SOCIAL ACCEPTANCE OF BIOFUEL FOR TRANSPORTATION IN PENINSULAR MALAYSIA

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A thesis submitted in fulfilment of the
requirements for the award of the degree of
Doctor of Philosophy

Faculty of Geoinformation and Real Estate
Universiti Teknologi Malaysia

APRIL 2017

DEDICATION

To my beloved father, mother and brothers

For their love, sacrifices, blessings and supports

To my lovely wife, Lee Yee Ying

For her patient and endless support

Dr. Choong Weng Wai

Professor Ir. Dr. Sharifah Rafidah Wan Alwi

Professor Dr. Abdul Hakim Mohammed

For their guidance and sharing of knowledge

ACKNOWLEDGEMENTS

My PhD journey is made possible through people I met who come forward with their support, advice and help. I am eternally grateful to them and wish to deliver my appreciation to them. First, I would like to express my gratitude to my main supervisor, Dr. Choong Weng Wai for his scholarly support, guidance and help in preparing my thesis. His monetary support in purchasing the analysis software license - SmartPLS version 3.0 and Sawtooth Software version 8.0 - allow me to deliver my research via an interesting yet fruitful approach.

My sincere appreciation also goes to my co-supervisors, Professor Ir. Dr. Sharifah Rafidah Wan Alwi, the Director of Process System Engineering Centre (PROSPECT) at Universiti Teknologi Malaysia and Professor Dr Abdul Hakim Mohammed, the Dean of Faculty of Geoinformation and Real Estate at Universiti Teknologi Malaysia for their willingness to sacrifice their precious time in providing valuable input to my study. Is my pleasure to be supervised by these knowledgeable and helpful scholars.

I wish to acknowledged the Malaysia Ministry of Higher Education in sponsoring my study via scholarship provided under the MyBrain 15 program. This generous scholarship is meaningful in supporting my daily life throughout my PhD journey which allow me to focus solely on my study.

I am grateful to my family members for their support, especially my parent, for their love, patient and encouragement. Last but not least, my special thanks are reserved to my wife, Yee Ying for her accompany and support. Others who had delivered their help to me also deserved my sincere appreciation. Unfortunately, it is impossible to list down their name in this limited space.

ABSTRACT

Social acceptance issues can emerge as a powerful barrier in biofuel development. Beside the delay in project implementation, project cancellation is the worst consequence resulted from overlooking the social acceptance issues. This study is conducted to investigate social acceptance of biofuel in Malaysia with an aim to propose methods to eliminate this social barrier. The social acceptance is examined in respect to socio-political acceptance, community acceptance, and market acceptance. For the purpose of identifying socio-political acceptance, a literature review had been conducted and supported with a discussion of socio-political acceptance of biofuel in Malaysia based on the identified six socio-political acceptance criteria, namely strong institution capacity, clear and consistent regulatory framework, favourable financial procurement system, supportive spatial program, promoting stakeholder involvement, and compliant to sustainable certification. In examining the community acceptance, smallholder planters' intention to supply oil palm residue was examined using an extended version of Theory of Planned Behaviour. 327 set of data were collected with questionnaire and subjected to data analysis using structural equation modelling. Findings revealed that subjective norm and perceived production benefits are the two most significant variables in predicting smallholder planter's intention to supply oil palm residue. In terms of determination of the market acceptance, 803 set of data were analysed using choice-based conjoint analysis to identify the preference of fuel attributes in consumer fuel choice. Five fuel attributes were examined, namely fuel product, fuel price, fuel mileage, fuel availability and vehicle acceleration. Based on the findings, suggestion to enhance social acceptance of biofuel was provided. This study will enrich existing literature by providing insight into social acceptance of biofuel from a developing country context. Policy makers and biofuel producers can benefit in formulating effective strategies to foster social acceptance of biofuel.

ABSTRAK

Isu-isu penerimaan sosial boleh menjadi halangan yang besar dalam pembangunan biofuel. Selain kelewatan dalam pelaksanaan projek, pembatalan projek adalah kesan yang paling teruk sekiranya isu penerimaan sosial diabaikan. Kajian ini dijalankan bagi mengkaji penerimaan sosial terhadap biofuel di Malaysia dengan matlamat mencadangkan langkah bagi mengatasi halangan-halangan berkaitan dengan isu penerimaan sosial. Penerimaan sosial dikaji dari segi penerimaan sosial-politik, penerimaan masyarakat, dan penerimaan pasaran. Bagi penerimaan sosial-politik, kajian literatur telah dijalankan dan disokong dengan perbincangan berkenaan penerimaan sosial-politik terhadap biofuel di Malaysia berdasarkan enam kriteria yang dikenalpasti, iaitu kapasiti institusi yang kuat, kerangka undang-undang yang jelas dan konsisten, sistem perolehan kewangan yang disukai, program sokongan spatial yang membantu, penglibatan pihak berkepentingan yang turut mempromosi, dan kepatuhan kepada pensijilan lestari. Untuk kajian penerimaan masyarakat, niat pekebun kecil untuk membekal sisa kelapa sawit telah dikenal pasti berdasarkan versi Teori Tingkah Laku Terancang yang diperluaskan. Sejumlah 327 set data yang dikumpulkan dari soal selidik dianalisis dengan menggunakan model persamaan berstruktur. Hasil kajian menunjukkan norma subjektif dan pandangan manfaat pengeluaran adalah dua pembolehubah yang penting dalam meramal niat pekebun kecil dalam membekalkan sisa kelapa sawit. Bagi kajian penentuan penerimaan pasaran, sejumlah 803 set data telah dianalisis dengan menggunakan analisis pilihan berdasarkan kumpulan bagi mengenal pasti keutamaan pengguna terhadap ciri-ciri bahan api. Lima ciri-ciri bahan api telah dinilai, iaitu produk, harga, jarak, ketersediaan dan pecutan kenderaan. Langkah untuk meningkatkan penerimaan sosial terhadap biofuel telah dicadangkan berdasarkan hasil kajian. Kajian ini akan memperkaya literatur sedia ada berkenaan penerimaan sosial terhadap biofuel dalam konteks negara membangun. Pembuat dasar dan pengeluar biofuel boleh mendapat manfaat dalam merangka strategi yang berkesan untuk mempertingkatkan tahap penerimaan sosial terhadap biofuel.

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LIST OF ABBREVIATIONS

AIM	-	Agensi Inovasi Malaysia
ASTM	-	America Society for Testing and Materials
ATTD	-	Attitude
AVE	-	Average Variance Extracted
B5	-	Biodiesel with 5% palm methyl ester blending
B7	-	Biodiesel with 7% palm methyl ester blending
B10	-	Biodiesel with 10% palm methyl ester blending
cc	-	Motorcycle engine size
CBC	-	Choice-Based Conjoint
CPO	-	Crude palm oil
EN	-	European standard
EPP	-	Entry point project
EU	-	European Union
FFB	-	Fresh fruit bunches
GHG	-	Greenhouse Gases
GM	-	Genetically Modified
GNI	-	Gross National Income
IEA	-	International Energy Agency
INT	-	Intention
ha	-	Hectare
kg	-	Kilogram
MAA	-	Malaysian Automobile Association
MITI	-	Ministry of International Trade and Industry
MJ	-	Mega joule
MPIC	-	Ministry of Plantation Industries and Commodities

MPOB	-	Malaysia Palm Oil Board
MSPO	-	Malaysia Sustainable Palm Oil
NGO	-	Non-governmental Organization
NIMBY	-	Not in my backyard
PBC	-	Perceived behavioural control
PEB	-	Perceived environmental benefit
PEMANDU	-	Performance Management and Delivery Unit
PEI	-	Perceived ecological impact
PLS	-	Partial Least Square
PPB	-	Perceived production benefit
PORIM	-	Palm Oil Research Institute of Malaysia
POIC	-	Palm Oil Industry Cluster
RFC	-	Randomised first choice
RM	-	Ringgit Malaysia
RON	-	Research octane number
RSPO	-	Roundtable on Sustainable Palm Oil
R&D	-	Research and development
SEM	-	Structural Equation Modelling
SMRT	-	Sawtooth Software Market Research Tools
SN	-	Subjective norm
SIRIM	-	Standard and Industrial Research Institute of Malaysia
TPB	-	Theory of Planned Behaviour
USDA	-	United State Department of Agriculture
US$	-	The United State currency
VIF	-	Variance Inflation Factor
WHO	-	World Health Organisation
WWF	-	World Wildlife Foundation

LIST OF SYMBOLS

f^2	-	Effect size
Q^2	-	Cross-validated redundancy
q^2	-	Predictive relevance
R^2	-	Coefficient of determination
β	-	Path coefficient
€	-	Euro currency

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CHAPTER 1

INTRODUCTION

1.1 Study Background

Transportation is imperative for human daily activities and economic development. An urban transportation system can shorten the time consumed in travelling as well as cost associated with logistic. However, due to its dependent nature on depleted fossil fuel as primary energy source, it is undeniable that transportation sector is contributing to the adverse environmental impact associated with the usage of fossil fuel. According to the report "*CO_2 Emission From Fuel Combustion Highlights (2011 Edition)*" (prepared by International Energy Agency, 2011), transportation sector is the second largest carbon emission sector, in which it is responsible for 23% carbon emission in year 2009. Besides carbon substances, other greenhouse gases (GHG) generated from transportation sector includes methane (CH_4) and nitrous oxide (N_2O). Among them, carbon emission is the major concern as it is rapidly increasing and this gas is the major contribution for the green house effects (Liaquat *et al*., 2010).

