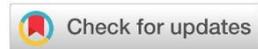


Research Paper

Converting Vehicle to LPG/Vigas: A Simple Calculator to Assess Project Feasibility

Eko Muh Widodo^{1*}, Muhammad Imron Rosyidi¹, Tuessi Ari Purnomo¹, Muji Setiyo²¹Department of Industrial Engineering, Universitas Muhammadiyah Magelang, Indonesia, 56172²Department of Automotive Engineering, Universitas Muhammadiyah Magelang, Indonesia, 56172Email: emwidodo@ummg.ac.iddoi: <https://doi.org/10.31603/ae.v2i2.2744>

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Abstract

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Until 2018, WLPGA reported more than 27 million LPG-fueled vehicles operate throughout the world. However, even though the Indonesian government has promoted LPG as an alternative fuel since the 1980s, its growth has not been seen. One of the reasons for the slow conversion program from gasoline to LPG/Vigas is the uncertainty of gathered profit or loss. Therefore, this article presents a simple calculator to assess the feasibility of investing in vehicle conversion, from gasoline to LPG/Vigas. A simple calculator developed with MS. Excel, with a standard economic parameter for an investment feasibility study. Input parameters including the estimated annual mileage, fuel consumption, gasoline prices, LPG / Vigas prices, the cost of the converter kit and its installation, engine standardization costs, maintenance costs with gasoline, and maintenance costs with LPG are considered to produce output parameters that include Break Even Point (BEP), Payback period (PP), Net Present Value (NPV), and Internal Rate of Return (IRR).

Key words: LPG Vehicles, Converting, Economic Analysis

Abstrak

Sampai tahun 2018, WLPGA melaporkan lebih dari 27 juta kendaraan berbahan bakar LPG beroperasi di seluruh dunia. Namun demikian, meskipun pemerintah Indonesia telah mempromosikan LPG sebagai bahan bakar alternative sejak tahun 1980an, sampai sekarang belum terlihat pertumbuhan yang signifikan. Salah satu dugaan penyebab lambatnya program konversi dari bensin ke LPG/Vigas adalah ketidakpastian laba atau rugi. Oleh karena itu, artikel ini menyajikan sebuah kalkulator sederhana untuk menghitung kelayakan investasi konversi kendaraan, dari bensin ke LPG/Vigas. Sebuah kalkulator sederhana dikembangkan dengan MS. Excel, dengan standar parameter ekonomi untuk sebuah studi kelayakan investasi. Parameter input yang mencakup estimasi jarak tempuh tahunan, konsumsi bahan bakar, harga bensin, harga LP/Vigas, biaya konversi, biaya standarisasi mesin, biaya perawatan dengan bensin, dan biaya perawatan dengan LPG dipertimbangkan untuk menghasilkan parameter output yang mencakup *Break Even Point* (BEP), *Payback Period* (PP), *Net Present Value* (NPV), and *Internal Rate of Return* (IRR).

Kata Kunci: Kendaraan LPG, Konversi, Analisis Ekonomi

1. Introduction

Recently, congestion in major cities in Indonesia has been a serious concern for

stakeholders. Congestion does not only affect driving time and driving stress, but also causes pollution and waste of fuel [1], [2]. In the future,



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Symbol	
C_i	: Cash inflow (IDR)
C_o	: Cash outflow (IDR)
i	: Bank interest (%)
I_o	: Capital cost (IDR)
n	: Period (month)
S	: Salvage value (IDR)
Abbreviation	
BEP	: Break Even Point
ICE	: Internal Combustion Engine
IRR	: Internal Rate of Return
LPG	: Liquefied Petroleum Gas
NPV	: Net Present Value
OEM	: Original Equipment Manufacturer
PP	: Payback Period

electricity-based vehicles such as Electrified Vehicles, Hybrid Electric Vehicle (HEV), Plug in Hybrid Electric Vehicle (PHEV), Battery Electric Vehicle (BEV) and Fuel Cell Electric Vehicle (FCEV) will be the orientation of the development of automotive propulsion systems that are more environmentally friendly and sustainable [3].

