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Tandatangan :…………………………..

Nama Penyelia Utama : Dr. Chew Boon Cheong

Tarikh : 23rd June 2014

RENEWABLE ENERGY ADOPTION AS ENERGY EFFICIENCY: A CASE STUDY OF BIOMASS CONVERSION TO BIOFUELS IN PETRONAS MALAYSIA

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Laporan ini dikemukakan sebagai nenebuhi sebahagian daripada syarat penganugerahan Ijazah Sarjana Muda Pengurusan Teknologi (Inovasi Teknologi)

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Abstract

Technology adoption is in absorbing state as we are rarely observing a new technology being abandoned in a favor of old one (Hall and Khan, 2002). It is claimed that it will contribute to the economic development of a country and can act as a toll for competitive advantage to sustain with the development of an economy. However, Schumpeterian argue that the uncertainty about the benefits of a new technology slowing down the speed of diffusion for a larger size and strong market power due to multiple bureaucracy. Moreover, it is more expensive for a larger an older firm to adopt new technology because they have many resources and human capital (H. Rebecca and C. Kim, 1990). Besides, it is expensive to convert entire network to new technology. This dissertation is exploring in how technology adoption in biomass conversion to biofuel in Petronas, Malaysia. Biomass is uncommon in Malaysia. Therefore, it is required for researcher to consider the factors of biomass technology to be adopted in Petronas, Malaysia, the strategies that Petronas will proposed, and the innovative solution for the technology adoption to be occurred. The methodology used in this study is qualitative method. Questionnaires were distributed among 30 respondents which include Petronas' staff, University Technology Petronas' students, and residents in Tronoh. Petronas was chosen because this company had approached to green and sustainability in order to reduce the emission of Green House Gases (GHG). The finding of the study shows that the technology adoption for biomass is helpful to enhance the energy efficiency in Petronas, Malaysia.

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Chapter 1

Introduction

1.1 Introduction

Nowadays, the world‘s demand shows an increment for energy supplies and is predicted with an annual rate of 1.8% as countries develop (Alan, 2009). It is also estimated that an increment of 1% of world‘s population will add up to the emission of carbon dioxide gas (Scragg, 2009). Energy resource plays a major role to sustain our daily lives. As for usual, energy provide motive power and electricity. It enables industrial processes, food production, and clean water supply, sanitation in urban areas, transportation, and comfort in building and also for commercial activity. We are greatly depends on fossil fuels as our resource to get intense of energy for our domestic purpose. Due to this phenomenon, we are now striking our best way to find other source of energy which is efficient to be use in our daily lives. Some of the criteria of future energy resource should be less emission of Carbon Dioxide (CO2) and is renewable energy (Hugh, 2008).

The next step to be taken is to use biomass as the source of energy to manage our energy resource better. Even biomass conversion to biofuels technology or practices is uncommon in Malaysia, this kind of energy resource is suitable to implement in Malaysia has a strategic land to grow biomass plant. Biomass is biological material derived from living, or recently living organism. In the context of biomass for energy this often mean to use plant based material but biomass can equally apply to both animal and vegetable derived material (BIOMASS Energy Centre (BEC), 2011). Whereas, biofuels are liquid fuels which is derive from other materials such as waste plant and animal matter. There are two main types of biofuels – bioethanol and biodiesel (Biofuels Association of Australia, 2013)

According to Hugh (2008), Gross Domestic Profit correlates almost exactly with energy consumption in Malaysia. The high energy consumption in Malaysia is not only due to movement of goods by transport but also from the private motor car in the year 2000 has consumed twice the average of world gasoline consumption in liters per person. The energy consumption for food production is cover 2% and 17% cover for retail outlet, fertilizer, insecticide, pesticide, packaging and refrigeration (Hugh, 2008).

