

## GREEN TECHNOLOGY AND SUSTAINABILITY FOR RESIDENTIAL INFRASTRUCTURE

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### ABSTRACT

*Application of green technology and sustainability trending featured nowadays. Various advantages can be achieved if we start from the beginning to implement green technology and sustainability starting from the home ownership. Commencement of business from developed countries such as Japan and the United States, most developing countries now participate strides to implement green technology and sustainability in every aspect. Green technology and sustainability is no stranger in the construction industry in Malaysia. However, many efforts should be intensified so that the implementation of green technology and sustainability aspects of the residential infrastructure can be accepted by the public. This is because the power to buy and own a home with green technology and sustainability concepts are in the hands of the buyer or the public. To ensure that residential green technology and sustainable meet the characteristics favoured by the public, this study ensures that all parties involved in the construction industry either from the relevant authorities, government agencies, private organizations and developers can play a key role in providing the best for the community, the nation, and the future.*

Keywords: green technology, sustainability, residential infrastructure, housing development, policy

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### Introduction

The criteria of the green residential building consist of six elements, firstly, the community design and planning, efficient usage of resources, use of alternative resources, natural system, protection and safety, and reusing and recycling approach. All the developed countries have their own criteria and their criteria are related to each other. The main purposes of the criteria are to save energy, to use resources in an efficient manner and to conserve the environment. (Ismail et al., 2013). Green buildings are developed with objectives to produce a minimum destruction influence to the environment, and healthier spaces in live and work. An increase in interests among construction players such as architects, developers, urban planners, constructors and government since a decade ago. The green residential building is part of a branch of green development and green buildings. The green residential has focused on houses resources which can be controlled from being polluted by the environment and stressed on energy saving features. (Elias et al., 2013). Nowadays, green technologies play a very important role to promote a societal move toward sustainability. Green technologies are practical solutions to achieve economic development and human satisfaction in harmony with the environment. (Osman et al., 2012).

### Problem statement

The concept of sustainable housing requires a new understanding of the effective and sustainable housing in synergy. In order to get the attention about sustainable residential, it deserves to implement more efficiently in Malaysia such as in developing countries.

Barriers to green building demand, according to Aliagha et al. (2013) states that demand for green buildings, both commercial and residential, must come with some problems and challenges in different countries and regions while moving towards sustainable construction development. A study was carried out in Malaysia by Samari et al. (2013) showed that the main barriers to the development of green buildings in the country are a risk of investment, lack of credit resources to cover upfront cost, higher final price and lack of demand. Others barriers are lack of incentives, lack of building codes and regulation, higher investment cost, lack of strategy to promote green building, lack of public awareness, lack of design and construction team, lack of expertise, lack of professional knowledge, lake of database and information, lack of government support and lack of technology.

To prevent global warming, there need to be new practices, from the design phase to the operation of the building in order to increase the efficiency of energy consumption, so that the carbon footprint, global warming potential, and ozone depletion potential can be reduced (Komalasari et al., 2014). Abidin and Jaapar (2012) also listed the some of the hindrances to faster progress of green housing in Malaysia as lack of public interest and demand, the status quo in rules and regulation, organization disinterest, project cost escalation or high cost for green appliance and local authority enforcement and realised that the reduction in the energy consumption in the buildings is a major cost-effective way of reducing greenhouse gas emissions.

Nevertheless, the acceptance of the sustainability concept is not industry-wide as many developers, especially small and medium companies, are still reserving themselves. Implementation is believed to be low because of several factors such as lack of knowledge, poor enforcement of legislation, education, experience and passive culture (Abidin, 2010).

