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Article

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International Journal of Energy Economics and Policy

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2018, 8(6), 35-38.

Techno-Economic Analysis of Fuel Vehicles as Logistic Distribution Facilities in Indonesia by Considering the Carbon Emission Cost

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Received: 23 July 2018 **Accepted:** 03 October 2018 **DOI:** https://doi.org/10.32479/ijeep.6933

ABSTRACT

This study aims to perform a techno-economic analysis for the investment of the Vigas usage as substitution for Pertamax 92 fuel that is starting to be rare. The assessment is done by calculating the value of break even point (BEP), net present value (NPV), internal rate of return (IRR), and payback period (PP). In addition, this study also calculates the amount of carbon emission costs that must be incurred by the company when using Pertamax fuel 92 and Vigas. The analyzed pollutants are CO, HC, NOx, and CO_2. Based on the calculation results, BEP from replacement Pertamax 92 to Vigas can be achieved at the distance of 22.653.43 km. The value of NPV, IRR, and PP indicates that the investment is feasible to be realized. In addition, the cost of carbon emissions generated by Vigas is lower than Pertamax 92, with a difference of IDR 4,191,482.73.

Keywords: Carbon Emission, Fuel Vehicle, Techno-Economy Analysis
JEL Classifications: L52, O25, Q42

1. INTRODUCTION

The phenomenon of the development of the freight forwarding industry is currently increasing rapidly, it is because the increasing of consumer demand in freight forwarding services leads to the increase of companies entering the service market to compete and survive. Furthermore, based on the research of Piesto and King (2002), the increasing number of online retail trade causes the good shipment increasing (Cook and Dave, 2004). The shipment can be done by land, water, or air transportation. Land transportation becomes one of the most widely utilized. It is because land transportation can load resources in the long or medium term, and short distance from location to other location (Diaz-Parra et al., 2014).

Vehicles included in the land transportation modes, among others, train, truck, car, and motorcycle. Trains as an alternative transportation to delivery of goods have several advantages, including large transport capacity, relatively fast travel time, free from illegal charge and better goods security and better goods safety. However, trains are constrained by the very limited departure frequency. Moreover, there is several limitations for transporting goods by train, such as the prohibition of loading B3 transport and B3 waste that can be explosive, burning, reactive and corrosive. Then, delivery of goods by truck is banned in some areas due to emissions problems (Visser et al., 2014). Therefore, cars can be used as one of the modes of transportation that can deliver various types of goods and friendly to the environment. However, the car usage as a mode transportation to deliver goods is necessary to estimate the level of air pollution emissions from the motor vehicle. This can be fulfilled by using fuel-based emission factors, selecting the type of fuel, projecting the fuel price, and estimating the fuel consumption level of motor vehicles (Rabia and Ahmad, 2010).

Research related to transportation cost and vehicle fuel emissions have been done. Silitonga et al. (2012) conducted a research on economic standard and fuel label standard for vehicles in some ASEAN's selected countries such as Singapore, Indonesia, Malaysia, Philippines, Thailand, and Vietnam. The results showed that Singapore was a country that had adopted fuel labels and economic fuel standards, which played an important role for protecting public health and the environment from emission of transportation, where the commonly used fuels were biodiesel, ethanol, methanol, propane, hydrogen, and natural gas. Bakker et al. (2017) conducted research on the comparative analysis of the approach and status of sustainable low carbon transport policies in ASEAN countries and identified differences and similarities. Setiyo et al. (2016) performed techno-economic analysis of liquid petroleum gas (LPG) as an alternative fuel vehicle compared to RON 88 and RON 92 petrol for Indonesia's public transportation. From the literatures, it can be seen that there is a research gap, where there has no research that accommodates about the analysis of techno-economic fuel selection and analysis of emission costs simultaneously yet. Therefore, this study aims to perform a techno-economic analysis that considers transportation and emissions costs related to fuel selection.

The used method in this study is discussed in chapter 2. Then, in the chapter 3 is presented the analysis and result of the study. At last, the conclusion and advanced study will be presented in the chapter 4.