Biomass as energy resource has its potential to reduce some common effect of inefficient management of energy. Nowadays, we can observe that global warming has increase due to the emission Carbon Dioxide (CO2) gas to the atmosphere. Depletion of fossil fuels had become an influence for us to find a new source of energy. Besides, carbon dioxide gas that is emits by vehicle has become issue to the environmental problem. In the other hand, our Carbon Footprint also has become the factor that contributes to the global warming. At the same time, this global warming will endangered the ecosystem.

However, to ensure that we can manage the resource of fuels efficiently with no harmful effect to the environment, we first have to adopt the technology for biomass conversion to biofuels in Malaysia. This research is emphasizes in how Malaysia will adopt this technology in order to use biofuels as energy efficient in this country. There are some groups of adopters need to be study based on the TEMIF factors and the S-Curve Adopters to measure the technology adoption in Malaysia.

There are also some challenges in adopting the technology like the period of time, cost and expertise. This research will also help to find an innovative solution in order to create a more sustainable and efficient source of energy to our Earth.

1.2 Problem Definition

Due to the estimate depletion of fuel resource, this research has come out with some research questions in order to have a clear understanding regarding the content and effectiveness of the research. The factors of how the technology adoption of biomass conversion to biofuels in Malaysia is important to be known. By words, adoption means the decision of customers to purchase a new product or service (Scott, 2009). While technology is the application of scientific knowledge for practical purposes especially in industries (Oxford University Press, 2013). There are some groups of adopters which are including Innovators, Early Adopters, Late

Majority, and Laggards. The economic literature in diffusion of technology has debate the role of market structure and diffusion. Other factors include the size of firms, and availability of resources need in the investment of the technology. The third factors can be the potential risk associated with the use, development and marketing of technology. The fourth argument is that many new technologies are scale-enhancing, and therefore larger firms adopt them sooner because they capture economies of scale from production via the learning curve more quickly and can spread the other fixed costs associated with adoption across a larger number of units (S. Joseph, 1962). Uncertainty about the benefits of the new technology has become the factors that slowing down diffusion progress. Furthermore, the multiple level of the bureaucracy in large firms has impedes decision progress. Besides, it is more expensive in larger or older firm to adopt technology because there are many resources and human capital sunk in the technology. We also need to identify an innovative solution due to this issue in order to implement the technology efficiently.

The research question can be list as follows:

1) What are the factors of technology adoption for biomass conversion to biofuels in PETRONAS Malaysia?
2) What are the strategies of PETRONAS Malaysia in order to support the adoption of technology for biomass conversion to biofuels in Malaysia?
3) What are the innovative solutions in order to speed up the rate of technology adoption of biomass conversion to biofuels in PETRONAS, Malaysia?

1.3 Research Objective

This research consist several objectives. The objectives are shown as follows:

1) To identify the factors that encourages technology adoption for biomass conversion to biofuels in PETRONAS, Malaysia.

2) To identify strategies to adopt the technology for biomass conversion to biofuels in PETRONAS Malaysia.
3) To identify the innovative solution to enhance the efficiency of biomass conversion to biofuels in PETRONAS Malaysia.
4)

1.4 Scope

The scope of this research is to study the technology adoption for biomass conversion to biofuels for energy efficiency in PETRONAS Malaysia. Besides, this research will study how PETRONAS will use their strategies to maximize the usage technology for biomass conversion to biofuels. The research is conducted in Petronas Refinery Sungai Udang, Melaka in order to obtain an accurate and diversify information of the latest trend of biomass and its technology in Malaysia and Universiti Teknologi PETRONAS (UTP). PETRONAS was chosen as the most suitable organization to implement biomass technology because this organization is now moving on to a strategy of sustaining the green environment in Malaysia. Besides its own research in Biomass Laboratory located in Universiti Teknologi PETRONAS in Tronoh, Perak, PETRONAS also collaborate with Lanza Tech to further their initiatives in finding the solution of how to reduce the emission of Carbon Dioxide (CO^2) to the environment. As biomass conversion play the desired outcomes as well as PETRONAS objective to become ‗green', this organization is also suitable to adopt new technology especially biomass technology.