### Objectives

The objectives of this research are listed below:

1. To analyse the characteristics of green technology and sustainability for residential infrastructure
2. To determine the most important characteristics of green technology and sustainability for residential infrastructure

### Analysis scope

The analysis for the research will be concentrated on green technology and sustainability on residential infrastructure for building in civil engineering scope. Public were chosen as a respondents because they have the right to determine the home they want to live in. Public also selected as a respondent to identify their interest, knowledge, and awareness of green residential infrastructure. Questionnaire form for data collection for this research will be distributed to the civilian in Northern Malaysia. The study area encompasses three states in northern peninsular Malaysia which are Penang, Kedah, and Perak. 400 respondents were targeted in this study, where in Penang with 106 respondents, while Kedah with 134 respondents and the rest in Perak were 160 respondents only to be assessed. In all three states, there are differences in the number of respondents due to the population in each country.

### Literature review

#### Architecture Design, Planning and Infrastructure

The weighting of environmental sustainability indicators needs a client to have specific green goals such as the infrastructure is well functional and energy efficiency, economic or social criteria to discuss with an architect in the planning process before the design is developed and building construction. The weighting, setting and estimate targets for the sustainability categories helps the designer or architect understand the design choices which made using sustainability for example Efficient Layout Planning, Functional Efficiency, Environmental Quality, Economy, Safety, Social, Resources, and Future Maintenance. This green technology and sustainable value approach will transform any design goals into specific performance of the building and provide a framework for overall design by using the standardised report thus ensuring residential infrastructure sustainability. (Saroo and Allopi, 2013).

#### Green Technology and Sustainability

Conventional residential building construction is one of the sources of global warming. Basically, the conventional homes took large amounts of power and it produced a large amount of carbon dioxides and other pollution annually. Green Home Concept for sustainable residential infrastructure is an effort to reduce the impacts of conventional homes and any other pollution. Sustainable green home is a concept of a house with less energy consumption, water and other natural resources, this concept able to provide good air quality and comfort. Green homes able to generate less wastage, and it considered as a sustainable development for homeowners' lifestyle. Moreover, green homes reduce the expenses of the homeowners for a long term. The price of green home basically more expensive compared to conventional home due to of the green materials or product and green technology it used. However, these costs can be deducted and decrease in the long run since the sustainability green home has lower maintenance and lower operation costs. Therefore, since a green home is energy efficient and water efficient, it able to reduce the number of total utility bills. This is because of low-flow water fixtures, grey water recycling system, solar thermal system and day lighting. Green home also allows the homeowner to have a healthier life since the material use to the building has zero volatile organic compounds. Green materials have a lower toxic level of a chemical. Thus, the indoor and outdoor air of sustainable green homes is fresher and has less pollutant compared to conventional residential homes (Alias et al., 2010).