Besides the adverse environment impact associated with the usage of fossil fuel, transportation sector is also confronting energy security problem, in specific, potential energy shortage issue. Unlike power generation sector which may rely on other fuel mix such as coal and natural gas, transportation sector is almost totally depending on crude oil. According to Ong *et al*. (2012), petrol and diesel, the two major liquid fuels used in transportation sector, are account for more than 70% of the

total crude oil product. In addition, this sector is the largest energy consumption sector in Malaysia and has the faster annual energy consumption growth rate of 6.20% among other sectors (Ong *et al*., 2011). The recent reported final energy use in the year 2014 shows that this sector alone is consuming 24,327 ktoe or equivalent to nearly 47% of the final energy used in Malaysia (Malaysia Energy Information Centre). The final energy usage in year 2014 in accordance to respective sector is shown in Figure 1.1.

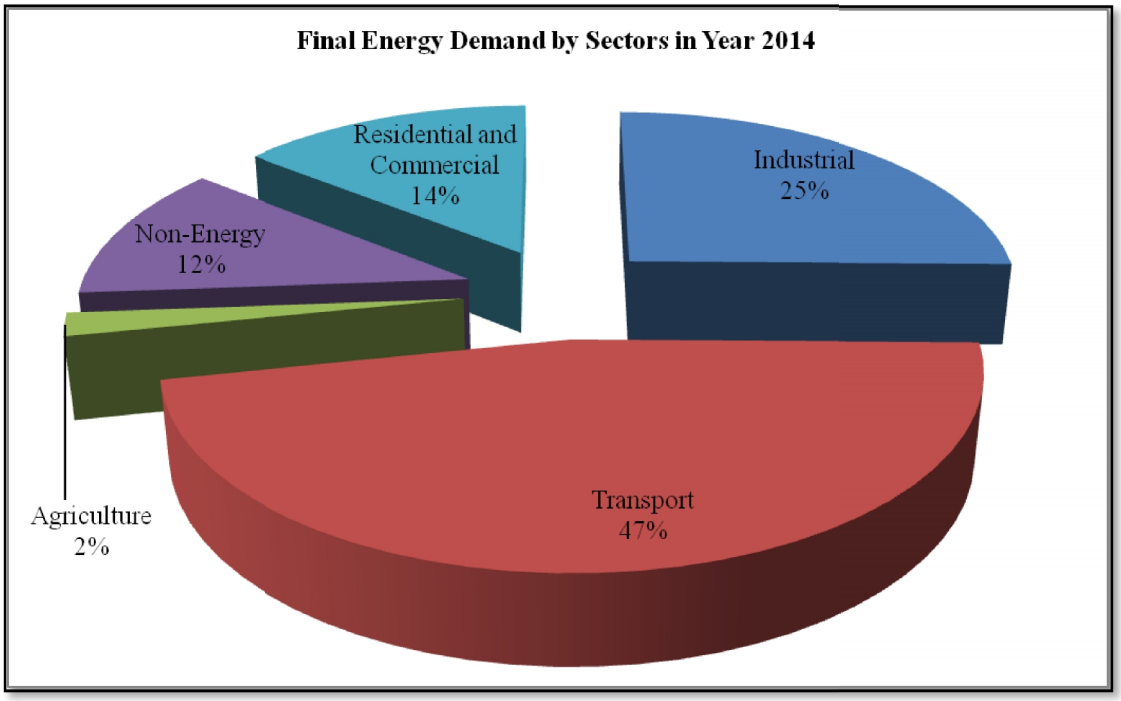

Figure 1.1: Final energy use by sector in Malaysia by the year 2014

Source: Malaysia Energy Information Centre (2016)

According to Yedla *et al.* (2005), road transportation is the main contributor for carbon emission as compared to others mode of transportation. Soylu (2007) stated that due to its convenience in providing door to door transportation, road transportation has the highest fuel consumption and emission per km travel than others transportation mode. The issue of carbon emission and potential energy shortage associated with transportation sector will become worse as global demand for transportation is forecasted to grow with 40% by year 2035 (International Energy Agency, 2011). The energy supply for transportation will become strained in respond to such a growth especially due to the depleted fossil oil prediction. According to Ong *et al*. (2011), current world's oil reserve is estimated to be

sustained for 40.8 years at current rate of production. After that, we need to operate our vehicle without gasoline and diesel. As to Malaysia, the country's oil reserve will be exhausted in around 20 years period (Oh *et al*., 2010; Ong *et al*., 2011) due to extreme usage of petrol and diesel in transportation sector. Since then, Malaysia will become net importer country for crude oil. Following the potential carbon emission as well as the concern on energy security, there is an urgent call for solution in reducing carbon emission from transportation sector as well as to ensure energy security.

In respond to the call of tackling energy security issue and adverse environmental associated with transportation, finding alternative fuels to serve as substitution to replace fossil fuel has been a main research agenda worldwide. The effort of focusing on alternative fuels as fossil fuel substitution is mainly driven by the reason of energy scarcity and concern towards environment (Ong *et al*., 2012). Biofuel (e.g. bioethanol and biodiesel) is one of the examples of alternative fuel. Other than the aforementioned alternative fuel, researchers are also focusing in hybrid, plug-in hybrid, electrical vehicle and hydrogen fuel cell technology. Among these technologies, it is undeniable that hydrogen fuel and electrical vehicle have a promising zero carbon emission for vehicle. However, the promise of zero emission is very optimistic for the initial stage of electrical vehicle development. Although it is zero in carbon emission for the tailpipe, we need to consider also the resources used for electricity generation as electrical vehicle need electrical charging.

As acknowledged by Vliet *et al*. (2011), GHG emitted from electrical vehicle may range from 0g/km (with renewable energy sources as electricity generation) to as high as 155g/km (using coal based electricity generator), depend on the use of energy source in electricity generating for charging purpose. As to today, Malaysia is relying primary on natural gas for electricity generation, which account for 50.04% fuel mix in electricity generation in year 2013 (Malaysia Energy Statistic Handbook 2015). The other mixes of fuel in electricity generation are coal (38.00%), hydro (8.40%), oil (1.10%), diesel (1.2%) and others (0.90%). This shows that Malaysian still largely dependent on fossil fuel in their electricity generation. There may be a tendency of zero emission for tailpipe (electrical vehicle) in transportation sector but the impact will cause an increase of carbon emission at the power generation sector.

On the other hand, hydrogen fuel is still in the laboratory stage of research in Malaysia (Mohamed and Lee, 2006; Oh *et al*., 2010). Although hydrogen is abundant in nature, extraction technology to produce hydrogen is expensive (Mohamed and Lee, 2006). According to Oh *et al*. (2010), series of studies are being carried out to harness hydrogen as energy carrier in fuel cell for transport. Based on the Malaysian hydrogen energy roadmap, the hydrogen is estimated to be ready as an attractive and competitive source used in Malaysia by year 2030. Therefore, although electrical vehicle and hydrogen fuel are the primary choice as a long term solution to address issue of adverse environment impact and energy scarcity in transportation sector, yet, both are impossible to react immediately with the urgent need for Malaysia to face with increasing GHG emission and energy usage in transportation sector.

Among these alternative fuels and technologies, biofuel has emerged as the most promising substitution fuel to respond to the urgent call of solution to face with the increasingly greenhouse gases emission (Lim and Lee, 2012). In general, biofuel is a term that falls under biotechnology field of study (Savvandou *et al*., 2010). According to Demirbas (2007), the term biofuel includes any liquid and gaseous form of fuel used in transportation, which are predominantly derived from biomass. Bioethanol and biodiesel are the two most promising biofuel products used as replacement fuel in transportation (Lim and Lee, 2012). Biofuel can be either used directly or blended with fossil diesel in transportation (Huang and Wu, 2008). Currently, 5%-20% biofuel blend with conventional fuel is being permitted worldwide (Jayed e*t al*., 2009) with several countries like Brazil had adopted 100% bioethanol program for the country's domestic market.

The usage of biofuel as alternative fuel can be traced back to year 1900 when Rudolf Diesel used peanut oil for internal combustion engine during Paris Exposition (Hira and de Oliveira, 2007). However, petroleum derived petrol and diesel are still in the dominant place for that period due to the fact that petroleum is the cheaper choice and is easily available (Demirbas, 2007a). Later, when oil price was sky rocketing, biofuel has attracted the interest of policy makers. For example, the Brazilian government had successfully implemented the Brazilian Alcohol Program (Proálcool) where bioethanol using sugar as feedstock were being produced in

commercial scale to reduce the country dependency on petrol. As concern on environmental issue and energy security being raised, biofuel has once again being highlighted to answer the call of searching for sustainable solution in addressing the aforementioned issues.

The promising benefits from biofuel usage have make biofuel being referred as one of the most promising replacement fuel in transportation at present. In term of technical benefits, current blended biofuel can be used directly in conventional engine without major modification (Bozbas, 2008; Jayed *et al*., 2009; Lam *et al*., 2009; Mekhilef *et al*., 2011) and blended biofuel can still be supplied with the existing petrol facility without revamping current fuel supply system (Van den Hoed, 2007). In other words, drivers need not to spend additional money to replace their vehicle engine whilst oil companies need not to invest additional capital to construct supportive fuel supply system to distribute biofue to consumers. This demonstrates that biofuel can be an economic viable option as substitute for petrol fuel and diesel used by transport.