1.5 Limitation

Two limitations are identified in this research. First of all, the case study is to investigate what are the factors of technology adoption for energy efficiency in PETRONAS, Malaysia. If the external validity needs to be attained, the outcomes could also be generalized and used at oil and gas companies. Therefore, the outcomes of the study are only applicable for PETRONAS, Malaysia. Secondly, researcher assumed that all respondents have provided honest and correct answer.

1.6 Summary

The implementation of biomass technology in PETRONAS, Malaysia is still needing further detail study. The rate of technology adoption for biomass still slow in Malaysia. Therefore, we need to seek more expert opinions regarding this theory in order to sustain the development of the technology in Malaysia. The method that usually used for this kind of case is the Delphi Method. A new strategy like analytical method or new policy need to be develop in order to ease the penetration of new technology to this country. Besides, government should play their role not only as the regulator of biomass policy but also need to be involved in term of funding that proactively participate to develop biomass as energy efficiency. The case study in PETRONAS is focused in how the technology adoption helps to enhance the energy efficiency in Malaysia by using biomass as the resource. This kind of renewable energy is seemed very suitable to be implement in Malaysia as Malaysia has the suitable climate, capital labor and many developing industries that try to penetrate the adoption of technology especially in energy efficiency sector. The technology adoption for biomass still needs to be study with care and details and with perfect closure of awareness in how to implement this technology in this country.

Chapter 2

Literature Review

2.1 Introduction

In this chapter, researcher will discuss about the definition of biomass and biofuels. Besides, researcher will also mentioned about the factors that encourage the biomass technology adoption. Then, the strategies to implement biomass technology adoption in an country or organization is also discuss in this chapter.

2.2 Definition of Biomass

Biomass is organic material that can be converted directly to burnable fuel which later becomes biofuel. Biomass sources can become from various sources like agricultural crops and residue, sewage, municipal solid waste, animal rescue, and industrial residue. Biomass also has some potential in acting as energy efficiency to replace the usage of fossil fuels. It has been estimated that biomass contributes to 39.7 – 45EJ/year to the global energy supply (9-15%) from a total 425 EJ (Parikka, 2004; Faaij, 2006). The potential global biomass energy contained in various biomass types. The great variation appears to be in the estimate of the biomass grown on surplus or marginal land (Hoogwijk et al., 2003). Marginal lands are those with little economic value but before this can be use the environmental impacts need to be determined. The marginal lad may be a specific wildlife habitat such as a wetland or forest. The diagram below shows some of biomass sources:

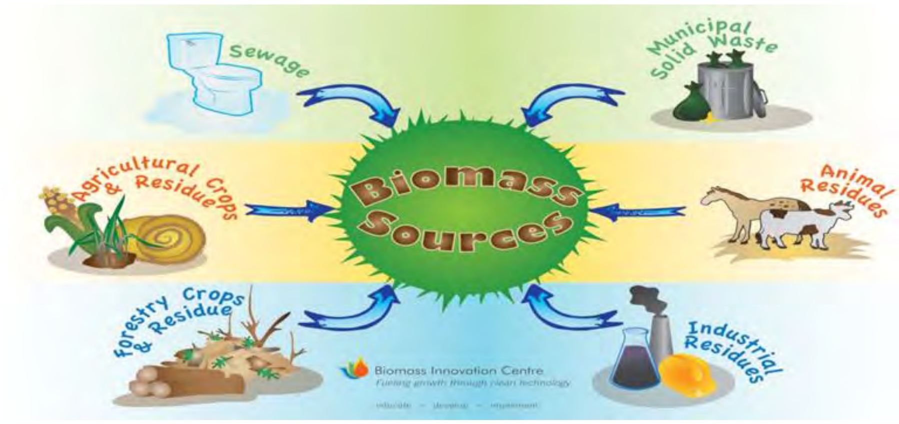

Diagram 1: Biomass Sources

Source: Biomass Innovation Centre (2013)

