Technology? Financial Viability or What? Challenges and Benefits of Eco and Reflective Roof in Malaysia

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Abstract. Adopt eco roof or reflective roof on the building consider one of the methods to reduce Urban Heat Island (UHI) effect and global warming from getting crucial as well as improve ecological and environmental quality. However, the awareness and application of eco roof and reflective roof are still considered low in Malaysia and the roofing technologies used are not advanced if compared to other Asian countries such as Singapore, Japan and Hong Kong. Aim of this research is to identify the challenges and benefits of eco roof and reflective roof to developers and seek for developers' level of awareness on eco roof and reflective roof. Quantitative method and Central Limit Theorem are applied in this research for data collection and analysis purposes. It is found that eco roof and reflective roof do bring benefits to nature and society. Government paly vital role in bringing awareness and encouragement in improving the usage of eco roof and reflective roof.

Keywords: Eco roof, reflective roof, Malaysia

1 Introduction

Climate change, a global calamity environmental issue resulted by extreme human activities (Ismail, Samad, Rahman & Yeok, 2012) caused observable, unpredictable and unprecedented effects either on a local or a global scale (Begum, 2017). Human Development Report published by United Nations Development Programme (UNDP) in 2007 revealed Malaysia released 177.5 million ton of carbon dioxide (CO2) in 2004 which occupied 0.6% of the global total amount. High level of carbon dioxide emission lead to temperature rise and cause energy demand of cooling loads become higher and electricity bills become more expansive.

To maintain indoor temperature within comfort level, usage of HVAC systems will increase and consumption of air-conditioning energy in urban buildings is 13% higher compare to non-urban buildings (Baniassadi, Sailor, Crank & Ban-Weiss, 2018). Malaysia relies on energy extract from natural gas, coal, crude oil and other fossil resources to generate electricity. The stronger the dependency on fossil fuels resources, the higher the amount of CO_2 emissions release to atmosphere (Chik & Rahim, 2014;

Indati & Bekhet, 2014). Once the situation of exhaustible natural resources occurs, it causes an inevitable harm to environment (Grossman & Kruger, 1995). Roof trusted to be one of the method to solve the issue of reduce energy consumption (Lee, Lim, Chan & Von, 2017). Roof accounts nearly 20% to 25% of urban space areas (Raji, Tenpierik & Dobbelsteen, 2015). Eco and reflective roofs are suggested being use in order to reduce carbon emission and develop a greener environment for younger generation. According to Chan (2009), roof surface receives highest solar radiation through a whole day and roof insulation is vital to reduce air-conditioning load. Green Building Index-MS1525 published on CDP Seminar stated typical roof surface of terraced house in Malaysia gained highest amount of sunlight.
lease note that the first paragraph of a section or subsection is not indented. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either.

Table 1. Solar Heat Gains in Typical Malaysian Housing from (PAM CPD Seminar 14/02/2009)

	Single Storey Terrace	Double Storey Terrace	Five Storey Flats	Eight Storey Flats
Roof / Building Envelope Area (%)	68	45	30	18
Floor / Building Envelope Area (%)	32	55	70	82

2 Literature Review

Eco roof widely known as green roof or rooftop garden. It is a modern energy efficient construction technology with vegetation planted on top of growth medium in an open space without using additional land with various benefits such as enhance heat transfer, improve thermal insulation of a building and absorb rainwater fall (VanWoert, Rowe, Andresen, Rugh, Fernandez, & Xiao, 2005). Department of Planning and Local Government of South Australia (2010) identified green roof system consists vegetation, filter layer, drainage material, insulation, substrate, water-proofing membrane and root barrier.

Types of eco roof used in current market can classified into 3 categories: extensive eco roof, intensive eco roof and semi-intensive eco roof. Extensive green roof has thinner layer of substrates and lighter loading aspects compared to intensive green roof. It requires minor maintenance and irrigation with limit selection of vegetation and has limited accessibility (Nagase & Dunnett, 2010; Berardi, 2016). Extensive green roof is

more suitable for retrofitting building as it is lightweight and minimize increasing structural load on the existing roof (Ardente, Beccali, Cellura & Mistretta, 2011).