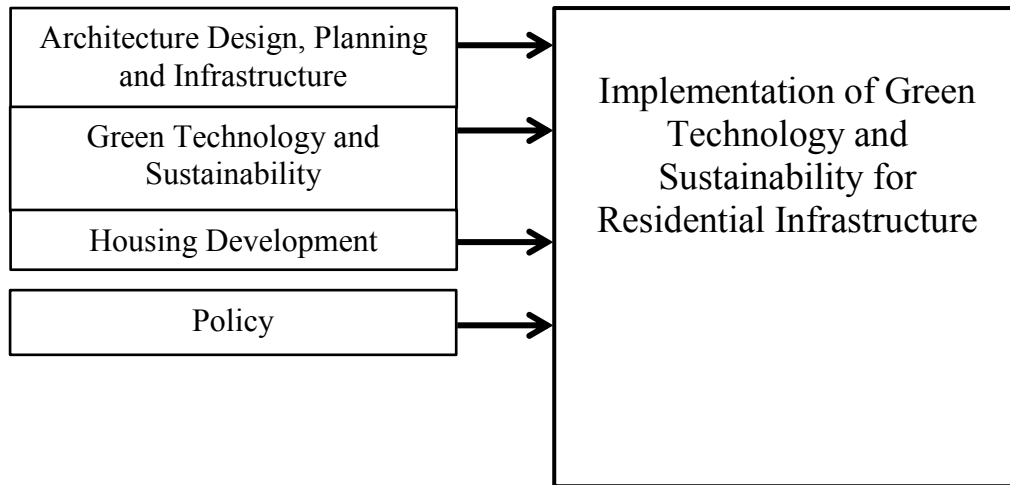
#### Housing Development and Policy

Green home development makes developers faced a lot of problems in developing green homes in Malaysia. In addition, most of the green materials need to import from foreign countries. Besides that, green technology material such as low-flow water system plumbing, the grey water recycling system, and many more green technology materials needs to be imported from overseas since a lack of material and resources to get in Malaysia. This situation leads to the increase in green home price compare to other conventional home because of due to the occurrence of the extra costs. Homeowners would still prefer to buy a conventional home since the demand for a green home is low and expensive in price but the conventional home is much cheaper. Many of Malaysian lack of understanding and awareness towards a sustainable development of the benefits and concept of green home although the government and developers already promote green homes since the year 2007. Malaysians are lacking in. Most of the homeowners are not willing to pay more to buy a green home and this makes the demand of green home low and difficult to sell compare to conventional home (Alias et al., 2010).

#### Framework

Information obtained from the literature review identified the characteristics of green technology and sustainability for residential infrastructure. Therefore, the framework consists of a characteristic of green technology and sustainability for residential infrastructures have been listed to achieve this research.

Figure 1 Frame Work



**Results And Discussion**

The Statistical Package for Social Sciences, Statistics Version 20 software used to analyse the data. This study received responses of 400 sets of questionnaires to investigate the criteria of green technology and sustainability for residential infrastructure and to determine the level of importance of each criterion. This analysis is divided into two sections contained in the questionnaire:

- i. Section A: Personal Information
- ii. Section B: Green Technology and Sustainability for Residential Infrastructure

The Cronbach’s Alpha used to measure the internal consistency of questionnaire. Based on this Alpha value for the reliability test, the authors have been using the Cronbach Alpha for the reliability of the questionnaire.

Table 1 Cronbach’s Alpha Value

Cronbach’s Alpha	Number of items	Number of Questionnaire
0.915	20	400

Table 1 shows the reliability coefficients of Cronbach’s Alpha is 0.915, which indicates a high level of internal consistency and considered as excellent high-stakes testing internal consistency. Table 2 below explains the internal consistency Cronbach’s Alpha of the each value of Cronbach’s Alpha internal consistency by Sekaran and Bougie (2010).

Table 1 Consistency of Cronbach’s Alpha

Cronbach’s Alpha	Internal Consistency
$\alpha \geq 0.9$	Excellent (High-Stakes testing)
$0.7 \leq \alpha \leq 0.9$	Good (Low-Stakes testing)
$0.6 \leq \alpha \leq 0.7$	Acceptable
$0.5 \leq \alpha \leq 0.6$	Poor
$\alpha < 0.5$	Unacceptable

**Analytical Result of Personal Information**

Personal information is the first section of the questionnaires. This section designed to provide general information regarding the gender, age, marital status, a number of family members, race, religious occupation, highest formal education, household income, permanent residence and type of homeownership of respondents.

Table 3 Respondents Gender Information

Personal Information	Detail	Frequency	Percentage (%)
Gender	Male	192	48
	Female	208	52
	Total	400	100

Table 4 Respondents Age Information

Personal Information	Detail	Frequency	Percentage (%)
Age	18-29	216	54
	30-39	136	34
	40-49	42	10.5
	50 & above	6	1.5
	Total	400	100

Table 5 Respondents Marital Status Information

Personal Information	Detail	Frequency	Percentage (%)
Marital status	Single	214	53.5
	Married	182	45.5
	Divorced	4	1.0
	Others	0	0
	Total	400	100

Table 6 Respondents Number of Family Members Information

Personal Information	Detail	Frequency	Percentage (%)
Number of family members	1 to 2	64	16
	3 to 4	133	33.3
	5 to 6	153	38.3
	7 and above	50	12.5
	Total	400	100

Table 7 Respondents Race Information

Personal Information	Detail	Frequency	Percentage (%)
Race	Malay	341	85.3
	Chinese	36	9
	Indian	16	4
	Others	7	1.8
	Total	400	100