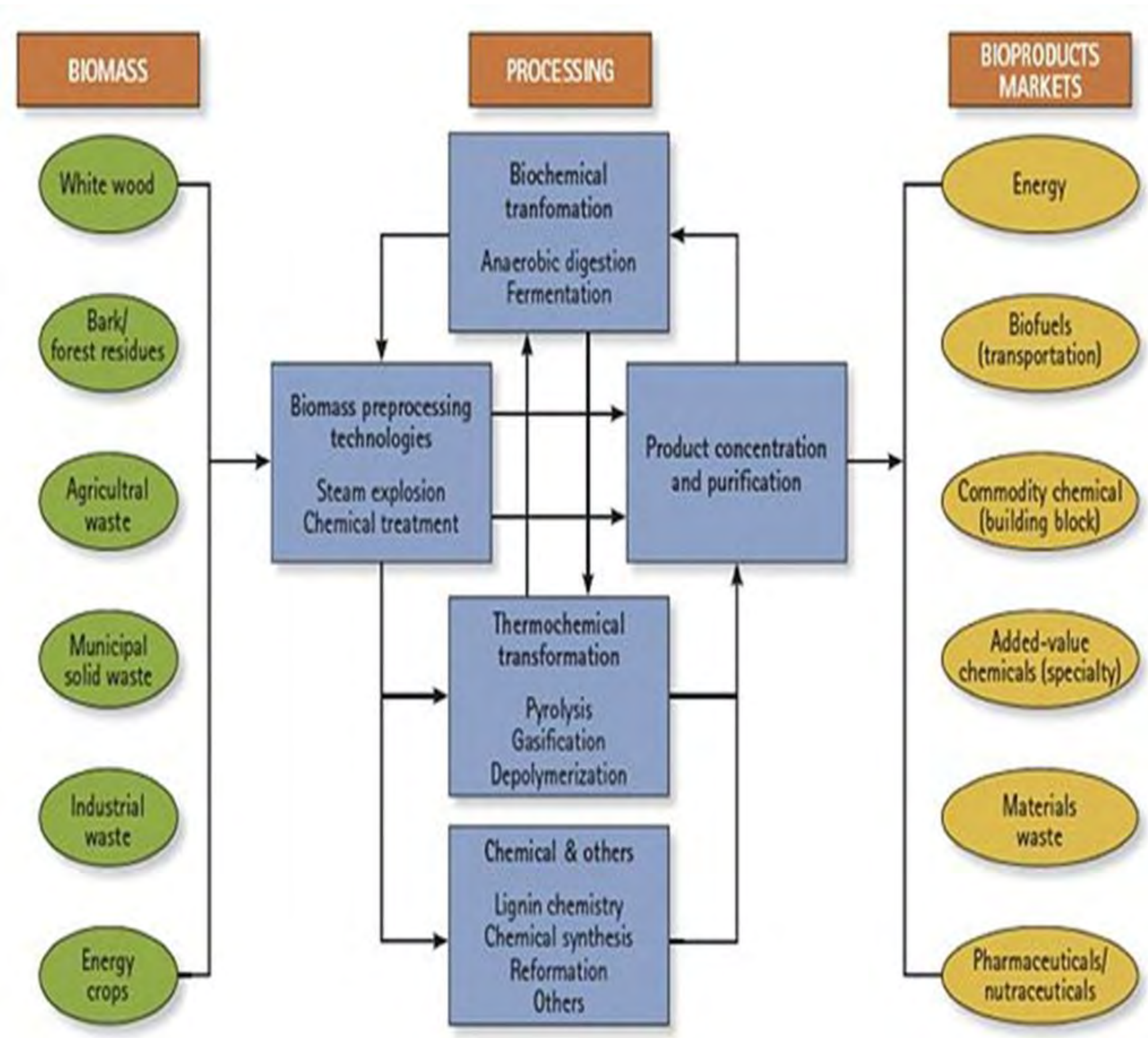

Diagram 2: Woody Biomass Properties

Source: eXtension, (2013)