Intensive green roof consists a thick growing medium layer wherein can support wide varieties of plants, trees and shrubs. It requires maintenance and it is accessible to public. This system requires specific and additional structural support from the building due to heavyweight of substrate (Kosareo & Ries, 2007; Peng & Jim, 2015). Articles carried out Berardi, GhaffarianHoseini and GhaffarianHoseini (2014); Luo, Huang, Liu and Zhang (2011) stated semi-intensive green roof demonstrated as a combination of intensive and at least 25% of extensive green roof. According to the United Kingdom's Green Roof Organization (GRO) code (2011), it requires lower additional structural support and maintenance than intensive green roof.

Table 2. List of building adopt eco roof (International project and Malaysia project)

Building with Eco roof	Types	Type of Building	Year	Location
8 House, Copenhagen, Denmark	Extensive	Multi-use building	2010	International project
ACROS Fukuoka Prefectural International Hall, Fukuoka, Japan	Intensive	Commercial building	1994	International project
California Academy of Science, San Franciso, California	Extensive	Office, Museum, Research Facility	2008	International project
Chicago City Hall, Illinois	Semi-intensive	Municipal / Government building	2001	International project
Dani Ridge House, Carmel, California	Extensive	Architecture firm	2006	International project
Cada Desa Condonimium, Taman Desa, Kuala Lumpur	Intensive	Condominium	2008	Malaysia project
Hilton & Le Meridien, Jalan Stesen Sentral, Kuala Lumpur	Intensive	Hotel	2003	Malaysia project
Idaman Residence, Jalan P. Ramlee, Kuala Lumpur	Extensive	Condominium	2008	Malaysia project
Islamic Art Museum, Tasik Perdana, Kuala Lumpur	Extensive	Museum	1998	Malaysia project

3.

Kiara 9, Mont Kiara, Kuala Lumpur	Intensive	Condominium	2011	Malaysia project

Doulos, Santamouris, Livida (2004), Synnefa and Santamouris (2012) defined reflective roof is a roofing system use natural white materials or artificial white paint on the roof surface to reflect incoming solar heat and decrease net radiation within the building. It provides atmospheric heating and enhances building energy savings (Coutts, Daly, Beringer & Tapper, 2013). It does not provide any additional waste and occupy characteristics of high solar reflectance and thermal emittance (Gartland, 2012). Coatings can be applied both on existing or new roofs of flat roof, low-sloped roof and steep-sloped roof.

5.

Challenges of eco roof agreed by most of researchers are it involves high maintenance cost and investment cost (Besir & Cuce, 2018; Shafique, Kim & Rafiq, 2018; Sangkakool, Techato, Zaman & Brudermann, 2018), limited expertise and inexperienced professionals, lack of relevant scientific data or research of this technology in the construction industry (Chow, Bakar & Deck, 2016; Ismail, Aziz, Nasir & Taib, 2012; Irga *et al*.,2017) and government constraints such as lack of promotion, subsidies or statutory mandate (Ismail et al, 2018; Brudermann et al, 2017; Townshed, 2007). Challenges of reflective roof from Testa and Krarti (2017), Synnefa and Santomouris (2012), Revel *et al*. (2014) findings are it easily lose reflectivity owing to the accumulation of dirt and weathering condition and the site topography and building regulations can limit the application of reflective roof (Sproul, Wan, Mandel & Rosenfeld, 2014).

Main benefits of eco roof are reduce Urban Heat Island effect (Cascone *et al*, 2018; Rowe, 2011; Abbass, Sailor & Gall, 2018), energy consumption by decreasing cooling and heating load of HVAC system (Ziogou, Michopoulos, Voulgari & Zachariadis, 2018; Ismail, Samad & Rahman, 2011) and mitigate stormwater runoff (Fauzi, Malek and Othman, 2013; Korol & Shushunova, 2016).