Table 8 Respondents Religious Information

Personal Information	Detail	Frequency	Percent (%)
Religious	Islam	343	85.8
	Buddhism	28	7.0
	Hindus	17	4.3
	Others	12	3.0
	Total	400	100

Table 9 Respondents Occupation Information

Personal Information	Detail	Frequency	Percentage (%)
Occupation	Public Sector	90	22.5
	Private Sector	144	36.0
	Student	136	34.0
	Others	30	7.5

	Total	400	100
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Table 10 Respondents Highest Formal Education Information

Personal Information	Detail	Frequency	Percentage (%)
Highest formal education	PMR and below	2	0.5
	SPM	60	15.0
	Diploma	100	25.0
	Degree	193	48.3
	Master/PHD	45	11.3
	Total	400	100

Table 11 Respondents Household Income Information

Personal Information	Detail	Frequency	Percentage (%)
Household income	Below 2000	138	34.5
	2000-4000	148	37.0
	4000-6000	75	18.8
	6000 and above	39	9.8
	Total	400	100

Table 12 Respondents Permanent Residence Information

Personal Information	Detail	Frequency	Percentage (%)
Permanent residence	Yes	350	87.5
	No	50	12.5
	Total	400	100

Table 13 Respondents Type of Homeownership Information

Personal Information	Detail	Frequency	Percentage (%)
Type of homeownership	Own house	149	37.3
	Rented house	91	22.8
	Family house	152	38
	Others	8	2
	Total	400	100

**Analytical Results Using Ranking Analysis**

This finding indicates green technology and sustainability for residential infrastructure in northern peninsular Malaysia. The analysis classified into four parts in Section B in the questionnaire as below:

Part 1: Architectural Design, Planning and Infrastructure

Part 2: Green Technology and Sustainability

Part 3: Housing Development

Part 4: Policy

**Part 1: Architectural Design, Planning and Infrastructure**

Table 14 Architectural Design, Planning and Infrastructure

Code	Architectural Design, Planning and Infrastructure	Important and Strongly Important		Rank
		N	%	

1a	Consumer perception and knowledge of green architectural design and green infrastructure criteria for residential.	299	74.8	5
1b	Architectural design and infrastructure may effect to the demand and supply of sustainable residential building.	332	83	1
1c	Architecture design and infrastructure with green technology and sustainability criteria enhance the public interest.	322	80.5	4
1d	The constructions of smart homes and smart city may improve transportation system, save energy, time and cost.	328	82	2
1e	Landscape with walkways, bike lanes, green and safe is the preferred criteria of a residential area.	327	81.8	3

Based on results of the analysis as shown in Table 14 respondents perceived that architectural design and infrastructure may effect to the demand and supply of the sustainable residential building. This criterion is important in every architectural design, planning, and infrastructure. At the same time, these results indicate that most respondents aware of green technology and sustainability for residential architecture design and infrastructure is important because when a high demand from users certainly supply will be implemented. The second highest ranking is the second question of this part, where the constructions of smart homes and a smart city may improve the transportation system, save energy, time and cost. These results indicate that infrastructure such as good transportation system, time saving, cost saving and extremely user-friendly and eco-friendly fulfils the needs of the public. This item is important as to set up the infrastructure will require best planning the start from the beginning. Third highest ranking of architectural design, planning and infrastructure are the landscape with walkways, bike lanes, green and safe is the preferred criteria of a residential area. This criterion is important to encourage people to adopt a healthy lifestyle and avoid contamination. Overall, respondent concerned about architectural design, planning, and infrastructure. The average of the results of the analysis indicates that all the items contained in this architectural design, planning, and infrastructure part are in scale 4, which is important.

