong operator for energy efficiency in building. It positively influences on building EE practices in Malaysia. The GBI as a green feature is premier allocated assessment tool for EE.

Fulfilling of EE program is required to be implemented by all building sector involvers. Indeed, Procuring Architectural and Engineering Services for Energy Efficiency and Sustainability are a minor part of the building construction cost [10] (Table II). It encourages clients to obtain such as services, while they will utilize the immense benefits during building lifecycle.

TABLE II. TYPICAL ADDITIONAL EXPANSION IN SUSTAINABLE DESIGN PROJECT, SOURCE; US DEPARTMENT OF ENERGY [10]

Activity	Minimum cost	Maximum cost
Additional A/E fees for "greening" of building	0% of project costs	5% of project costs
Energy modeling	Approximately $10,000 for a simple building	$20,000 to $50,000 for a complex building
LEED facilitation	0.25% of project cost for large building	0.50% of project cost for small building
Enhanced commissioning*	0.25% of project cost for large building	0.50% of project cost for small building

V. ENERGY EFFICIENCY PASSIVE DESIGN

What are the positive characteristics of a sustainable building? This is supported by Ang et al. 2008:5 [11] who mentioned that "financial benefits, a longer building life-cycle and a healthy environment for occupants are some of the attributes commonly promoted as positive characteristics of a sustainable building." The fundamental aim of growing the level of sustainability in buildings is to decrease the environmental impact of the building all over the entire building lifecycle from design and construction [12], [13].

Annual energy consumption of a typical Malaysian office building as a most consumer type of energy is about 250 KWh/m2 [14]. This is significantly more rather than the other developing countries. In spite of a great number of people usually spend much part of their time in office building; energy efficiency is not completely employed in the design, operation and maintenance of office buildings in Malaysia. Need to the implementation EE design throughout the country especially in buildings areas, architects are required to concentrate on implementing of EE passive design as an environmental solution [15].

VI. RESEARCH METHODOLOGY

Based on Table III, to establish the current passive EE design practices in Malaysia, the relevant methodology in three (3) steps is planned.

TABLE III. RESEARCH ACTION PLAN

Step		Action
1	Content analysis	It is Reviewing related to Passive Energy Efficiency Design articles in buildings indicators.
2	Interpretive study	It is to capture Passive Design methods related to "energy efficiency" in a sample size of energy efficient consultants in building.
3	Validation	It is to be validated by building management professionals in a brain storming session, to criticize the finding (expert input/expert panel).

VII. CURRENT PASSIVE ENERGY EFFICIENCY DESIGN PRACTICES IN MALAYSIA

Conducting interviews to 24 consultants on literature based identified practices in Malaysia, current established building passive energy efficiency design practices (BPEEDP) are as table IV.

TABLE IV. BUILDING PASSIVE DESIGN EE PRACTICES

BPEEDP	Author*									
	16	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*
Daylight Harvesting	✓		✓	✓		✓	✓			
External Sun Shading	✓						✓	✓		✓
Wall Insulation	✓	✓		✓	✓	✓	✓	✓		
Roof Insulation	✓						✓	✓		
Windows to Wall Ratio	✓		✓	✓		✓	✓		✓	✓
Core Locations	✓		✓	✓		✓	✓	✓		
Building Form				✓		✓			✓	
Shape Selection	✓			✓		✓	✓	✓	✓	
Glazing Properties	✓					✓		✓	✓	
Air-Well Ventilation			✓			✓	✓			
Air-Tightness in Building				✓		✓				
Zoning Requirement			✓	✓			✓			
Interior Design Layout			✓	✓						✓
Skylight Design				✓						

Note. : indicate the consideration of factor (in row) by author (in column).
*Authors name as reference list.

VIII. CONCLUSION

Energy efficiency is a significant potential towards the development of sustainable energy to reduce the impact of the energy on the vital environment. The government of Malaysia acknowledges the advantages and importance of energy efficiency in the country and a number of action plans and measures have been taken to guarantee.

Necessity of implementing energy efficiency all over the country particularly in construction buildings sector, architect designers require to implement established passive energy efficiency design practices. In term of importance, these practices in order are daylight harvesting, external sun shading, wall and roof insulation, windows to wall ratio, interior layout design, core location, building form and shape selection, glazing properties, air-well ventilation, air tightness, zoning requirements, and skylight design.

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REFERENCES

[1] M. Zaimi Abd Majid, H. Bin Lamit, A. Keyvanfar, and A. Shafaghat, Conceptual Intelligent Building (IB) Design Framework to Improve the Level of User Comfort Towards Sustainable Energy Efficient Strategies: Proposal Validation (April 30, 2012), OIDA International Journal of Sustainable Development, Vol. 04, No. 01, 2012, pp. 11-18.

[2] T. Ching Sin, S. Bte Mohd Sood, L. Yow Peng, Sustainability Development through Energy Efficiency Initiatives in Malaysia, ©15-ICIT 26-28/7/11 in Malaysia ST-4: Green & Energy Management, 2011

[3] W.M. Adams, 'The Future of Sustainability: Re-thinking Environment and Development in the Twentyfirst Century', The World Conservation Union, IUNC, Report of the IUCN Renowned Thinkers Meeting, 29-31 January 2006.