In term of feedstock, there are variety types of readiness feedstock that can ensure continuous supply of feedstock for biofuel production (Lam *et al*., 2009). It is proven whereby an amount of oil-bearing crops had been studied and reported in scientific reports in term of their readiness and suitability to be used as feedstock for biofuel. For examples, coconut oil (Kalam *et al*., 2003), coffee oil (Oliveira *et al*., 2008), palm kernel oil (Chongkhong *et al*., 2007), rape seed oil (Rashid and Anwar, 2008), rubber seed oil (Ramadhas *et al*., 2005), soybean oil (Kim *et al*., 2004) and sunflower oil (Stamenković *et al*., 2007). Beside oil-bearing crops, there are also advanced feedstock like algae (Janaun and Ellis, 2010; Lim and Lee, 2010) and *Jatropha Curcus* oil (Janaun and Ellis, 2010; Lim and Lee, 2010). The feedstock for biofuel production varies according to the country due to the easy availability and cost consideration reason. For example, soybean in United State, rapeseed in Europe and palm oil in Malaysia. Even in one respective country, different oil-bearing crops will be used for biodiesel production. For instance, in Brazil, palm kernel and soybean is used for the north region while soybean, castor bean, cotton seed and sunflower seed are preferred in southeast region (Pinto *et al*., 2005). In other words, biofuel producers have diverse choice of feedstock for biofuel production.

From the political point of view, biofuel is an attracting option for policy makers as a strategy to embed sustainability aspect into energy usage, to respond to adverse environmental issues, to ensure energy security, to respond to soaring oil prices, and to stimulate rural area development with energy crop plantation (Reijndres, 2006; Bomb *et al*., 2007; Jayed *et al*., 2009). For the rural area, energy crops plantation can be an effective strategy to enhance socio-economic development of rural area. The plantation of energy crop will provide employment opportunity to the local residents and improve their household income. As a result, energy crop based biofuel is welcome by the policy makers. Recently, the World Health Organisation (WHO) has made an alarming statement that emission from nitrogen emission diesel can cause lung cancer to public who inhale it (Kitamura, 2012). This is believed will further trigger the usage of cleaner fuel in transport to reduce the risk to public health.

Besides that, in term of marketability, worldwide biofuel production has been growing over the past few years with an increase of 43.2% and 22.7% in biodiesel and ethanol production respectively between 2001 and 2006 (Birur *et al*., 2007). Balat and Balat (2008) predict this growth trend will be continuing with a further booming growth in the next few years. At present, ethanol and biodiesel are the two main biofuels used as alternative fuel for transportation (Savvanidou *et al*., 2010). As mentioned by Ong *et al*. (2012), ethanol is currently in the leading position in biofuel market as ethanol has a larger share in global biofuel market than biodiesel. Conversely, biodiesel has a great opportunity than ethanol in future as demand for biodiesel is increasing faster than ethanol, especially in the European Union and Asia regions (Ong *et al*., 2012). The new large potential market in future will focus in China and India, as well as Brazil (Hanna *et al*., 2005; Pinto *et al*., 2005).

From the aforementioned, biofuel (including both bioethanol and biodiesel) is seem to promise a lot of benefits to a variety of stakeholders. Policy makers can depend on it as an effective strategy for climate mitigation, energy security and rural area development; biofuel producers, engine manufacturers and oil companies can viewed it as a business opportunity; local community can involved in renewable energy technology development with employment guarantee; whilst consumers can contribute to environment protection via their consumption pattern of choosing

biofuel as fuel driven their vehicle. Collectively, these strengthen the status of biofuel as the most promising alternative fuel to replace fossil fuel. However, this sound perfect substitute has its disadvantages and applied limitation. It is important to highlight these disadvantages and limits as these are the drawback for biofuel development and will contribute to the failure for higher blended biofuel introduced in future if these drawbacks are remain ignored.

In term of technical disadvantage, biofuel driven engine is found to be less competitive to petrol fuel due to its cold start problem, lower energy content and high viscosity that will contribute to higher copper strip corrosion and difficulty in fuel pumping (Demirbas, 2007a). These problems are associated with the use of vegetable oil for biofuel production, as the chemical content of vegetable oil is somehow different from fossil fuel and will cause problems for traditional petrol run engine. To respond to problem associated with the usage of biofuel, flexi-fuel engine had been designed. The flexi-fuel driven vehicle can be driven by and support both conventional fuel and bioethanol. However, this flexi-fuel technology is currently available for petrol run engine whilst it is not applicable for diesel run engine. In other words, the diesel run engine vehicles still face with the aforementioned technical problems. A summarized of potential problems and causes for using vegetable oil in diesel engine can be referred to Jayed *et al*. (2009).

The usage of energy crops based feedstock for biofuel production had been critiqued as a contributor for adverse environment impacts. The relying on agriculture products for biofuel production will stimulate demand for agricultural land to accommodate with the increasing demand of feedstock for biofuel production. Tropical rainforest had been cleared for the energy crops' plantation and biomass cultivation (Larson and Williams, 1996). A report prepared by the World Wildlife Foundation (WWF) critiques Indonesian practise of clearing the country tropical rainforest to make more available lands for the country oil palm plantation in order to increase the yield of palm oil for biodiesel production (Glastra *et al*., 2002). In addition to the forest clearing practice, Glastra *et al*. (2002) acknowledged that fire clearing is the most frequent used method in deforestation and cause hazes in South East Asia countries.

The clearance of forest will result in losing of flora and fauna. For instance, *Orang Utan* extinction in Malaysia had been claimed to be associated with the expansion of oil palm plantation on previous forests land which is the habitat for *Orang Utan* (Whyte *et al*., 2006; Tan *et al*., 2009). Other environmental issues associated with the crop based biofuel are large amount of water used not only during the plantation period but also during the production of biofuel, as well as the fertilizers and pesticides usage (Patzek *et al*., 2005). The practice of crops based feedstock for biofuel production had been animadverted by environmental protection groups with some of the aggressive groups are trying to boycott any products that produced from unsustainable manner (Whyte *et al*., 2006).

Besides that, biofuel produced from agricultural products has been plunged into the debate of food vs fuel. With the increasing demand for biofuel worldwide, more edible oil will be used for biofuel production. As more agricultural products being used for biofuel production, there will threaten the supply of edible oil. It is well known in the economic point of view that when supply lowers than demand, price will increase. Thus, there is a fear of increase in food price and as a result it will cause protest and chaos (Tan *et al*., 2008). In addition, the usage of edible oil as feedstock for biofuel production is being critiques as unethical (Kerschbaum *et al*., 2008; Srinivasan, 2009). There are still million of citizens from the Third World Countries facing with starvation issue. If there is an extra of agricultural products, it should not be used as biofuel feedstock and left million of people starved to death.

In term of economic perspective, the cost of feedstock for biofuel production is a critical challenge in biofuel development which will hinder the market diffusion for biofuel. Although low blended biofuel can be used directly in current engine system but the cost of production is relatively high and make it hard to compete with petrol fuel if no government intervention support the development and subsidies of biofuel. Raw material cost is the largest portion of the total production cost for biofuel. It is estimated that raw material contributes to about 75% - 80% of the total production cost of biofuel (Demirbas, 2009). Other costs involved are labour and catalyst used in chemical reaction (Haas *et al*., 2006). The high feedstock cost has result in high selling price of biofuel compared to conventional petrol fuel. For instance, palm based biodiesel was sold at about RM 2.80 per litre whilst petrol

diesel sold at RM1.70 per litre as on 24 March 2009 (Mekhilef *et al*., 2011). The higher price of biofuel has distracted the consumers from purchasing biofuel for their vehicle; instead, conventional fuel is still preferable especially when the price of biofuel is higher than petrol fuel (Bomb *et al*., 2007; Pacini and Silveira, 2011).

These abovementioned disadvantages of biofuel are strong barriers that can hinder biofuel development. Nevertheless, researchers are still being attracted by the benefits associated with biofuel, therefore, numerous efforts had been carried out to address the disadvantages of biofuel. It is noticed that majority of the disadvantages are in related to the agricultural crops based feedstock. For examples, forest clearance, rocketing of food price and loss of biodiversity due to increase plantation area of energy crops. Researchers had suggested the use of second generation biofuel which use non-edible oil as biofuel feedstock. Example of second generation biofuels are algae (Janaun and Ellis, 2010; Lim and Lee, 2010) and *Jatropha Curcus* oil (Janaun and Ellis, 2010; Lim and Lee, 2010). However, the production technology of advanced biofuel is still limited for commercial scale production. Therefore, the first generation biofuel still dominant the biofuel market. In line of that fact, efforts and research are carried out to minimise the impact of crops based biofuel. It is noticed that technical improvement is always being the centre of study for biofuel. Quality and performance improvement is the focus to increase the credibility and diffusion of biofuel into current fuel market. As a matter of fact, beside technical barrier, social acceptance can emerge as a powerful impediment to hinder the development of biofuel. However, this issue is neglected and receives little attention compared to other renewables.