2. METHOD

From the transport sector the source of the emissions problem is the fuel. Used petroleum fuel produces large pollution, so that, it is needed an environmentally friendly fuel replacement, for example is the usage of LPG (As'adi and Djaja, 2017). LPG has a derivative product that is liquid gas for vehicle (LGV) or also known as Vigas. LGV has RON 98 that is equivalent to Pertamax fuel. Therefore, this study will discuss about techno-economic analysis on the Vigas fuel usage as a substitute for Pertamax on four-wheeled vehicles, as well as the calculation of emissions from each fuel. The methodology that is used in the study will be shown in Figure 1.

2.1. Techno-Economic Analysis

2.1.1. Break even point (BEP)

BEP is the breakeven point in which the position of the amount of income equals or balances to cost, so there is no profit or loss in a company. The used formula for BEP analysis consists of two kinds, namely the basic unit and the basis of sales. In this study, the BEP is calculated by basic unit formula, which perform by calculating how many miles distance must be taken by the vehicle to get a breakeven point. As for the calculations performed, use the equation (1).

$$BEP = \frac{FC}{(P_{Pertamax} - VC_{Vigas})} \quad (1)$$

Where, FC is the cost of capital. $P_{Pertamax}$ is the pertamax fuel cost per kilometer. VC_{Vigas} is the Vigas fuel cost per kilometer.

2.1.2. Net present value (NPV)

NPV method is used to calculate the present net (present time). NPV is the comparison between PV net cash with PV Investment over the life of the investment. NPV can be calculated using equation (2).

$$NPV = \begin{array}{l}(Ci_0 - Co_i) + \frac{(Ci_1 - Co_1)}{(1+i)} + \frac{(Ci_2 - Co_2)}{(1+i)^2} + \ldots \\ + \frac{(Ci_n - Co_n)}{(1+i)^n} + \frac{S}{(1+i)^n} - I_0\end{array} \quad (2)$$

Where, Ci is cash inflow, Co is cash outflow, i is bank interest, n is period, S is residue at the last period, and I_0 is initial investment cost.

If net benefit (Ci-Co) and interest (i) are assumed to be unchanged in period n, so the equation (2) can be written as equation (3).

$$NPV = \frac{(Ci - Co)x\left[1-(1+i)^{-n}\right]}{i} + \frac{S}{(1+i)^n} - I_0 \quad (3)$$

2.1.3. Internal rate of return (IRR)

IRR is an interest rate (not a bank interest) that describes the profit rate of a project or investment in a percentage at which the NPV value is zero.

2.1.4. Payback period (PP)

PP is a valuation technique to find out how long the period required to return investment from a project or business. The value of PP can be calculated using the equation (4).

$$PP = \frac{Investment\ costs}{Accumulative\ proceed} \quad (4)$$

To assess the feasibility of a business or project in terms of PP:
If: PP > the project economic life, it will be not feasible.
PP < the project economic life, it will be feasible.

2.2. Carbon Emission Analysis

Motor vehicle exhaust emissions are measured in grams per vehicle per km in a trip/journey. Vehicles with different fuel types will produce different emission levels as well (Yuliastuti, 2008). This study will compare the value of exhaust emissions based on two types of fuel, namely Vigas and Pertamax 92. The composition of exhaust emissions are calculated, including CO, NOx, HC, and CO_2. The carbon emission analysis is accomplished by calculating the conversion of tons of carbon to the cost.

3. DISSCUSION AND RESULT

This study describes four-wheeled vehicles as a means of distribution logistic, where mileage per year is assumed to be 62,400 km. The used fuel price per liter is based on current prices

(June, 2018), where Vigas cost is IDR 5100 and Pertamax 92 cost is IDR 8600. The Parameters used in the study, are presented in Table 1.

3.1. Techno-Economic Analysis

3.1.1. BEP

In this study, to calculate the BEP, it is assumed to be not changed in fuel cost. Based on the calculation, the fuel cost per km of Vigas and Pertamax 92 are IDR 659.77 and IDR 1,189.49. Using those values to calculate the BEP, it is known that the BEP value for switching from the Pertamax 92 fuel to Vigas is obtained at a distance of 22,653.43 km.

3.1.2. NPV dan IRR

In performing NPV calculations, it is assumed that the interest rate used is 1% per month and the calculation period is 60 months (5 years). Using the equation (3) and the parameters in Table 1, the NPV and IRR transition results from Pertamax 92 to Vigas are shown in Figures 2 and 3. Based on these results, it can be obtained the NPV as big as IDR 110,558,985.02, where the NPV >0, so the replacement investment of Vigas as substitution of Pertamax 92 is considered feasible.