However, the total price of ownership of electric-based vehicles is still relatively high compared to vehicles based on internal combustion engines (ICE), which are commercially available. Therefore, the application of alternative fuels such as Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG) is reasonable to reduce pollution, though both of them share disadvantages due to their properties, especially in output power [4], [5].

In developed countries such as the United States, Japan, Australia, South Korea and countries in Europe LPG-fueled vehicles are available as Original Equipment Manufacturer (OEM) products. On the contrary, in developing countries such as in India and Thailand, the practice of using LPG is dominated by conversion systems. For OEM products, LPG kits technology has equalled Multi Point Injection (MPI) and Gasoline Direct Injection (GDI) technology for gasoline engines, but for LPG conversion vehicles,

many still use Vapor Phase Injection (VPI) and even Converter-Mixer (CM).

There are several types of costs that must be considered by the vehicle owners and the government before converting private vehicles or public fleet to LPG. Liu et al. [6] identify costs for conversion, which include capital costs, maintenance costs, and fuel costs. However, the report does not specify the components included in the three main costs. In the online cost calculator for calculating BEP of LPG compared to gasoline, it is also only globally available which identifies annual mileage, conversion costs, and differences in gasoline prices with LPG [7]–[9].

Meanwhile, there are several additional costs that must be included in the calculation to get the right investment decision. Based on the experience of a number of countries that have successfully promoted LPG as a substitute for gasoline, there is a significant role for the government so that the vehicle owners are interested in converting their vehicles to LPG, for example by reducing annual taxes and inspection cost or providing tax amnesty [10]–[12].

According to the conversion provisions provided by Propane Education and Research Council [13], [14], not all vehicles that come to conversion facilities can be served directly. A number of technical requirements must be met for the car to be converted, including a complete mechanical inspection of the engine from oil leakage, compression pressure, noise and emissions. If the technical requirements are not completed, the vehicle owner must incur additional costs before conversion as the cost of machine standardization. This cost is unpredictable, depending on the condition of the vehicle to be converted. Therefore, the conversion cost model is presented in Figure 1, as reported in previous authors' study [15].

Therefore, this paper presents a simulation of conversion calculator from gasoline to LPG that has considered the pre-conversion cost and the difference in maintenance costs, considering that LPG-fueled vehicles have the opportunity to use engine oil longer than vehicles operating with gasoline [16].

