Housing developers and home owners awareness on implementation of building insulation in Malaysia

A. M. Al Yacouby[1], M. F. Khamidi[1], Y. W. Teo[1], M. F. Nuruddin[1], S. A. Farhan[1], S. A. Sulaiman[2] & A. E. Razali[3]
[1]*Department of Civil Engineering, Universiti Teknologi PETRONAS, Perak, Malaysia*
[2]*Department of Mechanical Engineering, Universiti Teknologi PETRONAS, Perak, Malaysia*
[3]*Monier Sdn. Bhd. Selangor, Malaysia*

Abstract

Buildings account for 40% of energy consumption. In a hot humid climate zone a great deal of this energy is consumed in cooling and air-conditioning. Thermal insulation provides a practicable and cost-effective means of reducing system electricity consumption and CO_2 emissions. Building insulation refers to any construction material in a building used as insulation for thermal purposes. This term also applies to acoustic insulation, fire protection and impact insulation. This paper presents a study on awareness of housing developers and home owners on the utilization of insulation materials in the building industry. The research aims to address and determine challenges facing the implementation of building insulation techniques in Malaysia, where currently houses with insulation represent less than 2% of the total stock of 4.5 million units. In this study two methods have been implemented i.e. (1) a quantitative survey in the form of two different sets of structured questionnaires for housing developers and end users, and (2) qualitative research in the form of a semi-structured interview targeting various professionals and stakeholders from the construction industry. The study suggests that around 75% of house occupants use air-conditioner units to improve the indoor thermal comfort and only 22% of the respondents were aware of the effects of insulation on thermal performance of

WIT Transactions on Ecology and The Environment, Vol 148, © 2011 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/RAV110211

their houses. The implementation of building insulation will have an immediate impact on reducing total energy demand and mitigating GHG's emission in Malaysia.

Keywords: building insulation, energy consumption, hot humid climate, Malaysia, thermal comfort.

1 Introduction

The implementation of insulation materials in the building industry play an important role in the heating and cooling needs of a building, especially in a hot humid climate zone such as Malaysia. During the "COP 15" climate change negotiations in Copenhagen, 2009, Malaysia made a conditional commitment to reduce CO_2 intensity per unit GDP by 40% by 2020, relative to 2005 levels [1]. The electricity savings potential as well as the economic and environmental impact of building insulation have been well established. Building insulation refers to any object in a building used as insulation for thermal purposes [2]. It reduces the cost of heating and cooling by over 40% [3]. This term also applies to acoustic insulation, fire protection and impact insulation. During clear sky conditions up to about $1kW/m^2$ of solar radiation can be incident on a roof surface and between 20% and 90% of this radiation is typically absorbed [4] Thermal performance of a building is mainly affected by the thermal properties of the building envelope i.e. roof and external walls. For low rise buildings, roof is the critical part as it represents more than 70% of solar heat gain [5]. However, for high rise building, the scenario is totally opposed as walls and external cladding are the critical components of heat transfer. Therefore, implementation of insulation materials in the building construction industry will minimize the thermal heat gain and heat losses through the building envelope. This cost effective technique is mainly intended to reduce electricity consumption in the building sector.

Energy conservation in the buildings sector became an important issue in building design as a consequence of the energy crises of 1973. Currently, the energy consumption in the building sector constitutes around 40% of total energy consumption in terms of primary energy – of this, around 46% in developing countries [6]. Air conditioning and refrigerators represent the main source of electricity consumption in the Malaysian residential buildings [7]. Electricity consumed by household's appliances i.e. refrigerators and air conditioner units is mainly produced from fossil fuels. On one hand, these fossil fuels are releasing a lot of green house gases (GHGs) to the atmosphere. On another hand, the fossil fuels from which electricity is generated are not sustainable and depleting day by day. A good example is the case of sustainability of oil and gas in Malaysia which is increasingly becoming an issue. With projections predicting the country will became a net oil importer in the coming few years [8]. Therefore, implementation of building insulation might be an effective solution to resolve this issue. Insulation is a cost effective technique that can improve thermal performance of housings and consequently diminish the electricity consumption in the Malaysia building sector. Improving thermal performance of building

envelope can make a significant contribution to reducing overall building energy usage.