Figure 1: Research Methodology

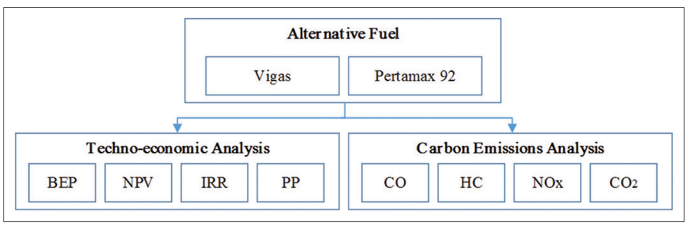


Figure 2: Net present value

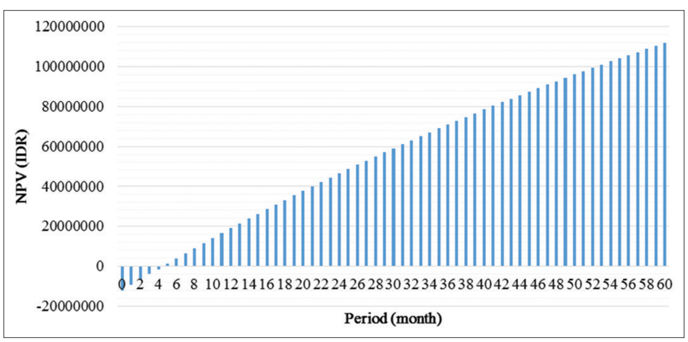
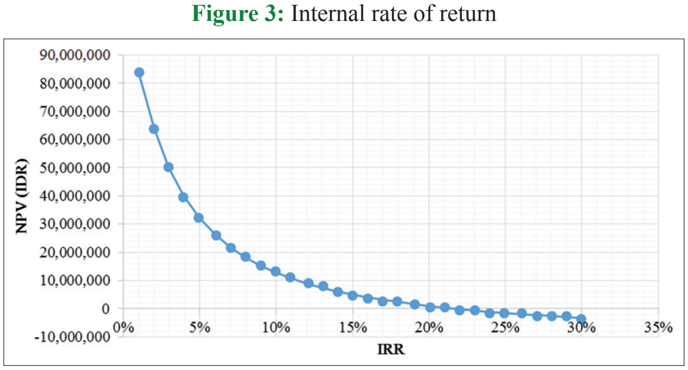


Figure 3: Internal rate of return



Another criterion used to look at the extent to which this investment is feasible, is used IRR. By using the numbers can be calculated the amount of IRR is equal to 21.74%. This means that at an interest rate of 21.74% per annum then the NPV of net benefit obtained is zero.

3.1.3. PP

In this study, PP is calculated using proceeds or net cash flow to recoup the investment expenditure. Net cash flow is derived from the amount of the saving cost of fuel replacement Pertamax 92 to Vigas, that is equal to IDR 2,754,550 per month. With an investment cost as big as IDR 12,000,000 then the value of PP generated is 4.36 months. This shows that the PP value < economic life of investment, so the replacement of this fuel is feasible.

3.2. Sensitivity Analysis

Sensitivity analysis aims to determine the extent to which the dependence or sensitivity of the feasibility level of fuel replacement Pertamax 92 with Vigas against the possibility of price changes during the investment is still in the economic period. In this study, sensitivity analysis is done by making changes to the increase of mileage, fuel cost, and the procurement converter kit cost by 5% and 10%. The result is presented in the Table 2 and Figure 4.

In this analysis, the investment criteria index provides a feasible assessment for the continuity of the vehicle fuel replacement program. In the current situation (normal), the IRR value is almost