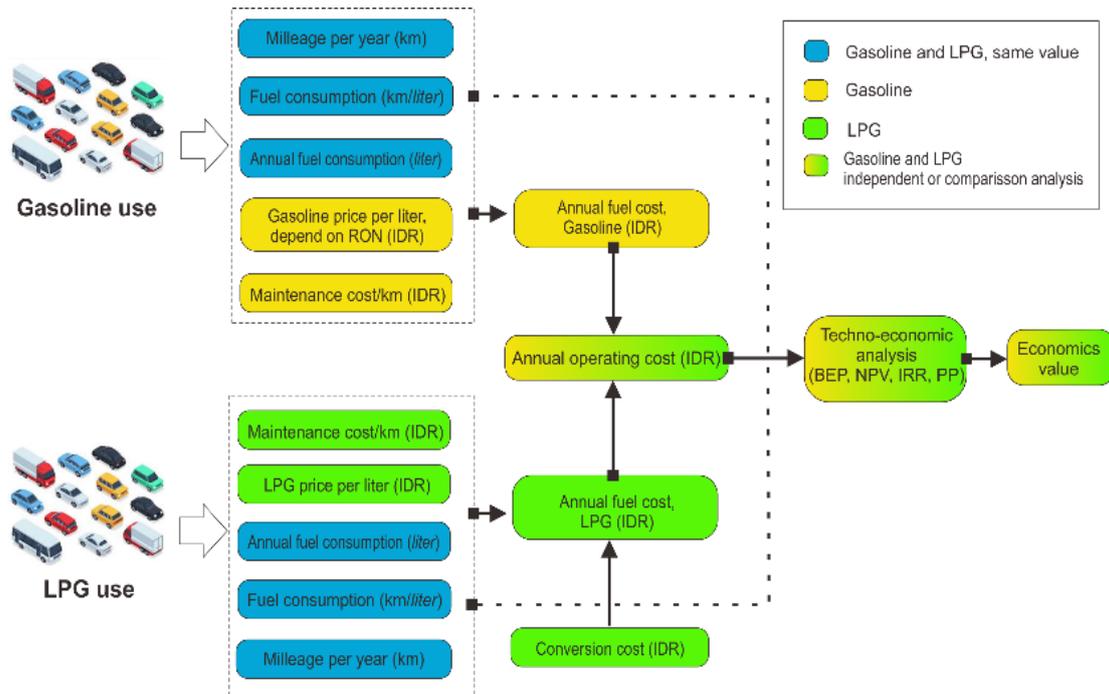


Figure 1. Modeling for calculator formula [15].

2. Method and Steps to Create Calculator

2.1. Cost Analysis

As mentioned earlier, there are several costs that must be considered by vehicle owners to convert to LPG, which can be grouped into capital costs, fuel costs, and maintenance costs. This calculator can be used as a means to help calculate quickly based on input parameters entered. These input parameters include:

- estimated annual mileage,
- fuel consumption,
- gasoline price,
- LPG / Vigas price,
- the cost of the converter kit and its installation,
- engine standardization costs,
- maintenance costs with gasoline, and
- maintenance costs with LPG.

As an output, this calculator can display:

- Break Even Point (BEP),
- Payback period (PP),
- Net Present Value (NPV), and
- Internal Rate of Return (IRR)

2.2. Sheet Organizing

This calculator is made in MS. Excel which consists of four sheets, as presented in Table 1.

Table 1. Sheet organizing

Sheet	Description
1	Instructions
2	Sheet to calculate Break Even Point (BEP) and Payback Period (PP)
3	Sheet to display the Net Present Value (NPV)
4	Sheet to display Internal Rate of Return (IRR)

With M.S. Excel is further customized, users simply enter numbers in yellow cells. Simulation results are displayed in graphs below to be more easily understood by the user.

2.3. Formula to Calculate Project Feasibility

The feasibility of investing in vehicle conversion from gasoline to LPG uses three main parameters, namely NPV, IRR, and PP, which have been discussed in previous authors' study [17]. NPV is calculated using Equation (1) as follows.

$$NPV = (C_{i_0} - C_{o_0}) + \frac{(C_{i_1} - C_{o_1})}{(1+i)} + \frac{(C_{i_2} - C_{o_2})}{(1+i)^2} + \dots + \frac{(C_{i_n} - C_{o_n})}{(1+i)^n} + \frac{S}{(1+i)^n} - I_0 \quad (1)$$

If net profit ($C_i - C_o$) and interest (i) are assumed not to change during the period n , and

the salvage values = 0, Equation (1) can be rewritten as Equation (2). Then, IRR is a condition where NPV is equal to 0. If NPV is greater than 0, it means a feasible investment.

$$NPV = \left[\frac{(Ci - Co) \times [1 - (1 + i)^{-n}]}{i} \right] - I_0 \quad (2)$$

After the NPV and IRR are known, the investment valuation is done by calculating the payback period. Payback period is the ratio between the cost of capital and accumulative profit as presented in Eq. (3). If PP is achieved less than the duration of installments, it means a feasible investment.

$$PP = \frac{\text{investment costs}}{\text{accumulative proceed}} \quad (3)$$

3. Result and Discussion

3.1. Sheet 1: Instruction

In the instruction sheet, it is written about the description and explanation for each sheet. In this sheet there is also a link to the next sheet just by clicking on the arrow or other appropriate marker, as presented in Figure 2. Instruction sheets can be customized as needed.

Gasoline to LPG/Vigas Calculator



Description

There are three types of costs that must be considered by vehicle owners to convert to LPG, which include capital costs, fuel costs, and maintenance costs. This calculator can be used as a means to calculate quickly based on input parameters entered. The input parameters include: (a) estimated annual mileage, (b) fuel consumption, (c) gasoline prices, (d) LPG / Vigas prices, (e) converter kit costs and installation, (f) engine standardization costs, (g) maintenance costs with gasoline, and (h) maintenance costs with LPG. As an output, this calculator can display Break Even Point (BEP), Payback period (PP), Net Present Value (NPV), and Internal Rate of Return (IRR).