Social acceptance has gain increasing attention of researchers in studying the successful implementation of renewable energy innovations. In addition, it is being used to explain opposition by the public against innovative renewable energy technologies. However, clear definition of social acceptance is rarely found (Wüstahagen *et al*., 2007), yet it is a prerequisite before conducting research to access on biodiesel acceptance issue. The word “social acceptance” is a combination of two different word of “social” and “acceptance”, where both the words have their own respective concept and approaches (Sauter and Watson, 2007). According to Sauter and Watson (2007), “social” is actually referred to the general society as a

whole, as well as the different societal group within that particular society. In the other hand, the word "acceptance" can be delineated in the form of a passive consent and an active involvement (Sauter and Watson, 2007).

Based upon the clarification of social acceptance in their separate original word given by Sauter and Watson (2007), two forms of social acceptance can be found in general, namely active and passive acceptance. The term "willingness" to use or purchase certain renewable energy by the public can be viewed as "active" social acceptance (Sauter and Watson, 2007). In the other hand, social acceptance can be viewed as "passive" if the public acceptance is fostered through a series of government policies, especially mandatory regulation. In fact, Sauter and Watson (2007) noted that social acceptance had been widely seen as passive consent rather than active by public for a particular renewable energy project. In either form of active or passive, social acceptance had been generally used to indicate technology infrastructure positively or serve as an indicator for not rejecting that technology (Wüstahagen *et al*., 2007).

The ignorance of social acceptance issue and misleading information regarding to social acceptance can cause unwanted defect on the diffusion of renewable energy technology. It is proven by Hisschemöller and Midden (1999) and Renn *et al*. (1995) that social protest towards an energy technology will cause delays and stagnation. This is mainly due to the societal conflict found in the implementation of renewable energy technologies in the 1980s (Huijts *et al*., 2007). The increasing research focus on the social acceptance of renewable energy technologies shows a significant public engagement in these innovative technologies. This indicates that the development of renewable energy is no longer merely depending on technical and economic aspect, but also social process in the form of public acceptance of renewable energy technologies.

In biofuel context, previous studies on biofuel also highlighted that public acceptance is essential for development of biofuel. As a matter of fact, social support is crucial in achieving the bioenergy target and bioenergy development (Blumer *et al*., 2013). Furthermore, Savvanidou *et al*. (2010) highlighted two significant reasons for the needs of study in social acceptance for biofuel. The first reason is that limited

studies in social aspect of biofuel and high dispersion of result obtained from previous study can cause difficulty in clarifying social acceptance for biofuel. Secondly, the degree of social acceptability of biofuel is not well established as biofuel is massively used only in several parts of world. In fact, most of the biofuel production countries in Southeast Asia region are focusing on exporting biofuel product instead of utilising it in their own countries (Ong *et al*., 2012). This further raise the question regarding whether biofuel is being accepted by the public. Thus, it will be essential for more research to be carried out to close this gap for a better understanding towards social acceptance of biofuel.

1.2 Problem Statement

The introduction of biofuel as an alternative fuel to replace fossil fuel can be seen as a strategy to address the potential energy security issue confronted in Malaysia (Ong *et al*., 2012) since Malaysian oil reserve will be exhausted within 20 years of time period (Oh *et al*., 2010) as a result from extreme usage of fossil fuel in transportation sector (Ong *et al*., 2011). Without the introduction of biofuel as an alternative fuel to replace fossil fuel usage, Malaysia will need to import fuel from oversee to support the domestic fuel usage. Consequently, Malaysia will be vulnerable to crude oil supply disruption and the fluctuation of oil price. These will further affect Malaysian energy independent.

In awareness on this issue, Malaysia had embarked into palm based biofuel R&D activities since 1982 with Malaysia Palm Oil Board being given the responsibility to develop the nation's palm based biodiesel product (Lim and Teong, 2010). The availability and abundance of palm oil has attract the policy makers to choose palm oil as the feedstock for palm based biodiesel. In addition, using crude palm oil as feedstock for biodiesel production enable Malaysia to sweep away the excess amount of palm oil supply stock and thus, strengthening the CPO price.

Nonetheless, feedstock abundance alone cannot ensure the success of biofuel development, technology viability is another vital component in the success of

biofuel production. Malaysia can either develop its own biofuel production technology or import the technology from nation that has successfully produce biofuel in making the biofuel production technology become viable. Developing own technology will require plenty resources to be channelled into R&D activities while the later will cause Malaysia become a technology dependent nation and this later strategy may not be a long term sustainable solution for Malaysia biofuel industry. In aware of this shortage, Malaysia has involved in biofuel development by developing the nation own biofuel technology in which Malaysia palm based biodiesel production technology not only being adopted by the local biofuel producers, it also attracting interest from oversee, such as Korea and Thailand (Lau, 2015).

Although Malaysia has successfully develop the nation own biofuel production technology and become the pioneer of the palm based biodiesel production technology, however, the introduction of biofuel product into Malaysian domestic market has confronted with social barrier cause by lack of understanding and ignorance of social acceptance issues. The following will discuss in detail on the social acceptance issues associated with biofuel development.

Following the Triangular Model of Social Acceptance by Wüstenhagen *et al*. (2007), there are three dimension of social acceptance, namely socio-political acceptance, community acceptance and market acceptance. In general, socio-political acceptance indicates general public opinion, stakeholders' opinion and policy makers' opinion in matters related to biofuel implementation. Although Malaysia has been involved in palm-based biodiesel since 1982, the public's only experienced biodiesel when B5 biodiesel launched in 2011. Thus, biofuel can be perceived as a new fuel for Malaysia, and public opinion toward this "new fuel" is worth investigating (Savvanidou *et al*., 2010) since Delshed *et al*. (2010), who investigated the public opinion toward biofuel technologies and selected policy measures, have acknowledged that biofuel may not be a favourable option for all.

Beside biofuel policy and its production technology, disputes associated with biofuel usage are worth investigating to reveal public acceptance. Some of the disputes will affect public daily activity, for instance, food security concern.

Insecure food supply and increase in food price can cause protest against biofuel production using edible oil (Tan *et al*., 2008). Although biomass has generally been considered as an alternative feedstock to drive away biofuel from food versus fuel issue, its impact on food price is arguable. For example, Thompson and Meyer (2013) argued that using biomass as feedstock for biofuel production still could affect food price if it is perceived as a competitor to agricultural crop for land allocation.

In addition, using genetically modified (GM) crops for biofuel production is another public acceptance issue (Fischer *et al*., 2010). In general, the genetic modification of non-edible crop is more acceptable than vegetable crops (Koh and Ghazoul, 2008) for biofuel production. For Malaysia, the full oil palm genome map has been reported by Singh *et al*. (2013b). The discovery of the Shell gene provide an opportunity for using genetic technology to increase palm oil yield (Singh *et al*., 2013a). Malaysia Palm Oil Board has the intention to use genetic technology for oil palm plantation in the future to enhance production of palm oil, as well as for sustainability concerns (Ismail, 2013). It is plausible that this genetically modified palm oil will be used for biofuel production since its limitation for food product has strengthened. The public possibly will be concerned that the excess supply of oil from genetically modified oil palm tree may be channelled to food production.

At the same time, media played an important role in informing the general public about both the benefits and negative consequences of biofuel usage. Media is able to shape public perception about biofuel and its related issues (Wright and Reid, 2011). This will influence public acceptance for biofuel. A recent study conducted by Cacciatore *et al*. (2012) revealed that wording used to label biofuel would affect public opinion towards biofuel usage. According to them, the word "biofuel" is perceived as more environmental friendly and is able to move away bioenergy fuel from food versus fuel criticism than the word "ethanol", which triggers public perception on corn-based ethanol that caused the food versus fuel debates. Thus, perceived benefits and belief in negative consequences and how these are being portrayed by media are also crucial for understanding public acceptance in the biofuel context.

Another aspect incorporated within the socio-political dimension is stakeholder acceptance. Industry players and environmental protection groups are the two predominant stakeholders in biofuel development. Industry players include biofuel producers, plantation industry stakeholder, oil companies and automobile stakeholders. These players play significant roles in ensuring continuous supply of feedstock, engines compatible to run biofuel, efficient fuel supply and distribution to consumers and introducing flexi-fuel vehicle to further support the penetration of biofuel, respectively. Overlooking opinion of certain industry players are the major reason for the Malaysian government to cancel the Envo Diesel Program (Sorda *et al*., 2010; Jayed *et al*., 2011), the delay of B5 Biodiesel Program implementation (Er, 2011; Ong *et al*., 2011a) as well as the recent postponement of 10% blending percentage of biodiesel (Khoo, 2016).

Besides industry players, environmental protection groups also play a significant role. Some environmental protection groups are lobbying to boycott palm oil products (Whyte *et al*., 2006) due to the belief that oil palm plantations are the main cause for forest clearing and extinction of *Orang Utan* (Tan *et al*., 2009). Haze pollution is another adverse environmental impact faced in the South East Asia region (Glastra *et al*., 2002). In fact, oil palm consortiums have been blamed for haze pollution in the South East Asia region (Belford, 2013). Therefore, stakeholder acceptance is vital, not only to foster acceptance and promote biofuel usage; yet, to produce biofuel in a sustainable manner.

