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TECHNO-ECONOMIC FEASIBILTY OF BIODIESEL IN MALAYSIA

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ABSTRACT

Utilizing biodiesel from non—edible resources replacing diesel in power generation sector would reduce significant amount of carbon footprint. Biodiesel has lower carbon monoxide (CO) and carbon dioxide (CO_2) providing large environmental benefits. This paper aims to study economic feasibility of applying Callophyllum Innophyllum (CI) biodiesel in power generation sector replacing diesel by varying economic factors. Although CI has advantages in technical aspects high production cost due to limited supply still is a disadvantage to CI biodiesel commercialization. A techno-economic assessment for biodiesel production is studied from feedstock acquisition till biodiesel consumption by analyzing its payback period and internal rate of return (IRR). The result shows that CI biodiesel is a feasible option considering influence of selling price, tax incentives as well glycerol selling price.

Keywords: renewable energy resources, techno-economic feasibility, non-edible biodiesel, biodiesel for power generation

NONMENCLATURE

Abbreviations

CI	Callophyllum Innophyllum
IRR	Internal rate of return
CO_2	Carbon dioxide

1. INTRODUCTION

Energy is the key for development and wellbeing of a country. The demand for energy increases as a nation is developing in line with population growth, expansion of industrial and commercial sectors. In Malaysia, need of energy has constantly increase as the country is striving to achieve further economic development. Despite considerable external and domestic factors Malaysian economy managed to record a growth of 4.2% in 2016 beating the odds of the subdued global demand and low commodity prices[1]. This has resulted in, increment in usage of fossil fuels which led to steady declining of local indigenous resources.

As a country with own fossil fuel deposition, Malaysia is heavily dependent on conventional fossil fuel to generate energy for the nation specifically in terms of electricity generation, 91% in 2014[1]. According to a study, oil reserves in Malaysia are predicted to last only for another 30 years whilst natural gas for 40 years [2]. Besides, Malaysia is the largest carbon dioxide (CO_2) producer after Thailand and Indonesia. As for 2011, around 54.8% CO_2 emission is from power sector alone in Malaysia. This number is assumed to increase triple fold by 2030 as country is still strongly focused on utilizing natural gas and coal in the electric sector [3].

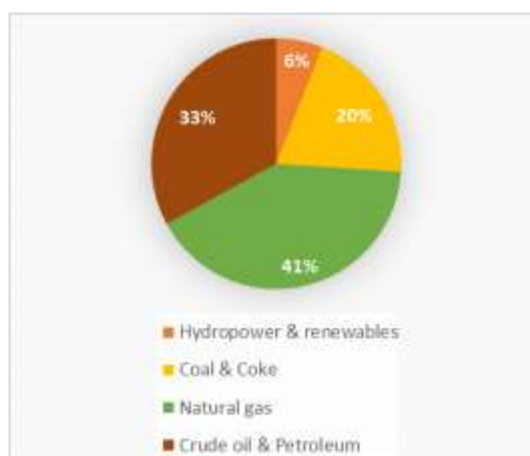

Fig 1 Energy Supply Source Malaysia[1]

In such dire situation, the penetration of renewable energy in the generation market still seems sluggish although many first world countries such as Iceland, Sweden and Germany have proven the effectiveness of obtaining clean and cheaper energy through renewable sources.

Referring to Fig 1, the contribution of renewable energy in satisfying energy of nation's demand is lesser than 6% based on data retrieved by the Energy Commission on 2016.

Green policies being implemented by the government such as Ministry of The Energy, Science, Technology, Environment and Climate Change (MESTECC) has aimed to increase production of electricity from 2% to 20% from renewable energy sources by 2030[3]. Malaysia has also joined Paris agreement to reduce 45% of greenhouse gases (GHG) by 2030. In order to achieve this, decarbonizing the electric power sector is the most crucial, fastest, and economical method. Considering most plants are coal based or natural gas, utilizing biodiesel from non—edible resources replacing diesel in power generation sector would the best initial step to reduce carbon footprint.

There are various studies done on optimizing biodiesel for application in transportation. However, very few studies are conducted on economic potential of biodiesel in energy sector. This paper focuses on Malaysia's energy sector and analyze the techno economic feasibility of applying Callophyllum Innophyllum (CI) biodiesel in power generation sector replacing diesel.

The main objective of the study is to identify how following variables affect the global economic process of CI biodiesel;

i. Biodiesel selling price
ii. Taxing system
iii. Glycerol selling price

2. Callophyllum Innophyllum (CI) Biodiesel

Biodiesel is a type of fuel with cleaner burning properties compared to fossil fuels. It is obtained by chemically processing triglycerides in either edible or non-edible plant oil through transesterification[4]. There are wide range of feedstock available to promote production of biodiesel globally. Approximately, there are around 350 crops recognized as probable feedstock for biodiesel industry[5].