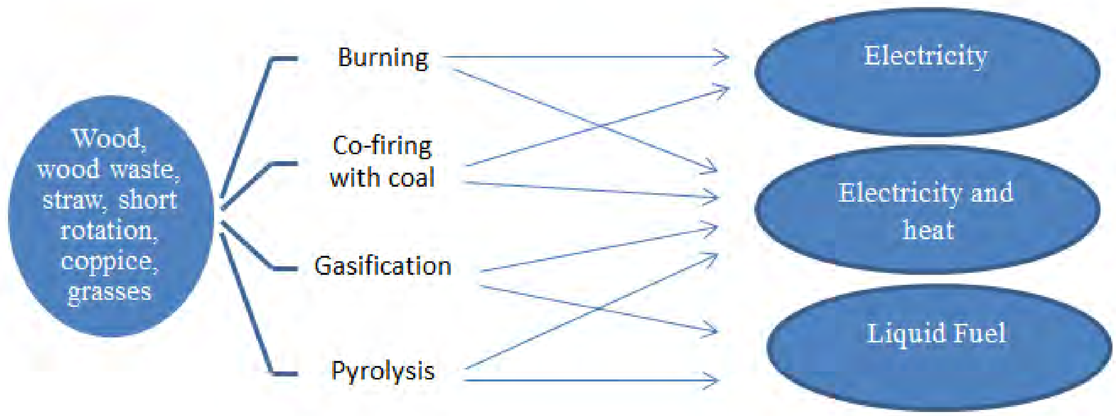

Diagram 3: Process of Biomass Conversion

Source: Alan (2009)

2.3 Definition of biofuels

Gas and diesel are actually ancient biorender. But they are known as fossil stirs because they are made from decomposed stock and animals that have been buried in the ground for millions of years. Biofuels are interchangeable, except that they\'re made from plants grown twenty-four hours. Much of the gasoline in the United United States Department of State is blended with a biofuel—ethanol. This is the same stuff as in soaker salute, except that it\'s made from corn that has been intemperately processed. There are various ways of making biofuels, but they generally use material thought, fermentation, and physiological state to modify down the starches, sugars, and other building block in plants. The leftover mathematical product are then neat to produce a fuel that cars can use.

Countries around the part are using various kinds of bioshake. For decades, Brazil has turned graminaceous plant into alcohol, and some cars there can hurry on virginal ethanol rather than as add-on to fossil fuels. And biodiesel—a diesel-like fuel commonly made from palm tree vegetable oil s generally available in EU. On the face of it, biofuels look like a great method. Compartments are a subject field root of atmospheric carbon, paper oxide, the main nursery gas that causes globular warming. But since plants absorb carbon oxide as they produce, crops grown for biofuels should suck up about as much carbon dioxide as comes out of the tailpipes of cars that hurt these fuels. And different underground oil reserves, biofuels are a renewable resource since we can always grow more crops to turn into fuel.

Unfortunately, it's not so simple. The knowledge of organic touch the crops, making plant food and chemical substance, and processing the embedded into fuel consumes a Jew of Energy Department. It's so much push that there is debate about whether ethanol from drippiness actually provides more good health than is needed to grow and process it. Also, because much of the energy used in production comes from ember and natural overstate, biofuels don\'t put as much oil as they use. For the future, many think a better way of making biofuels will be from grasses and saplings, which contain more polyose. Polysaccharide is the tough material that perpetrate up plants' cellwalls, and most of the weight of a plant is polysaccharide. If polysaccharide can be turned into biofuel, it could be more effective than current biofuels, and let loose less carbon oxide (National Geographic, 2013).