Policy makers' support for biofuel is another aspect of socio-political acceptance. The increasing usage of biofuel is closely related to supportive governmental programs and policies (Scarlat and Dallemand, 2011). However, there is difficulty in obtaining policy maker opinion. Policy maker opinion is hard to sustain especially for democratic countries where elections are held to select the parliamentary representative for a respective period. In order to gauge policy maker opinion, reviewing existing biofuel policy is crucial. Criteria for denoting a supportive biofuel policy include (i) strong institutional capacity (eg., Sovacool and Ratan, 2012); (ii) clear and consistent regulatory framework (eg., White *et al*., 2013); (iii) favourable financial procurement system (eg., Wüstenhagen *et al*., 2007); (iv) supportive spatial program (eg., Hall, 1991); (v) promoting stakeholder involvement

(eg., Wüstenhagen *et al*., 2007); and (vi) compliant to sustainable certification (Cansino *et al*., 2012). Collectively, these criteria can be used to indicate socio-political acceptance of biofuel. However, a positive sign in socio-political acceptance is not synonymous to favourable conditions for biofuel development. Indeed, there are another two dimensions that require attention.

In the biofuel context, community acceptance will cover two important stages of biofuel production, namely the collection of feedstock for biofuel production and production of biofuel. This dimension of acceptance will focus on the sitting controversy of biofuel project. This sitting controversy can be observed in two facets: first, landscape change due to crops plantation; and second, in relation to sitting of refinery factory for biofuel production.

For the feedstock collection discussion, the grow pattern of agricultural crops will cause changes in landscape (Zoellner *et al*., 2008). Existing plants and forests will be cleared for energy crops plantation, which will trigger concern for aesthetic views and environmental issues. In addition to that, introducing new crops for biofuel production will face resistance from local farmers who are unfamiliar with these new crops and generally prefer traditional cultivation practices (Amigun *et al*., 2011). Adoption of modern cultivation technique and sustainable farming practice are another challenge (Duvenage *et al*., 2013). Moreover, farmers are concerned with economic benefits (Rossi and Hisrinchs, 2011), land right conflict (Mintz-Habib, 2013), logistic cost and market constraint (Qualls *et al*., 2012).

Although Malaysia had the intention to move its biofuel feedstock from palm oil to biomass, the issue of landscape change due to crops plantation is still worrying. Biomass is planned to be obtained from the oil palm plantation area whereby the demand for biomass may lead to competitive land allocation for crop (the oil palm) used for agricultural products and for biofuel production. This grow pattern will still trigger concern for landscape changes. In addition to that, the willingness of planters to collect harvesting residual and palm oil producers to collect production residues are another community acceptance issue. Cost associated with the collection of residues and logistics may hamper planters and palm oil producers' interest in biomass. Brough *et al*. (2013) reveal non-industrial private forest owners are willing

to collect woody biomass for biofuel production, with some are even willing to do so for free (Becker *et al*., 2013). However, these studies are limited to non-industrial forest owner while the Malaysian circumstance could provide in-sight from the perspective of oil palm planters.

Beside the changes of landscape and land use conflict, the sitting of refinery factories or biofuel production plants can emerge as a community acceptance issue as well. To the best of the knowledge of the authors, only Amigun *et al*. (2011) reported that a biofuel refinery facility is facing resistance in South Africa due to the conflict between national and local interest. It is reckoned that economic benefits offered from the operation of the refinery plant have lead to overlooking consequences associated with biofuel refinery plants, especially adverse environmental impact (Shelfa, 2010). Increase in employment opportunity and income generation has shifted concern from potential sitting controversy of biofuel refinery plant (Shelfa *et al*., 2011). However, local residents are actually concerned with the increase in traffic and tension on water supply (water competition between domestic usage and biofuel production usage), following the operation of a biofuel refinery plant in their neighbourhood (Shelfa *et al*., 2011).

As there is increasing demand for second-generation biofuel production, there is also expressed concern for the future development of first-generation biofuel production that may decrease the economic benefits enjoyed by the local residents (Shelfa *et al*., 2011). Thus, any change in current biofuel refinery infrastructure is also subjected to local community appraisal and acceptance (Ng *et al*., 2011). This implies that biofuel refinery plants will face local acceptance issue during two stages. First, when the biofuel refinery plant is introduced to the neighbourhood. Second, even if local residents are welcoming biofuel refinery plants, a future change in biofuel technology and refinery infrastructure may put biofuel refinery plant in confrontation with local appraisal.

Issues surrounding community acceptance are mainly due to the reason that local involvement in biofuel development is perceived as passive consent (Rossi and Hinrichs, 2011). Their role in biofuel development is driven by a series of government efforts in introducing biofuel and biofuel projects launched by investors.

The passive role among local residents prevents them from active involvement in biofuel development, and a lack of channel for them to voice opinion regarding project placement decision. This has misled policy makers and project owners in their project implementation decisions (Rossi and Hinrichs, 2011). Lack of local involvement during renewable energy project placement discussion is the main reason for local residents against renewable energy plants (Zoellner *et al*., 2008).

In the biofuel project, Duvenage *et al*. (2013) highlight how equal active local participation via corporative body benefit the Green Fuel Project in Zimbabwe. Conflict surrounding the issue of land ownership for energy crop plantation can be reduced while trustworthiness of outsiders can be enhanced (Duvenage *et al*., 2013). In addition to land ownership conflict, public involvement in biofuel projects will benefit in terms of information and knowledge delivering (Rogers *et al*., 2012), driving biofuel production toward sustainable feedstock plantation (Di Lucia, 2010), and satisfying different societal groups (Milder *et al*., 2008). However, public engagement is dependent on local authority and project owners' will. To what extent that project owners and local authority are willing to allow public involvement in spatial planning procedure for projects, as well as the refinery plant sitting is imperative for effective public participation in biofuel projects. Due to its limitation on public participation, researchers are suggesting that local residents who perceive fair treatment will have a favourable perception of renewable energy projects (Firestone *et al*., 2012). However, similar studies are limited for biofuel context.

In the last dimension, market acceptance dimension, biofuel will be viewed as the product produced from renewable energy technology. Market acceptance is also known as consumer acceptance. The focus of this dimension will be limited to consumers' preference in choosing biofuel for their vehicle. As aforementioned, biofuel can be perceived as a new fuel for Malaysia. At present, 7% palm methyl ester is mandatorily blended with fossil diesel. It is true that consumers have no option when injecting fuel at petrol stations since diesel sold at petrol kiosks are biodiesel. However, this shall not hinder efforts to understand consumer acceptance for biofuel product. In fact, Malaysia can be an interesting case study for consumer acceptance. Malaysian is enjoying a relatively cheap fuel cost for a long period, as a result of government subsidies. Market penetration of palm-based biodiesel is

backed with government subsidies. According to Economic Report 2012/2013, Malaysian government debt has surpasses 50% of the national gross domestic product (Department of Treasury, 2013). When the B5 Biodiesel Program covers the whole nation and the blending percentage increases, additional subsidies will further burden Malaysia's government budget. Thus, subsidisation is not a long-term solution and sustainable strategy to drive incremental usage of biofuel (Yang, 2010). In realising this issue, Malaysia government had removed fuel subsidies following the implementation of Subsidies Rational Program starting December 2014.

Following the possible failure of subsidies to drive future adoption of biodiesel, investigating market acceptance via understanding consumer choice in alternative fuel becomes a plausible solution for market penetration of biofuel. In general, price has become the major concern for fuel purchasing option (Pacini and Silveria, 2011). Although biofuel price is generally higher than those of fossil fuel, consumers are actually willing to pay more than its actual selling price (Savvanidou *et al.*, 2010). However, when the price of fuel is the same, other factors will become significant in influencing consumer choice for fuel (van Vliet *et al*., 2010). These factors include fuel economy (Popp *et al*., 2009), refuelling convenience (Van de Velde *et al*., 2009), perceived safety to both user and public (Browne *et al*., 2012), fuel performance (Zhang *et al*., 2011), ownership cost (Mabit and Fosgerau, 2011), reduced social and environmental impacts, such as lower food price (Skipper *et al*., 2009) and carbon emission (Van de Velde *et al*., 2009). In addition, health concern is another influencing factor. Recently, the World Health Organisation has made an alarming statement that nitrogen emission from combustion diesel can cause lung cancer to the public who inhale it (Kitamura, 2012). This is believed will further trigger resistance to biodiesel, as nitrogen emission from biodiesel is higher than petrol diesel. In contrast, collection of oil palm residual for biodiesel production will decrease the possibility of using fire to clear oil palm plantation area that has been blamed as the major cause for haze pollution in the South East Asia region. This leads to an interesting point in studying consumer acceptance if health impact is considered.

There is an interesting issue for bioethanol that is worth highlighting. Bioethanol has an advantage compared to biodiesel with the invention of flexi-fuel

engine. This flexi-fuel allows consumers to inject the cheaper fuel in between petrol and bioethanol. In this case, consumer acceptance for bioethanol can be either bioethanol as the biofuel product or the adoption of flexi-fuel engine. Market acceptance study for bioethanol is alike with biodiesel with the exception that the adoption of flexi-fuel engine will delve into Wüstenhagen *et al.'*s (2007) suggestion of consumer role as investor. Consumers need to invest additional money in vehicle purchase for flexi-fuel engine before they can enjoy the benefits of purchasing cheaper fuel in the long run. It also can be arguable that the adoption of flexi-fuel engine is similar to adoption of other alternative technologies for automobiles, such as hydrogen fuel and electric vehicles. However, there is one significant characteristic that is different for flexi-fuel engine, as it offers fuel-switching opportunity to consumers to enjoy cheaper fuel cost. Thus, examining consumer acceptance for biofuel is specific and cannot be generalised for other alternative fuel and automobile technologies.