However, currently 95% of world biodiesel production depends on first generation biodiesel feedstock which are edible feedstock such as palm, rapeseed, soybean and sunflower. It can be observed that the price range of vegetable oil has increased tremendously in recent years[5]. Large number of agricultural crops used as biodiesel feedstock leads to global imbalance to market demand in terms of food market equilibrium, land allocation for agricultural activity and redundant food supply. Furthermore, leading to deforestation to satisfy demand for agricultural activity.

CI is a type of non-edible feedstock. Non-edible feedstocks are not suitable for human consumption and such feedstock commonly has ability to grow on barren lands, some can even survive in drought [6]. As there is no competition with the food industry, the non-edible feedstock will remain at low cost and ensuring sustainable biodiesel production. Additionally, these plants can play great role in reducing concentration of CO_2 in atmosphere. The positive traits of CI including the low requirement of water and fertilizer, high resistance to pest and diseases, high adaptability in most climates and high seed and oil yield [7].

3. Potential of CI Biodiesel in Electricity Generation

As the country's Gross Domestic Product increased magnificently throughout the years, the energy demand also grew. By the end of year 2016 the figure increased to 24 784ktoe indicating an increase of 105% compared to year 1978 [2]. As of 2016, power generation industry in Malaysia relies 30.5% on diesel[1]. Referring to table 2, biodiesel has high potential to substitute diesel as it has similar properties and satisfies the US American Society for Testing and Materials standard (ASTM) D6751 and European standards (EN) EN14214 biodiesel standard. Whilst having similar properties to diesel it also has reduced emission enabling Malaysia to reduce greenhouse gases. The only disadvantage of CI biodiesel is its high production cost.

Properties	Diesel	CI biodiesel
Density at 15° C (kg/m^3)	849.2	922
Flash Point (°C)	53	170
Kinematic Viscosity at 40°C (mm^2/s)	2.30	5.40
Calorific value (Mj/kg)	42.5	38

Table 2 Property comparison of diesel and CI biodiesel[8]

Currently, most of the power plants run using natural gas. However, the issue with natural gas is it cannot be stored for long term. When there is insufficient natural gas, diesel distillate will be used to power the plant. CI biodiesel can replace diesel distillate as it has higher calorific value as well as higher flash point [9].

Roles of CI biodiesel in power generation;

i. Start-up fuel in coal power plant
ii. Stand by fuel in power plants
iii. Fuel for black start engine
iv. Fuel to test emergency gen set

4.0 Conceptual Design and Data Collection

The techno-economic assessment for biodiesel production begins from feedstock acquisition and ends with biodiesel consumption. CI needs to be processed in three steps known as transesterification to be converted to Callophyllum Inopyhllum Methlyester (CIME). During, transesterification triglycerides are broken down to diglycerides, monoglycerides and finally to glycerol. Through this process, the oleaginous feedstock is converted to biodiesel [10]. Firstly, oil will be extracted from the seeds. This ensures efficiency of removal of free fatty acid (FFA). Secondly, the oil will go through esterification. In this process, methanol and acid catalyst (sulphuric acid) are added to convert FFA to ester. Next, transesterification is carried out with alkali catalyst (sodium hydroxide). Finally, purification is done by removing trapped methanol.

Technical and Economic Aspects	Data
Project Lifetime	20 years
Plant Capacity	50 000 ton
Initial Capital Cost	$ 20 Million
Depreciation model	8%/year
Operating Cost	$530 /ton FAME
Maintenance cost	2% capital cost annually
Replacement cost	$ 12.5 million
Taxes	15% of biodiesel sales
Crude Callophyllum Innophyllum oil price	$3080/ton
Glycerol Price	$ 0.25/kg
Biodiesel Conversion Efficiency	98%
Glycerol conversion factor	0.0985

Table 1 Technical and Economic data

Table 1 show the major economic parameters used in this work such as plant capacity, initial investment and operating cost. The major economic assumptions have been done according to information from literature [11].In this work, internal rate of return (IRR) and payback period has been compared. This works aims to show tendencies and comparisons rather than absolute numbers.

4.1 Payback Period

Payback period calculation determines the duration a business takes to earn back invested amount from net cash flow. This analysis takes into consideration of variable factors to determine the shortest time to gain initial investment.

$$PP = \frac{Capital\ Cost}{Cash\ flow}$$

4.2 Internal Rate of Return (IRR)

IRR is expected compound annual rate of return that is earned through project.

$$IRR = \sum_{t=1}^{t} \frac{C_t}{(1+r)^t} - C_0 = 0$$

Where

C_t =net cash inflow during the period t
C_0=total initial investment costs
r=the discount rate
t=the number of time periods

5.0 Results and Discussion

The price of CI is on the high compared to palm biodiesel and diesel, around RM 4/L. This is due to the limited demand and there is no professionally cultivated plantation available. The only location that manages this plant professionally (196 hectares) is in Central Java, Indonesia[12]. To obtain CI crude oil, Malaysia must import from Indonesia in limited quantity. This situation can vary significantly, if CI is cultivated locally. With successful plantation in Malaysia, CI biodiesel will be available in the range of RM 1.50 to RM 2.20 making it an economical choice. Varying biodiesel price, tax and glycerol price gives insight to the feasibility of CI biodiesel.