[4] M. Zaimi Abd Majid, H. Lamit, A . Keyvanfar, A . Shafaghat, I. Sarrazin Mohammad, T. Malik, M. Pirmohammadi, Sustainable Building Design Framework: Covering Intelligent Building, User Comfort and Energy Efficiency, Journal of Biobased Materials and Bioenergy, in press, 2013

[5] S.M. Shafie, T.M.I. Mahlia, H.H. Masjuki A. Andriyan, Current energy usage and sustainable energy in Malaysia: A review, Renewable and Sustainable Energy Reviews 15, 2011, pp. 4370– 4377.

[6] National Energy Balance 2009 Malaysia, Pusat Tenaga Malaysia (PTM).

[7] A. Dias Rubens, R. Mattos Cristiano, and J. A. P. Balestieri, The limits of human development and the use of energy and natural resources, Energy Policy, Volume 34, Issue 9, June 2006, pp. 1026-1031.

[8] S. Chyi Chua , T. Hui Oh, Green progress and prospect in Malaysia, Renewable and Sustainable Energy Reviews 15, 2011, pp. 2850– 2861.

[9] GREEN BUILDING INDEX DESIGN REFERENCE GUIDE & SUBMISSION FORMAT, www.greenbuildingindex.org, info@greenbuildingindex.org, Retreived December 2012.

[10] Procuring Architectural and Engineering Services for Energy Efficiency and Sustainability, a Resource Guide for Federal Construction Project Managers, U.S. Department of Energy, Energy Efficiency and Renewable Energy, Federal Energy Management Program.

[11] S. Ang, & S. Wilkinson, Is the social agenda driving sustainable property development in Melbourne, Australia? Property Management, 26(5), 2008, pp. 331-343.

[12] R. G. Reed, & S. J. Wilkinson, The increasing importance of sustainability for building ownership, Journal of Corporate Real Estate, December Issue 4 Vol 7, 2005, pp. 339 – 350. ISSN 1463-001X.

[13] S. Wilkinson, K. James, and R. Reed, Using building adaptation to deliver sustainability in Australia, Structural Survey Journal ISSN 0263-080X, Issue 1 Vol. 27, 2009.

[14] A. Chan Seong Aun, Energy Efficiency: Designing Low Energy Buildings Using Energy 10, 2004, pp. 14. Pertubuhan Arkitek Malaysia (PAM), CPD Seminar 7th August 2004, http://www.pam.org.my/Library/cpd_notes/Energy-Efficiency.pdf, Retreieved 14 April 2011.

[15] N. A. Ahmada, A. A. Abdul-Ghanib, Towards Sustainable Development in Malaysia: In the Perspective of Energy Security for Buildings, Procedia Engineering 20, 2011, 222 – 229

[16] R. Pacheco, R.J. Ordonez, and G. Martinez, Energy efficient design of building: A review. Renewable and Sustainable Energy Reviews, 16, 2012, pp. 3559–3573.

[17] S. Sadrzadehrafiei, K. S. Mat, and C. Lim, Energy consumption and energy saving in Malaysian office buildings, Models and Methods in Applied Sciences, 2011.

[18] Y. Rashida, M.S. Sulaiman, A. Aziz, H. Selamat, A. H. M. Yani, and M. Z. Kandar, (2011). Greening government's office buildings: PWD Malaysia Experiences. Procedia Engineering 21, 2011, pp. 1056 – 1060.

[19] A. C. Seong A., ENERGY EFFICIENCY. Designing Low Energy Buildings Using Energy 10, Pertubuhan Arkitek Malaysia, CPD Seminar 7th August 2004.

[20] Yassine, B. K. Ghali, N. Ghaddar, I. Srour, and G. Chehab, A numerical modeling approach to evaluate energy-efficient mechanical ventilation strategies. Energy and Buildings, (2010), doi:10.1016/j.enbuild.2012.08.042, 2012

[21] K. Flodberg, Very low energy office buildings in Sweden. Simulations with low internal heat gains, Department of Architecture and Built Environment, Division of Energy and Building Design, Lund University, Lund, ISSN 1651-8136, ISBN 978-91-85147-51-9, 2012.

[22] U. Heine, USA Today: Being and becoming – sustainable architecture in the USA, PLEA2009 - 26th Conference on Passive and Low Energy Architecture, Quebec City, Canada, 22-24 June 2009.

[23] J. Parasonis, A. Keizikas, A. Endriukaitytė, and D. Kalibatienė, ARCHITECTURAL SOLUTIONS TO INCREASE THE ENERGY EFFICIENCY OF BUILDINGS. JOURNAL OF CIVIL ENGINEERING AND MANAGEMENT. 18(1), 2011, pp. 71–80.

[24] A. AlAnzi, D. Seo, and M. Krarti, Impact of building shape on thermal performance of office buildings in Kuwait, Energy Conversion and Management 50, 2009, pp. 822–828.

[25] S. Abbaszadeh, L. Zagreus, D. Lehrer, and C. Huizenga, Occupant satisfaction with indoor environmental quality in green buildings, Indoor Environmental Quality (IEQ), Center for the Built Environment, Center for Environmental Design Research, UC Berkeley, 2006.