Biofuel is a unique issue to be studied as compared to the other type of renewable energies. With the implementation of National Biomass Strategy 2020, Malaysia has the intention to produce biofuel from biomass. Producing biofuel required a refinery plant. This makes the location of refinery factory as a potential issue to be perceived by the local community. On the other hand, biofuel product falls inside the categories of alternative fuel used in transportation. Just like other alternative products, biofuel producers are interested in consumer preference and perception in order to produce a product which can satisfy the customer's need. These two unique features owned by biofuel require researchers to look into a broader scope of social acceptance rather than just focussing on a particular community acceptance or market preference in judging the acceptability of biofuel in society.

Nonetheless, existing studies were focusing on one respective social dimension. For instance, Savvanidou *et al.*(2010) has examined the factors that influence the willingness of using and purchasing the biofuel products. However, their study is limited at the acceptance level of end products. Delshed *et al*. (2010) who investigated on the public opinion toward biofuel technologies and selected policy measures also had a limitation like Savvanidou *et al.*(2010), in which their

research is limited to disclose acceptance in general level of public acceptance. Not to mention Brough *et al*. (2013) and Becker *et al*. (2013) whose study only focused on farmer's perspective in indicating the community acceptance of the forest based biofuel. It is clear that acceptance of public throughout the process of biofuel (from feedstock supply until it is purchased by consumer) remains unknown and is worth to be investigated.

In fact, social acceptance can be emerged as major social barrier in introducing biofuel to Malaysian. Unfortunately, there is lacking of academic literature and report that revealed social acceptance among Malaysian towards the nation biofuel program. This study has the intention to conduct a study with the aim to study socio-political acceptance in the promotion and initiating biofuel development in the beginning phase, then community acceptance is examined throughout the involvement of smallholder planters as feedstock supplier, finally, the market acceptance is to be scrutinized for an understanding of acceptance on the end products level which is consumer preference in fuel choice. These three dimensions must be met collectively in order to provide significant understanding on social acceptance and benefits to government and industry players to increase the usage of biofuel in Malaysia (Sovacool and Ratan, 2012).

1.3 Research Question

Based on the above mentioned problem statement and issues of social acceptance surround biofuel development in Malaysia, the central research question is thus, what is the social acceptance issues surrounding palm based biofuel in Malaysia? In addition, a secondary question for the research will be how to enhance the social acceptance of palm based biofuel in Malaysia?

1.4 Objectives of Research

In order to respond to the issues of social acceptance of biofuel in the context of Malaysian and to provide an understanding on social acceptance of biofuel in Malaysia context, the main purpose for this study is to eliminate the potential social barrier via in-depth understanding on social acceptance issue surrounding biofuel in Malaysia, subsequently, provide suggestion to eliminate the social barrier by enhance the social acceptance of biofuel in Malaysia.

1.5 Scope of the Study

This section will disclose the scope of the study, in term of study subject between biodiesel and bioethanol, as well as the scope of socio-political acceptance, community acceptance and market acceptance that will be conducted to reveal social acceptance of biofuel in Malaysia context.

1.5.1 The Study Subject

As mentioned, biodiesel and bioethanol are the two most common biofuel products used to replace conventional diesel and petrol, respectively. Both biodiesel and bioethanol can be further divided into first generation biofuel and second generation biofuel, based on the feedstock used for the biofuel production. The first generation of biofuel use edible oils as feedstock, such as sunflower oil, rapeseed oil and palm oil. On the other hand, the second generation biofuel is using non-edible sources, predominantly agricultural residue (include forest biomass) and wastes from municipal and industry. Each and every feedstock has its own supply chain and production route which is unique and cannot be generalised for others. Due to this uniqueness, feedstock used for biofuel production in Malaysia needed to be identified prior to conducting study for the purpose of identification of community and market acceptance.

At present, the palm based biodiesel - using crude palm oil as feedstock for the production of palm methyl ester which will later being blended with conventional diesel - is the only biofuel product available for Malaysian transportation sector. Beside palm based biodiesel, the second generation bioethanol produced from oil palm residue is receiving Malaysian government attention as well. This can be noticed from the formulation of the National Biomass Strategy that aims to fully capture the potential of 83 million dry tonnes of oil palm residue (AIM, 2013) that is produced as by product of the oil palm industry. Approximately 75% of this residue (oil palm frond and oil palm trunk) is available at plantation site, with the remaining 25% - consisting of empty fruit bunches, palm kernel shell and mesocarp fibre - obtained at the oil palm mill after palm oil is extracted. In compared to oil palm residue produced at the oil palm mill which has been used for steam production at the mill or further processed as pellet for power generation, the potential of the oil palm frond and oil palm trunk has not been fully utilised. From a technical view point, both the oil palm frond and the oil palm trunk have been proven to be viable options for bioethanol production (Yamada *et al*., 2010; Prawitwong *et al*., 2012; Zahari *et al*., 2014; Ofori-Boateng and Lee, 2014). The oil palm frond and trunk are being estimated to have 17.5 MJ/kg and 15.7 MJ/kg of energy content, respectively (Chow *et al*., 2008).

From the abovementioned, the first generation palm based biodiesel is currently the only commercialise biofuel product for the Malaysian domestic market with the second generation bioethanol being regarded as a potential alternative for petrol driven vehicles. In comparison, although public acceptance had been cited as one of the challenges for the palm based biodiesel development in Malaysia (Lim and Teong, 2010), nonetheless, following the success penetration of biodiesel into the domestic fuel market, one can conclude that this first generation of palm based biodiesel is supported by current institutional framework and receive considerable acceptance by public.

On the other hand, there is limited knowledge about the social acceptance of the second generation bioethanol in Malaysia. Furthermore, although the first generation biofuel produced from edible oil is an initiative to mitigate greenhouse gases emitted from fossil fuel usage and strengthen energy security, there is

increasing concern about biofuel adverse impact on food supply and the environment. Using edible oil and converting agricultural land for energy purposes have been claimed to disrupt the food supply (Rajagopal *et al*., 2007), which will lead to increase in food prices (Naylor *et al*., 2007). Moreover, converting land use for planting energy crops can increase greenhouse gases emissions (Searchinger *et al*., 2008). Loss of the carbon sink is expected if deforestation is conducted to clear land for energy crop plantations (Fargione *et al*., 2008). Other ecological impacts associated with first generation biofuel include loss of biodiversity, loss of water catchment area and intense fertilizer usage (Mohr and Raman, 2013; Pimentel *et al*., 2009; Popp *et al*., 2014). To address these adverse impacts associated with the use of first generation biofuel, studies are focused on non-edible oil and lignocellulosic biomass, which consist of agricultural waste that is left behind after harvest. It is argued that using agricultural waste and lignocellulosic biomass can prevent direct competition between food and fuel production (Tilman *et al*., 2009; Valentine *et al*., 2012). Thus, mitigating food price increases and concern for land conversion. In term of energy utilisation, the second generation biofuel is more preferable than the first generation technology (Mizsey and Ray, 2010). Furthermore, a biorefinery concept using waste as feedstock for value-added products has been suggested as a sustainable strategy (e.g. Ali *et al*., 2015) in reducing negative environmental impact caused by agriculture wastes while reducing the production cost since biomass can be a relatively low cost feedstock (e.g. Zahari *et al*., 2015).

Based on the above, in term of the subject of the research, this study is focused on bioethanol rather than biofuel in general, and palm based bioethanol in specific rather than other feedstock or bioethanol in general.

1.5.2 Scope of Social Acceptance

As to the investigation of social acceptance, this study is referring to the triangular model of acceptance suggested by Wüstahagen *et al.* (2007). However, it is acknowledged that it is impossible to study each aspects suggested by Wüstahagen *et al.* (2007) in his triangular model of acceptance as some of the aspects are in

related to wind power for power generation which are in appropriate to be studied in the context of biofuel used as alternative transport fuel. In addition, it is also impossible to study all the social acceptance issues which had been highlighted in the problem statement due to time constraint and cost involved to conduct such a comprehensive study. Therefore, it is wise to narrow down the scope of study for each social acceptance dimension.

This study will focus on drawing the socio-political acceptance of biofuel in Malaysia context based on the socio-political acceptance criteria, namely, (i) strong institution capacity; (ii) clear and consistent regulatory framework; (iii) favourable financial procurement system; (iv) supportive spatial program; (v) promoting stakeholder involvement; and (vi) compliant to sustainable certification. An overview of Malaysia biofuel development will be conducted in order to provide input for the discussion of socio-political acceptance of biofuel based on the socio-political acceptance criteria.

In addition to socio-political acceptance, securing the supply of oil palm residue is a prerequisite for the success of bioethanol production, and this requires an understanding of oil palm planters' motivation to supply oil palm residue from their plantations. It has been suggested that the involvement of various actors (from feedstock producer to biofuel consumer) is essential to a successful bioenergy development (Pehlken *et al*., 2016). Being the biomass supplier, farmers' involvement in biomass supply chain is necessary to reduce biomass supply uncertainty, in particularly remote areas (Bot *et al*., 2015). Furthermore, as local residents, their participation in bioenergy system is also being claimed as an important social sustainability criterion for bioenergy system (Buchholz *et al*., 2009). Although project sitting can be receive considerable amount of local opposition, however, in Malaysia, the biofuel production facility is incorporated into existing palm oil refinery plant. By doing so, biofuel project is preventing from local opposition as show in the case of standalone and visible wind power facility. Therefore, the community acceptance of biofuel study in Malaysia will focus on the smallholder planters' involvement as feedstock supplier for biofuel production.