**Part 2: Green Technology and Sustainability**

Table 15 Green Technology and Sustainability

Code	Green Technology and Sustainability	Important and Strongly Important		Rank
		N	%	
2a	Consumer perception and knowledge about the necessity of green technology and sustainability for residential infrastructure.	311	77.5	5
2b	Green technology installations such as solar panels, rainwater harvesting systems or environmentally friendly equipment can save energy and protect the environment.	340	85	2
2c	Criteria of energy efficiency and renewable energy are important for green residential building.	328	82	3
2d	Assessment of the Green Building Index (GBI) is a useful guide to consumers in choosing a dream home.	323	80.8	4
2e	Green technology for residential infrastructure reduces carbon, greenhouse gas, environment issues and improves social-ecological system.	340	85	1

Based on results of the analysis as shown in Table 15, based on the results of the analysis, it was found that the first ranking is the last question which is green technology for residential infrastructure able to reduces carbon, greenhouse gas, environment issues and improves a social-ecological system. Therefore, most of the respondent knew the importance of preserving nature and protecting the environment for future. The second highest ranking is about the green technology installations such as solar panels, rainwater harvesting systems or environmentally friendly equipment can save energy and protect the environment. This item is important in order to protect the environment from pollutions, save energy and cost. Third highest ranking of green technology and sustainability part is the criteria of energy efficiency and renewable energy is important for a green residential building. Most of the respondent agree that energy efficiency and renewable energy is important for residential building because of green technology able to provide the best solution for a better future. In short, green technology and sustainability are very helpful in the implementation of residential houses. Most of the result of this green technology and sustainability part indicate that all the items contained in scale 4, which is important.

**Part 3: Housing Development**

Table 16 Housing Development

Code	Housing Development	Important and Strongly Important		Rank
		N	%	
3a	Construction using green technology will enhance the housing development.	311	77.8	5
3b	Consumer perception on satisfaction for housing development against sustainable residential infrastructure.	323	80.8	4
3c	Relevant authorities should support the housing market and economic recovery in sustainable housing development sector.	337	84.3	2
3d	Well planned and strategic sustainable housing development facing the increase in house prices issues.	337	84.3	1
3e	A campaign should be planned by encouraging people to participate in “sustainable housing community.”	336	84	3

Based on results of the analysis as shown in Table 16, the fourth question from this housing development part is the first ranking because of the increase in house price issues due to well planned and strategic sustainable housing development. Concerning that if the criteria of the various initiatives undertaken to implement green technologies and the development of a well-planned and strategic but the high cost charged to the public. It will burden the homeowner and will lead to the development of sustainable buildings is difficult to accept the public. The second highest ranking for housing development part is the relevant authorities should support the housing market and economic recovery in sustainable housing development sector. This item is important to ensure that sustainable housing development able properly implemented. The housing market and economic problems must be overcome with the conscientious study of the responsibility for ensuring sustainable housing development and construction are not priced at a higher price. The third highest ranking is a “sustainable housing community” campaign is important to encourage people to participate and to create the awareness in instilling wise in saving energy and costs such as separating garbage, retaining rainwater for use in watering the plants and the use of solar energy.

**Part 4: Policy**

Table 17 Policy Analysis

Code	Policy	Important and Strongly Important		Rank
		N	%	
4a	The importance level of general knowledge by public about the residential infrastructure policies.	313	78.3	5
4b	Consumer perception and satisfaction of existing sustainable housing policy.	316	79	4
4c	Affordable housing development must apply the elements of sustainable and green technology.	333	83.3	2
4d	Significance of policy may effect to the demand and supply of residential industry.	331	82.8	3

4e	Policy in implementation of green technology and sustainability should be enforced among housing developers.	333	83.3	1
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Based on results of the analysis as shown in Table 17, first higher ranking is a policy in the implementation of green technology and sustainability should be enforced among housing developers. This item is important in order to ensure that housing prices will not be increased indiscriminately without compromising to the sustainable development. The second highest ranking is affordable housing development must apply the elements of sustainable and green technology. This item is often overlooked because of the particular houses are affordable housing. This is due to the aspects of sustainable housing construction should be carried out regardless of the type of home. The third highest ranking is the significance of policy may effect to the demand and supply of residential industry item. Significant of policy play an important role in ensuring that all parties concerned in the housing industry and users adhere to the instructions issued.

**Analytical Results Using T-Test**

Independent samples T-Test used to compare two means between groups design, a situation in which each participant is assigned to only one condition.