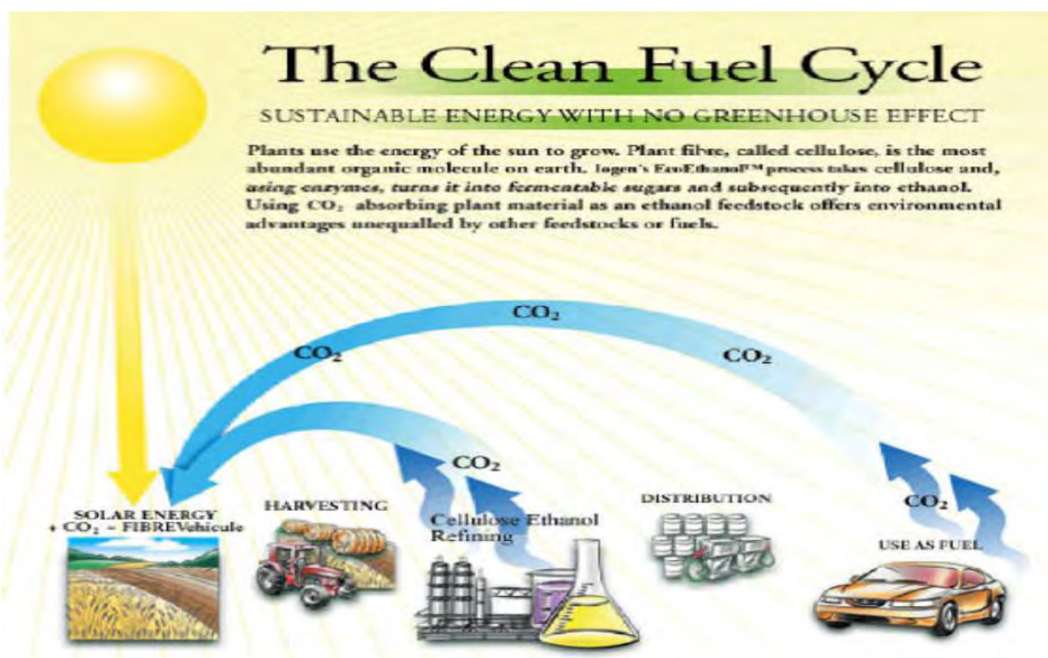

Diagram 4: The fuels cycle of Biofuels

Source: Hisham and Eid, (2008)

The two major outcomes of Biofuels are bioethanol and biodiesel. However, through a recent study, it is acknowledge that butanol was addressed as the more promising product to substitute fossil fuels. The energy content per liter of biofuels rather than petrofuel can be extracted as follows (Allan, 2009):

Fuel	MJ/L	BTU/L	Liter gasoline Equivalent
Petro-gasoline	32	30336	1.00
Bioethanol	19.6	18581	0.61
Biobutanol	29.2	27682	0.91
Petro-diesel	40.3	38204	1.25
Biodeisel	33.3	31568	1.04

Table 1: Energy content in different biofuels compared to Gasoline

Source: Alan (2009)

In the other hand, the nature of biofuels can be classified accordingly based on First-, Second-, and Third-generation of Biofuels. The first generation of biofuels is represented by biomass, biogas, biodiesel and ethanol. They are produce form energy crops such as sugarcane, maize, soybean, and sunflower. The Second Generation of Biomass is produced from lignocellulose biomass and waste which has better yield. The Third Generation of Biomass is produced through direct production of hydrogen and extraction of oil for biodiesel from microalgae (Alan, 2009).

The properties of Ethanol are similar to petrol in many aspects. The characteristic of petrol, bioethanol and butanol can be summarized as follows:

Characteristic	Petrol	Ethanol	Butanol
Boiling point (℃)	35 – 200	78	116 – 119

Density (kg/L)	0.74	0.79	0.81
Energy (MJ/kg)	44.0	27.2	40.5
Latent Heat of Vaporization (MJ/kg)	293	855	-
Flash Point (℃)	13	45	37
Octane Number	90-100	99	45

Table 2: The characteristic of petrol, bioethanol and butanol

Source: Alan (2009)