Benefits of reflective roof such as improved indoor and outdoor thermal comfort (Zinzi, Carnielo & Agnoli, 2012; Al-Obaidi, Ismail & Rahman, 2014), increase energy saving potential (Alchapar & Correa, 2016; Coutts, Daly, Beringer & Tapper, 2013; Zinzi & Agnoli, 2012; Gao *et al*., 2014) and decrease greenhouse gases emission (Synnefa & Santomouris, 2012; Hosseini & Akbari, 2016; Boixo, Diaz-Vincente, Colmenar & Castro, 2012).

From Syumi, Hamidah and Solehin (2013) finding, 94% of respondents agree green roof have potential and they agree cases of green roof increase in Malaysia. Awareness from Malaysian society towards implementing green project is still at very low level even though their importance had been proven by experts (Ashraf, Nurhayati & Jamilah, 2013). In European countries, 48% of public thinks cool roof technology is still new and not tested enough whereas 32% of them uncertain about cool roof's benefit (Synnefa & Santamouris, 2012).

In view of the potential of eco roof and reflective roof, there is no comprehensive research that identify the challenges and the perceived benefits of eco roof and reflective roof in Malaysia context.

This paper aims to investigate Developers' awareness level on eco roof and reflective roof and finds the main challenges and benefits of those roofing technologies to Developers.

3 Methodology

Developer registered under REDHA Malaysia, Sabah REDHA and Sarawak REDHA set as target population of this research. Developers were selected as they are the key player in the construction industry and they obtain the right to make final decision in deciding types of building element or structure that they wish to implement. Total 1,548 developers found from the member listing (REDHA, 2019), however only 593 of the developers provide company email address and 513 email are valid. Data collection method used are literature review and questionnaire survey form.

Survey form sub-divided into 3 parts: Section A to collect respondent's information whereas Section B and Section C aim to collect respondent's knowledge on eco roof and reflective roof. Example of challenges and benefits questioned in survey were summarized from other researchers' findings. Formula of Relative Important Index (RII) used for data analysis purpose to identify the ranking of challenges and benefits of eco roof and reflective roof. 5-point Likert scale adopted for respondents show their level of agreement with given statement or items on a metric scale from strongly disagree to strongly agree or from unaware to well informed.

TABLE 3. 5-point Likert scale used in questionnaire survey form

Measurement scale	1	2	3	4	5
Level of awareness	Unaware	Partially aware	Neutral	Informed	Well informed
Challenges / Benefit factors	Strongly disagree	Moderatel y disagree	Neutral	Moderatel y agree	Strongly agree

4 Result and Discussion

As the responses rate lower than 30%, therefore Central Limit Theorem (CLT) applied in this study. Findings of Kwak and Kim (2017) stated collect element from all

populations requires considerable effort and is often impossible to reach the target. Therefore, a subset of sample regarding to population can be used as a sample of sufficient size which random selected from certain large population. Total 32 responses received from developers in different states. Table 4 shown result of respondents' awareness level on eco roof and reflective roof and Table 5 and table 6 shown RII ranking for benefits and challenges for eco roof and reflective roof.

TABLE 4. Level of awareness on eco roof and reflective roof

Question 1: Rate your level of awareness on eco roof and reflective roof.

Awareness level	Eco roof		Reflective roof	
	Respondents (n)	Percentage (%)	Respondents (n)	Percentage (%)
Unaware	3	9.38	5	15.63
Partially aware	11	34.38	14	43.75
Neutral	12	37.50	9	28.13
Informed	6	18.75	4	12.50
Well informed	0	0	0	0
Total	**32**	**100.00**	**32**	**100.00**

Question 2: Do you think eco roof / reflective roof bring benefit and contribute to environment?

Agreement	Eco roof		Reflective roof	
	Respondents (n)	Percentage (%)	Respondents (n)	Percentage (%)
Yes	21	65.63	7	21.88
No	1	3.13	6	18.75
Maybe	10	31.25	19	59.38
Total	**32**	**100.00**	**32**	**100.00**

According to tabulation above, 37.50% of respondents show neutral awareness on eco roof and 21 out of 32 respondents agreed with the statement that eco roof able to bring benefit and contribute to environment. 43.75% of respondents show partial awareness level on reflective roof and 19 out of 32 respondents are uncertain that does reflective roof able make contribution to environment.