2 Review of previous studies

To the author's knowledge there are no previous studies that have dealt with the housing developers and home owner's awareness on implementation of building insulation in a systematic way, especially in Malaysia. However, the review of some existing literatures indicates that several successful researches addressing the benefits of buildings insulation have been conducted. For instance, Mahlia and Iqbal [9] conducted a cost benefits analysis and emission reductions of optimum thickness and air gaps for selected insulation materials for building walls. The study showed that insulation cost increases while cooling cost decreases, as the thermal resistance of insulation material increases. The study revealed that using fibre glass–urethane as insulation materials a costing saving of $71,773 can be achieved in 20 years for air-conditioned spaces.

Bolatturk [10] investigated the optimum insulation thicknesses on external walls of buildings based on both annual heating and cooling loads in Turkey. The study suggests that for heating load, optimum polystyrene insulation thickness varying between 1.6 and 2.7 cm, will result an overall energy savings between 2.20 and 6.6 $/m^2, and payback periods altering between 4.15 and 5.47 years depending on the location of the city. On the other hand, for cooling load, insulation thickness of 3.2 to 3.8 cm, with energy savings varying between 8.47 and 12.19 $/m^2, and payback periods between 3.39 and 3.81 years were recorded.

In general, adding more insulation is a good principle for a number of reasons; insulation is relatively inexpensive, it is very durable and it functions both summer and winter [11]. Insulation reduces the energy consumption of the air conditioning system. Wall and roof insulation can produce energy savings up to 77% [12]. A proper insulation material also indirectly reduces emission from power plant. Others studies related to benefits of roof insulation include [13–15].

3 Methodology and procedures

The authors opted for a cross-sectional design in this study. Survey questionnaires comprising sections that measure demographic information (i.e. age, sex etc.), education level, and working experience in addition to several sections that address the level of awareness of roof insulation were designed and sent out to housing developers, home buyers and professorial engineers. Survey data received from the respondents have been analyzed and the main obstructions and challenges affecting the implementation of building insulation in Malaysia have been determined. Further, the knowledge level as well as the acceptance criteria of building insulation among the home buyers and stakeholders has also been investigated. Furthermore, a semi structured interview which was mainly targeting professionals in construction industry was developed

in order to investigate the major factors affecting installation of building insulation in Malaysia. The major findings are discussed in section 5.1 and 5.2.

The survey was conducted from January to March 2011. There were 147 respondents who completed the study. All 147 questionnaires received from the respondents have been included in this study.

4 Types of building insulation

There are many types of insulation materials available in the market such as rock wool, polystyrene, aerogel, aluminium foil radiant barriers, etc. They differ in terms of material properties as well as in terms of their unit price. When these insulation materials are installed in the ceiling, walls, external cladding (spandrel) and floors of a building, heat flow into and out of the building is normally reduced. Consequently, the need for heating and cooling is minimized. Types of insulation in terms of functionality range from thermal insulation, fire rating insulation, impact insulation, and acoustic insulation. Designers normally specify and choose the insulation materials based on its functionality and cost. Thermal resistance (R-value) varies with thickness and is calculated by dividing the thickness of insulation board (m) by its thermal conductivity (K). Since the R-value is the measurement of a product's resistance to heat flow, the higher the R-value the better is the resistance to the flow of heat [16]. A typical drywall partition insulation detail is illustrated in Figure 1.

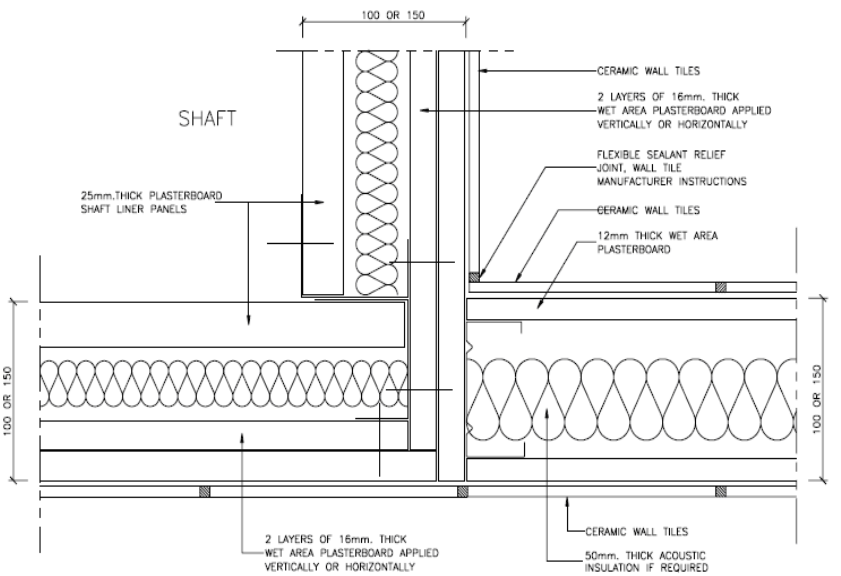

Figure 1: Typical details of drywall partition insulation.