Lastly, for the market acceptance, the consumer preference toward fuel attribute will be examined. A list of five fuel attributes will be included in the conjoint study. These fuel attributes are (i) fuel product; (ii) fuel price; (iii) fuel mileage; (iv) fuel availability; and (v) vehicle acceleration. The conjoint study will disclose how consumer prefer each fuel attribute and which fuel attribute is being preferred most in consumer fuel choice. Such input can added value to biofuel promotional and marketing campaign as well as to inform policy maker and biofuel producer to ensure that the biofuel product is meeting the consumer preference. Table 1.1 illustrates the limit and scope of study for social acceptance in the context of biofuel.

Table 1.1 : Limit and scope of study of social acceptance in the context of biofuel

Dimension	**Study Aspect**	**Explanation**
Socio-political Acceptance	Institutional Support	Institutional support will be reviewed based on criteria of (i) strong institution capacity; (ii) clear and consistent regulatory framework; (iii) favourable financial procurement system; (iv) supportive spatial program; (v) promoting stakeholder involvement; and (vi) compliant to sustainable certification.
Community Acceptance	Smallholder Planters' Perception	Investigating smallholder planters' intention to supply oil palm residue for biofuel production.
Market Acceptance	Consumer preference	Investigation of consumer preference on a combination of fuel attributes of (i) fuel product; (ii) fuel price; (iii) fuel mileage; (iv) fuel availability; and (v) vehicle acceleration.

1.6 Study Contribution

The research will benefit to four important aspects as discussed below.

1.6.1 Knowledge and Academic

Unlike previous studies which focus on particular aspect of social acceptance, this study aims to disclose a clearer and more complete picture of social acceptance for biofuel by considering socio-political, community and market dimension. By doing so, it will demonstrates the linkage between three dimensions of social acceptance for one subject study, which is biofuel that had not being investigated. Moreover, It is noticed that majority of the study of social acceptance had been carried out intensively on issue related to wind power and focusing on the opinion from developed countries. By disclose social acceptance of biofuel among Malaysian, it will contribute to the existing academic in term of diverse opinion from developing country and issues of social acceptance related to different type of renewable energy technology.

In detail, the six socio-political acceptance criteria that being proposed for examining the socio-political acceptance of biofuel within the Malaysia context will enrich the exiting literature, especially work's by Wüstahagen *et al.* (2007) and Sovacool and Ratan (2012) that focused on power generation sector. In advanced to the work by Wüstahagen *et al.* (2007) and Sovacool and Ratan (2012), this study identify two important socio-political acceptance criteria that are unique and related to biofuel for transportation sector, which are the supportive spatial-dependent project and compliant to sustainable certification. By doing so, this piece of work extend the original socio-political acceptance criteria from the original work which is essential in understanding the socio-political acceptance within the biofuel context.

In term of the community acceptance, a review of the existing literature shows that the majority of studies focus on developed countries, with biomass predominantly derived from the forest (Rämö *et al*., 2009; Joshi and Mehmood,

2011; Gruchy *et al*., 2012; GC and Mehmood, 2012; Markowski-Lindsay *et al*., 2012; Becker *et al*., 2013; Brough *et al*., 2013; Joshi *et al*., 2013; Leitch *et al*., 2013; Aguilar *et al*., 2014; Halder *et al*., 2014; Timmons, 2014). In terms of agriculture crop waste, annual crops, like corn stover (Tyndall *et al*., 2011; Bergtold *et al*., 2014; Caldas *et al*., 2014; Mooney *et al*., 2014; Skevas *et al*., 2014) and cereal straw (Altman and Sanders, 2012; Glithero *et al*., 2013; Wilson *et al*., 2014; Altman *et al*., 2015), are examined. In contrast, limited studies have been conducted to investigate the farmers' motivation when planting perennial crops, such as oil palm. Therefore this piece of work is claimed to have closing this gap by providing input from farmer that cultivate perennial crop (in this study, the oil palm).

In addition, the community study is expected to enrich the existing literature with the successfully application of extended Theory of Planned Behaviour theory in predicting smallholder planters' intention to supply oil palm residue, from a developing country context. This study contributes in filling the existing theoretical gap by responding to the call of research to examine relationship between attitudinal belief and attitude (Ajzen, 1991) which is overlooked by the previous studies (Becker *et al*., 2013; Brough *et al*., 2013; Leitch *et al*., 2013). Furthermore, this study advances the understanding of the relationship between attitudinal belief and other TPB core constructs by confirming that attitudinal belief will influence subjective norm, perceived behavioural control and finally, intention of smallholder planters to supply oil palm residue. The use of partial least square structural equation modelling is an important strength of this study that not only extend the application of this holistic technique in predicting the smallholder planters' intention to supply oil palm residue but also to enable researcher to draw a comprehensive causal model from the analysis. The interrelationships examined using this analysis technique provide insight understanding about relationship between attitudinal belief constructs and the TPB core constructs. This is an important contribution as this study demonstrates not only how smallholder planters' intention is influenced by attitude, subjective norm and perceived behavioural control but also to explain how attitudinal belief will infuence these TPB core constructs. Theoretically, it is important because it allows the researcher to understand clearly why the smallholder planters are involved in the bioenergy development as a feedstock supplier and it provides useful information for

the policy makers and biofuel producers to engage the smallholder planters to supply their residue.

As to market acceptance, the conjoint study provide input of consumer preference of fuel attribute when making their fuel purchase decision. In advance to previous studies (Fimereli and Mourato, 2009; Giraldo *et al*., 2010; Jensen *et al*., 2010; Farrow *et al*., 2011; Gracia *et al*., 2011; Jensen *et al*., 2012; Marra *et al*., 2012; Kallas and Gil, 2015), this study reveal the differences of preferred fuel attributes between car drivers and motorcyclists. In detail, this conjoint study revealed how the fuel attributes importance differ across respondent's background and fuel consumption pattern by car drivers and motorcyclists, respectively. This is expected to enrich existing studies that provide only a general model in explaining consumer preference in fuel choice, thus, closing the gap of understanding heterogeneity preference of consumers in their fuel choice.

1.6.2 Government Agencies and Policy Makers

Understanding the social acceptance issue of biofuel from the socio-political perspective, community perspective and market perspective can help the Malaysian government to formulate wise strategy which able to tackle specific factors that concerned by the respective societal group and will eventually contribute to increase usage of biofuel. It is expected that the results obtained at the end of this study will aid policy maker in formulating a more comprehensive renewable energy policy in promoting bioethanol as the alternative energy resources to the automobile industry as well as moving forward to a higher blended biodiesel product.

1.6.3 Industry Players

For industry players, they will be more alert toward securing their feedstock for bioethanol production as well as delivering bioethanol product that will satisfy consumer. With the survey on community acceptance, the determinants in fostering the smallholder planter's interest to supply oil palm residue for biofuel production can be identified. Based on the findings of the study, industry players can engage early to the local community with an effective promotional strategy for a better solution and collaboration in securing the feedstock for bioethanol production. On the other hand, the conjoint study in market acceptance will disclose consumers' preference towards fuel attribute in their fuel choice. This in turn will benefit industry player to provide biofuel that able to satisfy customer needs and to formulate effective biofuel promotional and marketing strategy to foster the acceptance of biofuel as alternative fuel for consumer vehicle. These will result in the ease of market penetration of bioethanol product and eventually will lead to better acceptance of higher blended biofuel in future.

1.7 Research Process

The research methodology for this study is designed to achieve the research objectives, in accordingly to the research questions. Since the social acceptance of biofuel will be examined in term of socio-political acceptance, community acceptance and market acceptance, there will be three distinct parts of research procedures that being followed by researcher. The detail discussion of each research procedure in respect to the social acceptance dimension will be presented in Chapter 3. A research flow chart is prepared and shown in Figure 1.2 for a better understanding on tasks that needed to be carried out in order to achieve the respective study objectives. The research flow chart will be discussed accordingly to the stages of the research flowchart in the following subsection.