2.4 Factors that encourage the Adoption of Biomass Technology (TEMIF)

2.4.1 Technical factors

Cite for renewable fuels is ontogenesis rapidly, and by 2020 the global socio-economic class for biodiesel is projected to be about 35 million t/a. Demand for renewable fuels is spurred by mandated usage levels and new governing under development in the field worldwide. Targets set for mandated bio-content let in: The new International organization dictum on renewable energy, which has set a target of 10% to be achieved by 2020, National governance in Finland, which has victim 20% content by 2020, and Legislation in the US, which will enjoin 20% content by 2022. In 2012, the European Commissioning proposed a branch of knowledge change to the EU‘s biofuel legislation. This defined splitting the existing 10% mandated biofuel content established for 2020 into two division, with biofuels produced from food work modified to 5% of total traffic fuel activity in 2020, and the remainder to be met by biofuels produced from cast aside, matter, and all new types of raw applier (Neste Oil, 2013).

In constituent to mandated activity levels set for biotake up, also global economic developments and the growth in the necessitate for petroleum products also play a part in shaping biofuel demand, as mandated usage levels are based on the overall consumption of touring traffic fuels in many countries. Activity for renewable fuels has full-grown steadily in late years as a result of rising bio-mandated content levels and thriving demand for dodo diesel. Global biodiesel demand in 2012 totaled 21.eight large indefinite quantity tons (21 million tons) (Neste Oil, 2013).

Competition is likely to increase significantly over the next few years, as the sales outlet prefers bounty-grade biofuels of the taxonomic group represented by Neste Oil's NExBTL renewable internal-combustion engine. Grade-property ‗drop-in' biofuels do not require grammatical relation to existing vehicle engines or existing distribution and logistics systems. Premium-degree renewable diesel is also not limited by the 7% compounding limit imposed on conventional biodiesel. Over one figure trillion t/a of new premium-sound property renewable diesel capacity is projected as likely to come on flow by 2015. This increased competition commute an opportunity for Neste Oil, as it will reinforce the benefits offered by premium-quality renewable diesel in the eyes of both customers and legislators (Neste Oil, 2013).

New technology presents risk for some users. They react differently toward this risk based on their innate characteristics, the wants and needs of their companies, and the behavior of other buyers. The Technology Adoption Life Cycle (TALC) models show different groups of customers adapt to discontinuous innovation at different times. This model helps high-tech marketers build the best strategy for each phase of a product's life. The diagram below shows the markets that develop along the TALC and the types of customers that dominate them.

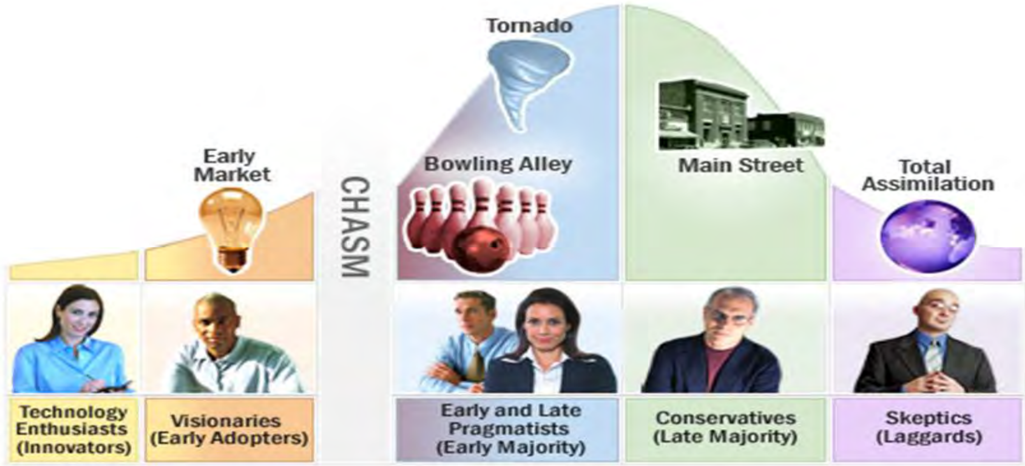

Diagram 5: Technology Adoption Life Cycle

Source: Chasm Institute (2013)