4.1 Thermal insulation

Building thermal insulation techniques control the passage of heat or cold from the external environment to the interior of the building. It helps to improve the efficiency of the heating and cooling systems provided in the building. The thermal insulation material can be considered for ceilings, pitched roofs, flat roofs, external and internal walls, timber and steel doors, external cladding specially spandrel areas, and floors. Heat loss in buildings generally occur through external walls, windows, ceiling, floors, plumbing vents, duct risers shafts, windows and doors. Building insulation materials are used to reduce heat transfer by conduction, radiation or convection. These materials are employed in varying combinations to achieve the desired indoor thermal comfort. Thermal Resistance R-values of common wall types are depicted in Table 1.

Table 1: Thermal resistance R-value of common wall types [3].

Wall construction	*Overall R-value*
Cavity brick	0.53
Solid brick (230 mm thick)	0.44
Solid concrete (100 mm thick)	0.23
Solid concrete (200 mm thick)	0.30
Aerated concrete (100 mm block)	0.78
Aerated concrete (200 mm block)	1.54
Mud brick (300 mm block)	0.40

The overall heat transfer coefficient U for a typical wall with insulation materials can be calculated by:

$$U = \frac{1}{\sum R_i} \tag{1}$$

where R_i is the thermal resistance of wall components.

Thermal conductivity (k-value) is a measure of the rate at which heat is conducted per m^2 per unit thickness through a particular material under specified conditions. Its unit is *W/mK*. Thermal conductivity values of common insulation materials are shown in Table 2.

According to Mahlia *et al*. [17], the optimum insulation thickness is normally determined by conducting life cycle cost or cost benefit analysis due to the installation of insulation material as follows:

$$C_i = AxC_A \tag{2}$$

where A is the surface area of insulation material, x the thickness, and C_A is the cost of insulation material per unit volume.

Table 2: Thermal conductivity values and unit rate cost of some insulation materials [17].

Type of insulation	*Thermal conductivity, k(W/m°C)*	*Cost of insulation CA ($/m3)*
Fiberglass–urethane	0.021	214
Fiberglass (rigid)	0.033	304
Urethane (rigid)	0.024	262
Extruded polystyrene	0.029	182
Urethane (roof deck)	0.021	221

5 Results and discussions

5.1 Popularity of building insulation

This part of study was mainly designed to address home buyers in order to determine the popularity of building insulation among Malaysian households as well as to determine the level of awareness of home buyers on benefits of building insulation. Overall, 50 people have participated in this study. The percentage of participants in terms of gender was found to be 46% male and 54% female. Overall, there are more female respondents. From Figure 2, we can see that around 60% of participants are below 24 years old, whilst respondents who were in the age range between 25–35 represent 24%. As evident from Figure 3, the majority (76%) of the respondents are planning to buy a new house within a three (3) year period. 68% of them can afford a house ranging below MR 300,000. This means designers need to consider insulation materials while maintaining the total cost within the acceptable limit. Indeed, home buyers would prefer to buy insulated houses. However, the study suggests that only 54% of the respondents are aware of what a building insulation is. Regarding the

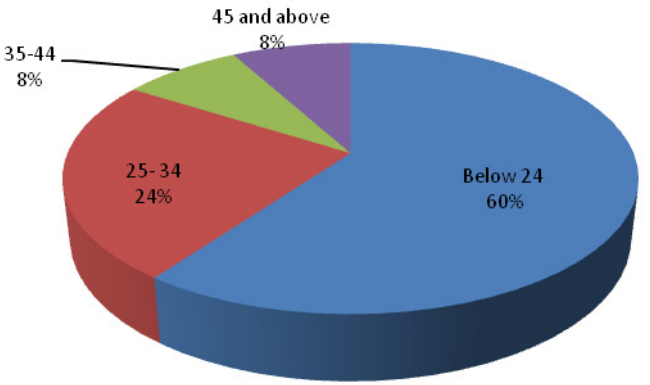

Figure 2: Respondents' classifications in terms of age.