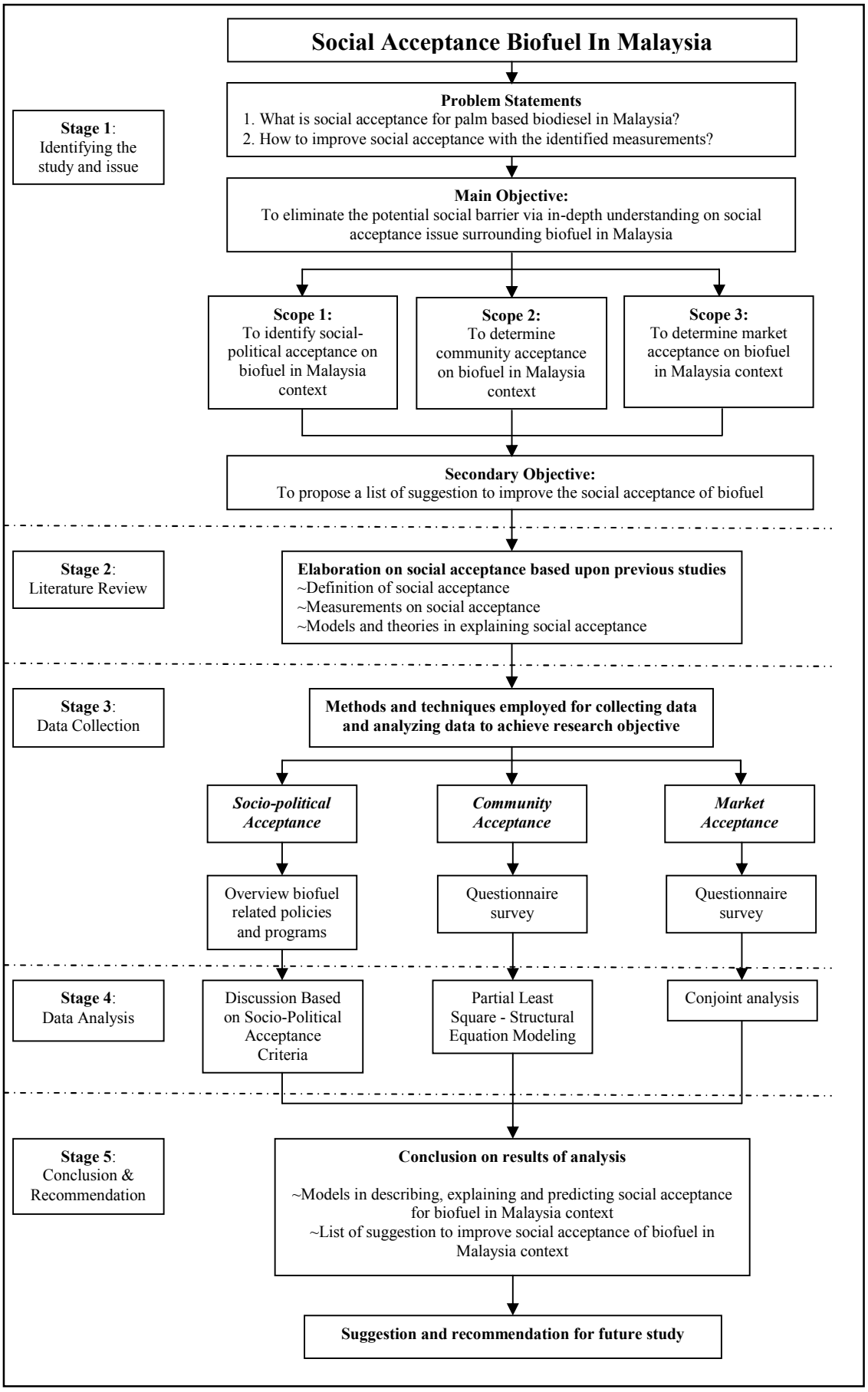

Figure 1.2 : Research flow chart for the study of social acceptance of biofuel

1.7.1 Stage 1: Identifying the Study and Issue

The first stage in any research is to identify a study as well as issue arises within the study. This stage is crucial as it will be the guideline for the research process until archiving the study's objective. Hence, in this stage, reading on previous research and related information from reliable sources with focusing on social acceptance of renewable energy, in specific biofuel, is vital as to give a brief idea on this study. Beside academic literatures and reports, government statements and news reported will be essential for identification of study issue related to social acceptance of biofuel in Malaysia. Furthermore, the objective for the study will be determined, as well as the scope for the study.

1.7.2 Stage 2: Literature Review

Literature review is the stage where main focus will be in reviewing the previous researches which are similar to the study. This is a theoretical part for the whole process. It serves as the backbone to support the whole study. Scholarly review will be conducted to examine the overall concept of social acceptance of biofuel through three dimensions, viz. social-political, community and market. Later, the literature search is extended to reveal elements for each dimension. The rationale is to provide a comprehensive review on existing knowledge related to social acceptance of biofuel. Elements identified in this stage will serve as the fundamental in questionnaire designation for the study of community acceptance and market acceptance. Besides that, the literature review will be used to determine the suitable research methodology for the study of community acceptance and market acceptance from previous researches. This is to minimize the inaccuracy of own design methodology which is not tested by other researches. As for socio-political acceptance, the list of socio-political acceptance criteria will be identified via literature review. This list of socio-political criteria will be used for later discussion of socio-political acceptance in Malaysia.

1.7.3 Stage 3: Data Collection

In the stage 3, data are collected based on the three dimensions of social acceptance. The relevant instrument to collect data will be designed and tested prior to the actual data collection. On top of that, the sample size, sampling strategy, targeted respondent will be identified.

1.7.3.1 Social-political Acceptance

The description of the social-political acceptance of biofuel in Malaysia is based on an overview conducted to reveal the biofuel development in Malaysia since the year 1982. Researcher validates and substantiates the findings by referred to existing government policies, incentives, statements and reports in relation to biofuel development in Malaysia.

1.7.3.2 Community Acceptance

The smallholder oil palm planters are the targeted respondents for the community acceptance. Their intention to supply oil palm residue for biofuel production will be examined with Theory of Planned Behaviour as the theoretical framework. The data was collected at the fresh fruit bunches collection centre in which it is the place where smallholder planters will send their harvest.

1.7.3.3 Market Acceptance

Input for market acceptance will be collected through a conjoint based survey among consumers. It is to reveals the consumer preference on the fuel attributes (fuel product, fuel price, fuel mileage, fuel availability and vehicle acceleration) in their fuel choice. The data was collected at petrol station in which this allow researcher to observe the type of vehicle driven by respondents as well as the fuel product purchased by respondents. Such information will be used for later segmentation analysis.

1.7.4 Stage 4: Data Analysis

Having collecting the data, each group of data will be analyzed according to their dimensions and a discussion will be conducted for each of the dimension.

1.7.4.1 Social-political Acceptance

Data collected via government policies, incentives, statements and reports will be compiled into sections to provide an overview of biofuel development in Malaysia, alongside with the institutional structure, supportive policies and programs. A discussion of socio-political acceptance will be drawn based on the identified socio-political acceptance criteria, which are (i) strong institution capacity; (ii) clear and consistent regulatory framework; (iii) favourable financial procurement system; (iv) supportive spatial program; (v) promoting stakeholder involvement; and (vi) compliant to sustainable certification.

1.7.4.2 Community Acceptance

Data collected from the smallholder planters via questionnaire survey will be analyzed using SmartPLS software. The validity and reliability of the measurement model and structural model will be disclosed before the examination of the structural relationship between variables. The results will able to reveal community acceptance of biofuel by answering which are the key determinants for smallholder planters in supplying oil palm residue.

1.7.4.3 Market Acceptance

Data gathered from market survey will be submitted for conjoint analysis. Conjoint analysis is a multivariate analysis technique used to measure the complex value systems that underlie the preferences consumers have for various product attributes when they make purchase decisions. It is to indirectly determine the importance that decision makers place on various aspects of the products or services they are considering, in this case, biofuel The analysis will help the stakeholders to understand how fuel attribute influence consumer fuel choice and which is the most

preferred fuel attribute by consumer. The data analysis will be conducted via Sawtooth Software's SSI Web platform.

1.7.5 Stage 5: Conclusion and Suggestion

A list of suggestion will be provided based on the findings from the previous stage. Subsequently, the result from the previous stage will be summarized with recommendation for future study. The limitation of this study will also be pointed out as reference for future study.

1.8 Outline of the Chapters

This thesis is organised and presented in eight chapters.

Chapter One is the introduction chapter for this thesis to provide an overview of the research conducted to examine the social acceptance of biofuel in Malaysia context. This first chapter consists of the background of the study, problem statement, research objective, research scope, significance of study, a brief explanation on research methodology and chapter layout.

Chapter Two will provide a comprehensive review on literatures related to social acceptance of renewable energy. There are three main discussions in this chapter which include (i) defining social acceptance, social-political acceptance, community acceptance, and market acceptance based on the proposed social acceptance framework for biofuel; (ii) theories and frameworks referred from previous studies, in specific to the respective social acceptance dimension; and (iii) a list of social acceptance indicators for each dimension of acceptance.

Chapter Three will provide a deeper explanation of methodology employed in this study. Data collection and data analysis method are the main discussion that fill

up this chapter. The data collection methods will include the background of the study area, identification of respondent, and the instrument for data collection for this study. The data analysis method will cover the elaboration on structural equation modelling and conjoint analysis in achieving the objectives of this study.

Chapter Four will present an overview of related institutional support in Malaysian biofuel development. Related policy and program will be presented and a discussion will focus on (i) strong institution capacity; (ii) clear and consistent regulatory framework; (iii) favourable financial procurement system; (iv) supportive spatial program; (v) promoting stakeholder involvement; and (vi) compliant to sustainable certification.

Chapter Five has a focus on community acceptance in which the smallholder planters' intention to supply oil palm residue will be examined via the partial least square-structural equation modelling. Discussion will be based on an extended Theory of Planned Behaviour to reveal planters motivation in supplying oil palm residue for biofuel production.

A discussion of consumer profile will be presented in Chapter Six. In brief, this chapter will present the result and finding from choice-based conjoint analysis and provide a discussion in related to consumer preference on fuel attribute in general before a detail discussion of the difference in consumer preference toward fuel attribute across .

Having presenting the findings and discussion of each respective social acceptance dimension, the Chapter Seven will provide a list of suggestion that aimed to enhance the social acceptance of biofuel in Malaysia based on the findings for the respective dimension of social acceptance.

Finally, Chapter Eight conclude the main findings, acknowledge the limitation of the study and provide recommendation for future study.

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