TABLE 5. RII ranking for benefits of eco roof and reflective roof

Question: To what extent would the following factors encourage you to invest in those roofing technologies?

	Eco roof		Reflective roof	
BENEFITS	**RII**	**RANK**	**RII**	**RANK**
Reduce building heat gain.	0.913	1	0.844	1
Reduce energy consumption and achieve a better energy performance for existing building.	0.881	2	0.819	2
Improve occupant's indoor temperature comfort.	0.838	3	0.756	4
Increase longevity life span of building roof.	0.838	3	0.619	9
Enhancement of biodiversity.	0.781	4	0.581	12
Cost saving potential.	0.750	5	0.806	3
HVAC equipment saving.	0.738	6	0.756	4
Reduce GHGs (greenhouse gases).	0.681	7	0.656	6
Improve microclimate condition.	0.673	8	0.694	5
Mitigate UHI (Urban Heat Island) in high populated areas.	0.663	9	0.650	7
Increase roof membrane's durability by reducing direct solar exposure.	0.650	10	0.644	8
Reduce smog formation.	0.631	11	0.569	13
Improve acoustic benefit.	0.613	12	0.594	10
Beautification.	0.550	13	0.438	14
Flexibility, simplicity and unique in design.	0.531	14	0.588	11

Respondents agreed both roofing technologies bring similar benefits which are able to reduce building heat gain and decrease energy consumption to achieve a better energy performance for existing building. Respondents do agree eco roof can improve occupant's indoor temperature comfort and increase longevity life span of building roof. Cost saving potential is another benefit of reflective roof that agreed by respondents.

TABLE 6. RII ranking for challenges of eco roof and reflective roof

Question: To what extent would the following factors discourage you to invest in those roofing technologies?

	Eco roof		Reflective roof	
CHALLENGES	**RII**	**RANK**	**RII**	**RANK**
High maintenance / repair cost.	0.913	1	0.800	4
Complex and complicated construction.	0.906	2	0.781	6
Lack of incentives / subsidies for building owner.	0.888	3	0.838	1
Economic constraints.	0.863	4	0.819	3
Susceptible to mold, weed and algae growth.	0.856	5	0.825	2
Outdated laws and regulations.	0.825	6	0.788	5
Subject to wear and tear.	0.806	7	0.800	4
Limited construction expertise and professionals.	0.769	8	0.688	9
Hard to get experienced installer and specialist companies.	0.756	9	0.713	8
Lack of communication, distribution and channeling of product data from government among public and private sectors.	0.738	10	0.738	7
This application not widely been used due to technology constraint.	0.706	11	0.656	10
Outdated technology.	0.681	12	0.656	10
Scarcity of material supply.	0.663	13	0.638	11
Lack of local research and studies.	0.563	14	0.550	12
The product may be visually unattractive or cause visual discomfort and glare.	0.519	15	0.550	12

Respondents have different view and perspective on the challenges of eco roof and reflective roof. Reasons such as the high maintenance and repair cost involved, complex and complicated construction of eco roof and the lack of incentives and subsidies for building owner in industry are the main challenges that limit application of eco roof. Main challenges of reflective roof are lack of subsidies of incentives and subsidies for building owner, this roofing technology is susceptible to mold, weed and algae growth and the economic constraints.

5 Conclusion

In a nutshell, findings proved eco roof and reflective roof do bring benefits to nature and society. Economic and technical factors are the main hurdle of the implementation of these two types of roof.

Government should raise public and private society's awareness on eco roof and reflective roof. At the same time, promotion of subsides, incentives or design guidelines of those roofing technologies do encourage building owners' willingness to adopt those roofing technologies, this will lead to a great possibility of participation from existing market.

The industry players especially green developers should utilize the benefits identified to enhance the marketability of their product at the same time play their role to contribute to the environment especially reduce UHI effect.

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