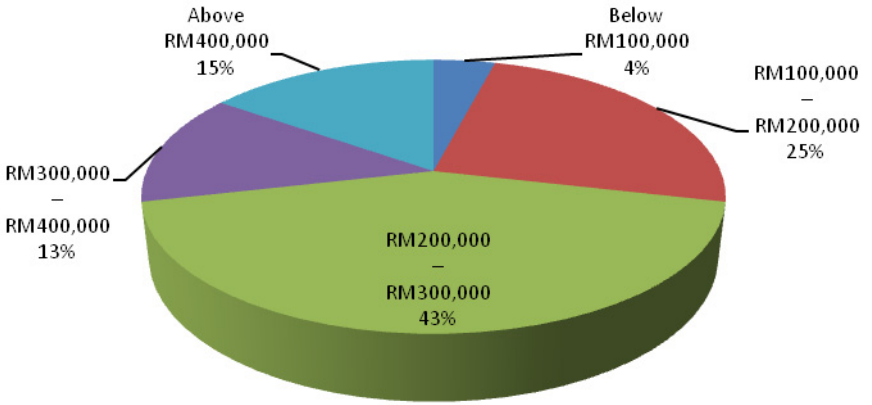

Figure 3: Home buyer budgets for new houses.

understanding level among the 54% who are familiar with the term "Insulation", our preliminary analysis found that only 15% of them have high level of understanding, followed by 63% medium and about 22% with low level. This clearly indicates that the building insulation is not a well understood term in Malaysia. Conversely, after reading a notice that consists of a brief description of buildings insulation and its direct benefits, i.e. cost savings associated with utility bills and reduction of green house gases emissions, 90% of the respondents showed their enthusiasm to provide building insulation in their houses.

This illustrates that home buyers have very high acceptance level on implementing building insulation, subject to have the necessary information pertained to advantages of insulation materials as well as the necessary education required to make the right decisions on usage insulation materials.

Figure 4 indicates that out 54% who are familiar with the building insulation, 56% of them knew the insulation materials from mass media (i.e. newspaper,

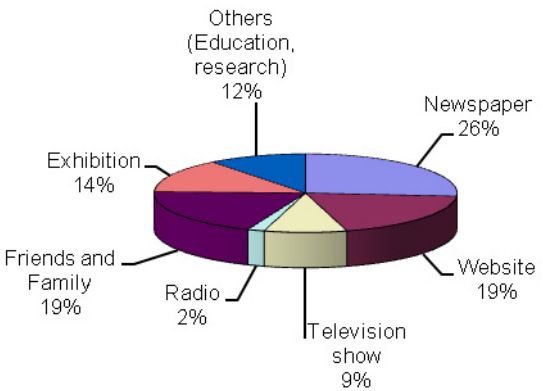

Figure 4: Knowledge sources of building insulation.

websites, television and radio, while knowledge sources from exhibitions represent only about 14%. Perhaps insulation manufacturers are not participating regularly in exhibitions pertained to housings and green buildings industries in Malaysia, which consequently lead to lack of awareness among the end users.

5.2 Implementation of insulation in the Malaysia construction industry

This section of the study was mainly intended to address developers, architects and engineers who are involved directly in the construction industry. Around 47 Malaysian developers who are registered under Real Estate and Housing Developers' Association (REHDA) of Malaysia have been participated. Analysis of returned questionnaires suggests that 60% of the respondents have completed over 15 projects during the last 20 years. However, only 40% of them have completed projects with building insulation. This clearly indicates that building insulation is not widely implemented in Malaysia. This might be because of either the lack of statutory regulations or its additional cost implications. Generally, having clear regulations from the local authority to insulate buildings will help moving forward to a sustainable development in Malaysia.

The survey results also show that the most fashionable insulation methods in Malaysia are the blanket type and loose fill insulation. This is due to their economical values and their easy installation process compared to loose-fill and spray form insulation.

In addition, as depicted in Figure 5, the majority (62%) of the respondents believe that benefits of insulation are sound barrier and achieving a better indoor thermal comfort. Only very few (18%) realized that insulation could enhance the energy efficiency of a building. It is clear that only 8% consider roof insulation to have cost saving implications in long term period.