Figure 4: Sensitivity analysis

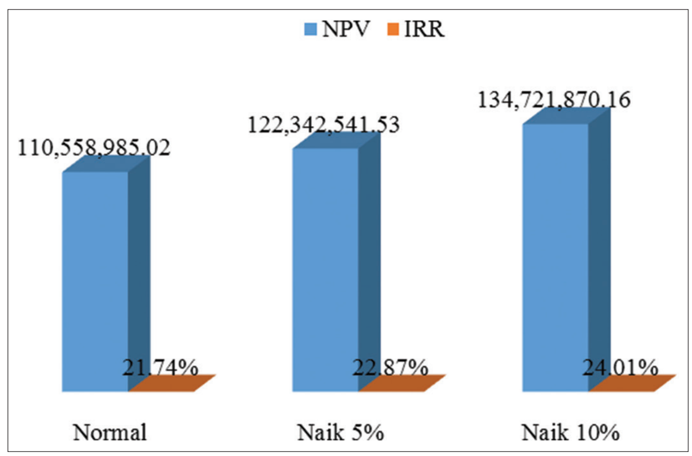


Table 1: The parameters

Information	Unit	Fuel	
		Vigas	Pertamax 92
Mileage per year	km	62,400.00	62,400.00
Fuel consumption	km/L	7.73	7.23
Fuel consumption per year	L	8,072.45	8,630.71
Fuel cost per liter	IDR	5,100.00	8,600.00
Fuel costs per year	IDR	41,169,469.60	74,224,066.39
LPG converter kit price	IDR	12,000,000.00	0.00
Cost savings from Pertamax to LPG	IDR	33,054,596.79	0.00
Residual value at the end of year 5	IDR	6,000,000.00	0.00

Table 2: The comparison result of sensitivity analysis

Parameter	Normal	Plus 5%	Plus 10%
NPV	110,558,985.02	122,342,541.53	134,721,870.16
IRR	21.74%	22.87%	24.01%

Table 3: Carbon emission

Parameter	Vigas	Pertamax 92
CO (gr/km)	0.95	0.12
HC (gr/km)	0.01	0.006
NOx (gr/km)	0	0.027
CO_2 (gr/km)	182.5	206.8

Table 4: The cost calculation of carbon emission

Pollutant	Vigas (IDR)	Pertamax 92 (IDR)
Carbon mono-oxide (CO)	168,781.04	21,319.71
Carbon dioxide (CO_2)	32,423,725.70	36,740,966.98
Nitrogen oxide (NOx)	0.00	21,855.30
Hydrocarbon (HC)	381.33	228.80
Total	32,592,888.06	36,784,370.79

close to the minimum investment feasibility but still feasible to be realized. Then, if there is an increase in mileage, fuel cost, and the procurement converter kit cost as much as 5% and 10%, indicating that this investment is more feasible to do.

3.3. Carbon Emission Analysis

The calculation of carbon emissions is done by converting the amount of tonnes of carbon produced from each fuel to the unit cost. The carbon emissions unit (g/km) of Vigas and Pertamax 92 are assumed to be same as the results of the research As'adi and Djaja (2017). The emission test result is presented in Table 3.

The emission/pollutant cost from research conducted in Canada in 2005 ($/ton) (Muziansyah et al., 2015):

1. Carbon Mono-oxide (CO)= $205/ton
2. Particulate (PM_{10})= $3,17/ton
3. Carbon Dioxide (CO_2)= $205/ton
4. Sulfur Dioxide (SO_2)= $1000/ton
5. Nitrogen Oxide (NOx)= $934/ton
6. Hydrocarbon (HC)= $44/ton.

By using the above data, it can be calculated the amount of costs incurred associated carbon emissions for each fuel Vigas and Pertamax 92 within 1 year, where the distance traveled by a vehicle is 62,400 km and the dollar price ($) is IDR 13,888.7. The calculation result is presented in Table 4. Based on the result of the calculation, it is found that the cost of carbon emissions of Vigas fuel is lower than Pertamax 92, with a cost difference as much as IDR 4,191,482.73 per year.

4. CONCLUSION

Based on techno-economic analysis of vehicle fuel, the replacement investment of Pertamax 92 to Vigas is declared feasible. Then based on the analysis of the carbon emissions cost that must be spent for each fuel, it can be seen that Vigas is lower than Pertamax 92. This means that Vigas is more environmentally friendly than Pertamax 92.

This study only considers two types of fuel and four types of exhaust gas pollutants from the vehicles, so that, in the future, can be done research for each type of fuel used in Indonesia as well as assessing exhaust gas pollution more fully. Eventually, it is expected that this study can be used as consideration for stakeholders of related Government to make a choice of vehicle fuel effectively and efficiently.

5. ACKNOWLEDGMENT

The research is supported by Institute for Research and Community Service, Sebelas Maret University with Hibah Penelitian Mandatory UNS (PM-UNS) Research Program (Contract No. 543/UN27.21/PP/2018).

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