5.1 Changes on the selling price of biodiesel.

Biodiesel selling price is a key variable of the process, it is a fundamental variable that will allow the economical feasibility. In Malaysia, price of biodiesel other than palm is controlled by Sustainable Energy Development

Authority (SEDA). The pricing arrangement are unsatisfactory under Feed in Tarif (FiT). For example, in 2019 biodiesel is priced RM0.3386/kwh under biomass category. Fig 2 shows the variation of pricing from RM0.30/kwh to RM0.40/kwh without tax. It can be seen the project is feasible with acceptable payback period and increasing IRR.

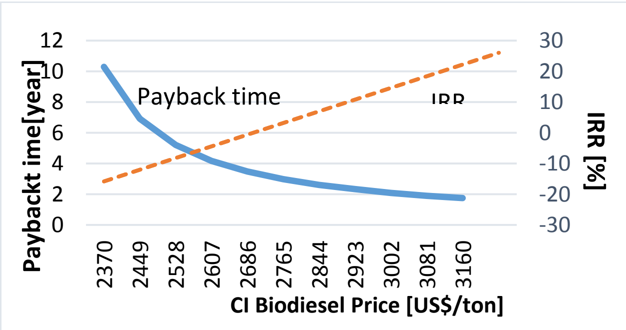

Fig 2 Variation of the payback period and IRR with varying biodiesel price with tax exemption.

5.2 Changes on Biodiesel Price with Tax

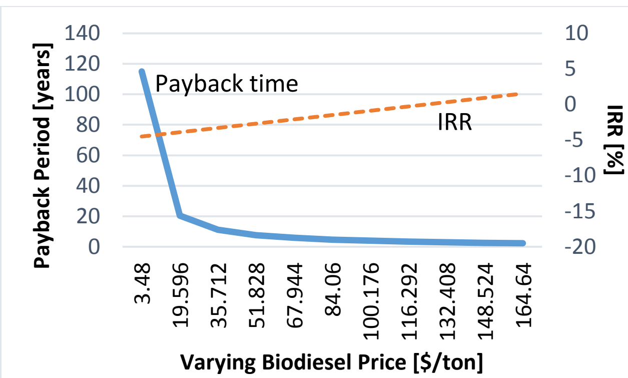

Fig 3 Variation of the payback period and IRR with varying biodiesel price with tax.

According to Fig 3, tax imposes negative cash flow for project. Biodiesel is attractive to consumer only when pricing is exempted from tax and higher rate is offered. Government hold the key in ensuring the success of commercialization of CI biodiesel fuel.

5.3 Changes on Glycerol Selling price

Market price of glycerol varies frequently and depends on purity and availability. Pharmaceutical grade glycerol (purity above 98%) could be sold at a price around 1.322 US$/kg [13], while industry grade glycerol produced from biodiesel industry has cheaper price due to lower purity and large amount of production. Glycerol sales add to the cash flow of the project. Glycerol selling prices aid in increasing IRR as well lower the payback period, as shown in Fig. 4 below.

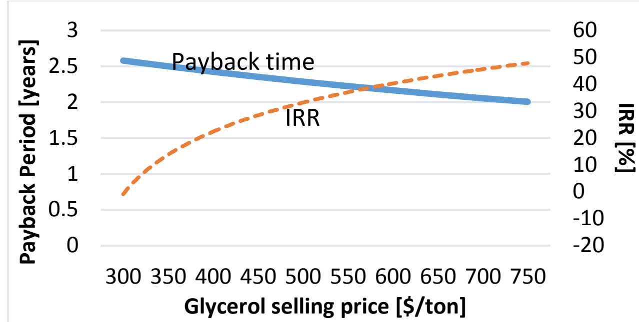

Fig 4 Variation of the payback period and IRR with varying glycerol price.

6.0 Conclusion

Economic study over a biodiesel process by varying biodiesel pricing, taxing as well as glycerol selling price affecting the internal return rate and the payback time was analyzed. It has been found that CI biodiesel has high potential to act as substitute of diesel in power generation industry. CI biodiesel can be used widely in power generation if its price is par with or lesser than diesel price. It is possible to achieve feasible cost of CI biodiesel. This can be achieved by higher selling price ensured by SEDA and tax reduction by the local government. Higher market price of glycerol aids as a support to reduce payback period and increase the IRR.

All the studies included in this work show that the payback time never tends to zero. This result is in accordance to a net investment in equipment that at least should be recovered. These results are of high interested since they show tendencies of how several relevant variables modifications can affect the IRR of a biodiesel plant. Even more, the fact that an idea of the evolution of the economic indicator as a function of several variables, allowing decision to be taken ahead.

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