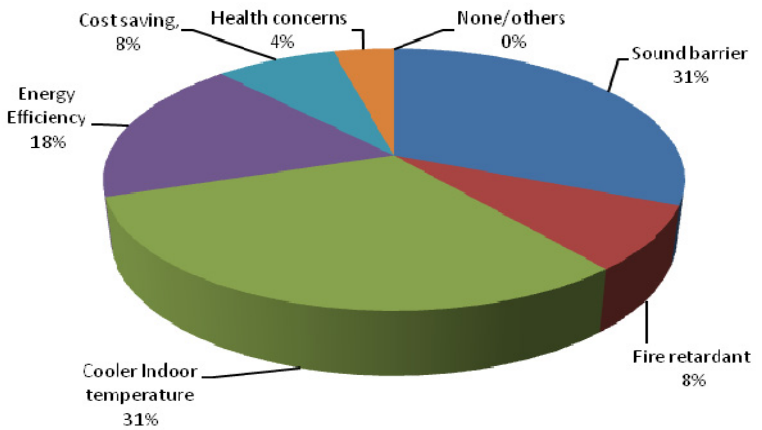

Figure 5: Respondent's opinion on benefits of building insulation.

According to the survey, 47% of professional engineers and architects have medium knowledge on building insulation, while their acceptance level to implement building insulation is about 67%. Besides, 80% of the respondents are not sure whether there are enough insulation manufacturers in the market although in reality there plenty of insulation manufacturers in Malaysia. Regarding the future consideration of roof insulation 80% of designers, and engineers stated that they will consider insulation in their future projects. 20% reported that they will not provide any building insulations in their future projects due to its additional cost and absence of any statutory regulations pertained to building insulation.

Although 100% of the developers stated they had no objection to provide insulation if required by the home buyers, only 60% of them will provide insulation if requested by the architects. The remaining 40% said their decision will be based on the total cost of insulation materials. This indicates that home buyer' decisions and the overall cost of insulation are the key factors governing the implementation of building insulation materials in Malaysia.

5.3 Insulation cost

Currently, the average rate of building insulation in Malaysia is about RM3 per square feet. However, 80% of the respondents prefer to spend less than RM2 per square feet on building insulation as presented in Figure 6. Although around 4% of the developers believe building insulation cost should be borne by the home buyers themselves, it is not practical to rely on home buyers to make decision on technical matters that might affect the building performance such as insulation. Perhaps, some people may not have the necessary technical back ground to make the right decision.

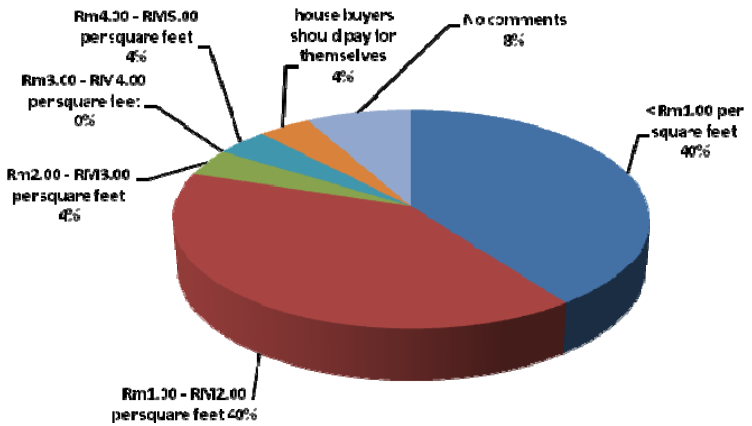

Figure 6: Acceptable range of insulation materials unit price.

5.4 Insulation on existing buildings

The survey was conducted within Klang Valley in Kuala Lumpur, comprising 50 home owners. The study revealed that 75% of occupants use air-conditioner units to improve the indoor thermal comfort of their houses and only 22% of them are aware that insulation can be used for thermal protection. Houses with thermal insulation in Malaysia were found to represent less than 2% of the total stocks of 4.5 million residential units [18] as presented in Table 3.

Table 3: Property stock report-Q2-2011 [18].