The Early Market- the Early Market is the phase in which a discontinuous innovation can grow from merely a technology with promise to a novel new product idea. Users at this point recognize that the technology is new and unproven but it has the potential for a breakthrough. The Early Market consists of two kinds of consumers (Chasm Institute, 2013):

1. *Technology enthusiasts* (techies) can be found in most every organization. They are always looking for state-of-the-art technology, but they typically don't have the money to fund further development. *Techies* provide a good test ground for a new technology. They are also gatekeepers to the rest of the TALC. Impress the technology enthusiasts, can result to get the attention of visionaries. If the techies are unimpressed, visionaries will look to another way of gaining competitive advantage (Chasm Institute, 2013).

2. *Visionaries* are industry revolutionaries looking for a breakthrough application that will give them a competitive business advantage. They see discontinuous innovations for the potential advantage

offered, especially if the technology can give them a clear edge over the competition. The challenge is that they may want to modify the innovation to address their specific issue, without regard to what the market wants or needs. Their importance lies in their ability to fund development as well as publicize it within an industry (Chasm Institute, 2013).

The Chasm- the Chasm represents a gap between the Early Market and the next phase which is the Bowling Alley. It develops when there are few if any remaining visionaries to sell to but pragmatists are not yet ready to adopt. Pragmatists do not see a complete solution to their problem. In addition, there is no group of references that have formed that they trust. In addition, they want to see the solution working live at customer sites. Revenue growth ceases or even recedes in the Chasm. The length of this market lull is uncertain (Chasm Institute, 2013).

The Bowling Alley- Market momentum picks back up in the Bowling Alley phase, as early pragmatists in certain customer segments to overcome their reluctance toward discontinuity and adopt the new technology to solve niche-specific problems. Pragmatists are reluctant to adopt new technology and prefer to follow the herd. Early pragmatists are forced out of their comfort zone to find solutions for broken, mission-critical business processes. The Bowling Alley phase takes its name from the market strategy that is appropriate. The key to success is to provide a complete solution for one segment while identifying closely aligned segments that could benefit from a similar solution. When the momentum from successfully capturing market share in the first segment (the lead bowling pin) is felt, this momentum is leveraged into adjacent segments. By dominating several segments, your company may start to emerge as a sector leader (Chasm Institute, 2013).

The Tornado- as the Bowling Alley phase further develops, a mass market sometimes emerges where the product is swept into a Tornado of demand. Up to this point, late pragmatists have delayed their adoption, waiting for the technology to gain a strong record of accomplishment and enough references from people they trust. In the Tornado, these pragmatists finally shift en masse to the new infrastructure, and they tend to go with the market leader.Only one company will emerge as the market leader around which the standard will be constructed. An influx of new customers creates a huge sales opportunity, and demand outpaces supply. One key to success in the Tornado is to expand the sales channel as fast as possible in order to capture market share at the expense of the competition (Chasm Institute, 2013).

Main Street- Once the new product and infrastructure are in place throughout the market, the Tornado gives way to the Main Street phase. The mass market stabilizes, and the standard product begins to experience a price decline. In this market, some conservative end users look for value-added extensions (+1 offers) that deliver additional benefit.Conservatives don't see value in technology just for technology's sake. They tend to stay out of the market as long as they can, finally making the leap because they fear being left behind. Conservatives are sensitive to price and demanding of value. The key to Main Street success is to offer the add-on products that can command a price premium from conservative customers (Chasm Institute, 2013).

Total Assimilation- Total Assimilation marks the end of the TALC. In many cases additional services will extend the life of aging legacy systems. In this phase, even skeptics will unconsciously or begrudgingly accept the technology, possibly obtained as a service or designed into an end product in which skeptics never see the technology. Skeptics are defenders of the status quo and want solutions that have no risk (Chasm Institute, 2013).

2.4.2 Environmental factor

PESTLE analysis is use to solve the problem. The element E (environment) was chosen based on the current situation of biomass. Tree biomass plantations can replace annual crops, heavily grazed pastures, or degraded lands can bring benefit to environment. First of all, it improves water