**Independent Samples T test**

The 20 items were categorized into four different dimensions of variables. A result indicates no statistically significant differences for respondent information with architectural design, planning and infrastructure, green technology and sustainability, housing development and policy variables. All P-value is more than .05. Therefore, the null hypothesis is accepted and concludes that there is no significant difference between the groups.

Table2 Example of T-Test Result for Gender

Part	Variables	P-value	Results
I	Architectural Design, Planning and Infrastructure	0.441	Not Statistically Significant
II	Green Technology and Sustainability	0.195	Not Statistically Significant
III	Housing Development	0.564	Not Statistically Significant
IV	Policy	0.354	Not Statistically Significant

\*p-value for Independent T-Test

**Analytical Results Using ANOVA**

The analysis of variance (ANOVA) allows to analysis for test hypothesis about two or more condition. In this analysis, ages of respondent used to analyse using one-way analysis of variance (ANOVA). Tables 19 show the analysis of variance for ages results for each variable.

Table 19 Analysis of Variance for Ages

Part	Variables	Test of Homogeneity of Variances	ANOVA	Result
I	Architectural Design, Planning and Infrastructure	0.529	0.528	Not Statistically Significant
II	Green Technology and Sustainability	0.531	0.297	Not Statistically Significant
III	Housing Development	0.588	0.047	Statistically Significant
IV	Policy	0.474	0.028	Statistically Significant

Table 4.28 indicates the results for each variable of green technology and sustainability for residential infrastructure. The 20 items were categorized into four different dimensions of variables. A result indicates no statistically significant differences for respondent information in ages with architectural design, planning and infrastructure, and green technology and sustainability variables because ANOVA value is more than .05. However, the result indicates statistically significant for housing development and policy variables due to ANOVA value is less than .05. Therefore, the null hypothesis is accepted for architectural design,



planning and infrastructure, and green technology and sustainability variables, while null hypothesis is not accepted for housing development and policy variables.

## Conclusions

Green technology and sustainability for residential infrastructure are committed to creating a better standard of living. This research is the review of green technology and sustainability for residential infrastructure which gives potential benefits to the environment, human, flora, and fauna where green technology and sustainability are able to reduce the impact on health and other environment issues. The research is able to provide a practical philosophy about the most popular characteristic in perspective of green technology and sustainability for residential infrastructure. Finally, policy actions in terms of politics, technology, economy and social can make a difference by providing guidelines to the authorities such as Kementerian Perumahan dan Kerajaan Tempatan, Kementerian Kesejahteraan Bandar, Perumahan Kerajaan Tempatan and Majlis Perumahan Negara to achieve green technology and sustainability for residential infrastructure in future. At the same time, guidelines by the authorities can be as guidance for developer, architect, engineer, contractor and public to implement green technology and sustainability in residential infrastructure in Malaysia. Malaysia is still less research on residential infrastructure that is based on the use of green and sustainable technology. The research was conducted by previous researchers may have been inappropriate use today. For example infrastructure or facilities in the former residential infrastructure is not focused on bike paths and bicycle park, this led to the less populated residential areas using bicycles as vehicles for daily use or cycling as a leisure activity. This is how sustainable landscape architecture practice in residential infrastructure able to convert to a healthy lifestyle. The next example about green technology and sustainability for residential infrastructure is a green roof system that should be used in each residence can reduce the cost air conditioning use during hot weather. In addition, through the use of clean energy technologies, such as solar power at home can help reduce the rate of growth of greenhouse gas emissions. Green technology and sustainability for each type of building construction are important because it takes an intelligent approach to energy, minimises waste and maximises reuse, creates resilient and flexible structures and promotes health and well-being. From the above statements, shows that the research about the green technology and sustainability for residential infrastructure that needed by the public is important to investigate and to obtain its level of adoption based on the most important characteristics of each residential infrastructure in green technology and sustainability context. This research is important in order to determine the demand and supply to implement the green technology and sustainability for residential infrastructure in future.

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