Residential units in Malaysia – 2011		
Existing Stock	*Incoming Supply*	*Planned Supply*
4,466,062	560,636	665,699

6 Summary of conclusions

This cross-sectional survey study was able to determine the current condition of building insulation as well as the challenges affecting implementation of building insulation in Malaysia. From this study, the following conclusions may be drawn:

1) 60% of housing developers participated in this study have completed more than 15 projects during the last 20 years. However, projects with building insulation represent only 40%.
2) Only 54% of the home owners in Malaysia are aware of what a building insulation is. The understanding level of building insulation indicates that only 15% have high level of understanding followed by 63% medium and 22% low.
3) 75% of occupants use air-conditioner units to improve the indoor thermal comfort of their houses, and only 22% are aware that insulation can be used for thermal protection. Houses with thermal insulation were found to represent less than 2% of the total stocks in Malaysia.
4) This study suggests that home buyers' decisions and the overall cost of insulation materials are the key factors governing the very slow implementation of building insulation in Malaysia.
5) Existence of clear regulations from the local authority instructing developers and consultants to consider buildings insulation for any new project will help moving forward to a sustainable development in Malaysia.

Acknowledgements

The authors sincerely express their thanks to Ministry of Higher Education (MOHE) for the financial support given to this research under FRGS.No.15-

8200-119. The support provided by the Universiti Teknologi PETRONAS, Real Estate and Housing Developers' Association Malaysia (REHDA) and Monier Sdn. Bhd is also highly acknowledged.

References

[1] International Energy Agency (AEI), KeTTHA/ IEA CCS Roundtable Putrajaya, Malaysia, March, 2011.
[2] Carl P. Insulating to reduce Heating cost, NDSU Extension Service (AE-1368), North Dakota State University Fargo, 2010.
[3] Sustainable Energy Info, Insulation benefits fact sheet, Sustainable Energy Victoria.
[4] Suehrcke, H., Peterson, E. L. and Selby, N., Effect of Roof Solar Reflectance on the building heat gain in a hot climate. *Energy and Building* (40), pp. 2224-2235, 2008.
[5] Vijaykumar, K.C.K, Srinivasan, P.S.S. and Dhandapani, S., A performance of Hollow tiles clay (HTC) laid Reinforced Cement Concrete (RCC) roof for tropical summer climates. *Energy and Buildings,* 39(8), pp. 886-892, 2007.
[6] Hameed, N., World Energy Scenarios to 2050, Issues and Options, Metropolitan State University, Minneapolis, MN, 2009.
[7] Saidur, R., Masjuki, H.H., Jamaluddin, M.Y., & Ahmed, S., Energy and associated green houses gas emissions from house hold appliances in Malaysia. *Energy Policy,* 35, pp.1648-1657, 2007.
[8] Cha, S.C. & Oh, T.H., Review on Malaysia natural energy development: Key polices agencies, programs, and international. *Sustainable Energy Reviews,* (14), pp.2916- 2925.2010.
[9] Mahlia, T.M.I. & Iqbal, A., Cost benefits analysis and emission reductions of optimum thickness and air gaps for selected insulation materials for building walls in Maldives. *Energy,* 35(5), pp.2242-2250, 2010.
[10] Bolatturk A., Optimum insulation thicknesses for building walls with respect to cooling and heating degree-hours in the warmest zone of Turkey. *Building and Environment,* (43), pp. 1055–1064, 2008.
[11] Lechner N., Heating, Cooling, Lighting: Design Methods for Architects. New York: John Wiley Inc, 1991.
[12] Mohsen M.S. & Akash B.A., Some prospect of energy savings in buildings. *Energy Conversion and Management,* (42), pp. 1307-1315, 2001.
[13] Barrios, G., Huelsz, G., Rechtman, R., & Rojas, J., Wall/roof thermal performance differences between air-conditioned and non air-conditioned rooms. *Energy and Buildings*, (43), pp.219–223, 2011.
[14] Taylor, P.B., Mathews, E.H., Kleingeld, M., & Taljaard, G.W., The effect of ceiling insulation on indoor comfort. *Building and Environment*, (35), pp.339-346, 2000.
[15] Ong, K.S., Temperature reduction in attic and ceiling via insulation of several passive roof designs. *Energy Conversion and Management,* (52), pp. 2405-2411, 2011.

[16] Ritchar T. & Bynum, J.R, *Insulation hand Book*, McGraw-Hill, United States of America, 2001.
[17] Mahlia, T.M.I, Taufiq, B.N., Ismail & Masjuki, H.H., Correlation between thermal conductivity and the thickness of selected insulation materials for building wall. *Energy and Buildings* (39), pp, 182–187, 2007.
[18] Valuation and Property Services Department, Property Stock Report Q2 2011, *National Property Information Centre (NAPIC),* 2011.