Instruction

- Sheet view
 - Sheet 1 = Instructions
 - Sheet 2 = Sheet to calculate Break Even Point (BEP) and Payback Period (PP)
 - Sheet 3 = Sheet to display the Net Present Value (NPV)
 - Sheet 4 = Sheet to display Internal Rate of Return (IRR)
- Users only need to enter numbers in yellow cells
- The simulation results are displayed in the Graph below

Go to the next sheet →

Note

This calculator has received Intellectual Property protection from the Ministry of Law and Human Rights of the Republic of Indonesia, with number 000114354. For anyone who will develop further, ethically you contact us.

Figure 2. Instruction sheet.

3.2. Sheet 2: Break Even Point (BEP) and Payback Period (PP).

In this sheet, an economic formula is applied. See Figure 3, there are several cells that are yellow (editable) and other cells are locked. The value given in the yellow cell will be processed into an output parameter and presented in two graphs. The BEP graph is given on the left and the Payback Period graph is presented on the right. The lines on the BEP graph and the bar in payback period graph change automatically according to the input parameters.

For example, a vehicle is estimated to cover a distance of 20,000 km per year, with a gasoline price of IDR. 9000 and LPG/Vigas of IDR. 5100, and conversion cost reaching IDR. 20 million, BEP will be obtained at 51,000 km with a payback period up to 31 months. This BEP will be faster if conversion costs are lower, as discussed in the previous study [15]. In this case, the consumption of gasoline and LPG is assumed to be the same because gasoline and LPG have almost the same content energy, around 46 MJ/kg. In Indonesia, LPG / Vigas is sold at gas stations in lsp (Gasoline Gallon Equivalent, GGE).

Gasoline to LPG/Vigas Calculator

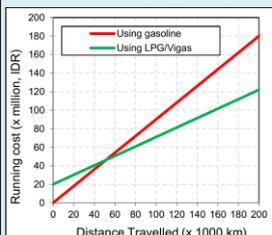
I. Input Parameter

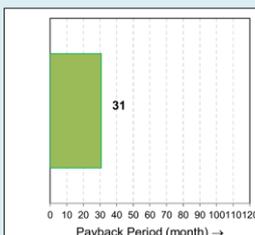
A. Annual distance travelled	=	20,000	km
B. Fuel consumption (estimation)	=	10	km/l
C. Gasoline price	=	9,000	IDR
D. Vigas price	=	5,100	IDR
E. Conversion cost	=	15,000,000	IDR
F. Pre-conversion cost (engine standardisation)	=	5,000,000	IDR
G. Vehicle maintenance cost with gasoline, include engine oil	=	3,000,000	IDR
H. Vehicle maintenance cost with LPG/Vigas, include engine oil	=	2,000,000	IDR

III. Output Parameter

Annual fuel consumption (estimation)	=	2,000	liter
Annual fuel cost (gasoline)	=	18,000,000	IDR
Annual fuel cost (LPG/Vigas)	=	10,200,000	IDR
Annual saving	=	7,800,000	IDR
Running cost per kilometer using gasoline	=	1,050	IDR
Running cost per kilometer using LPG/Vigas	=	660	IDR
Break Even Point (BEP) (distance)	=	51,282	km
Net annual saving	=	650,000	IDR
Payback Period	=	31	month

III. Break Even Point (BEP) and Payback Period (PP)





← Back to Instruction Go to NPV →

Figure 3. BEP and payback period sheet

3.3. Sheet 3 and 4: Net Present Value (NPV) and Internal Rate of Return (IRR)

Furthermore, after the BEP and payback period are known, the more important thing is NPV (sheet 3) which describes how feasible an investment is, based on the input parameters given in sheet 2. This calculator easily assesses the feasibility of the project by changing the value of capital costs, bank interest, and the estimated residual value of all equipment purchased at the beginning of the investment as shown in Figure 4 and Figure 5, respectively.

Compared to three calculators that are available online [7]–[9], this calculator has an additional feature in the form of investment feasibility parameters that have not been displayed in all three sources. However, they have other features, in the form of emission estimation and gasoline-LPG ratio factor, which have not been considered in this study.

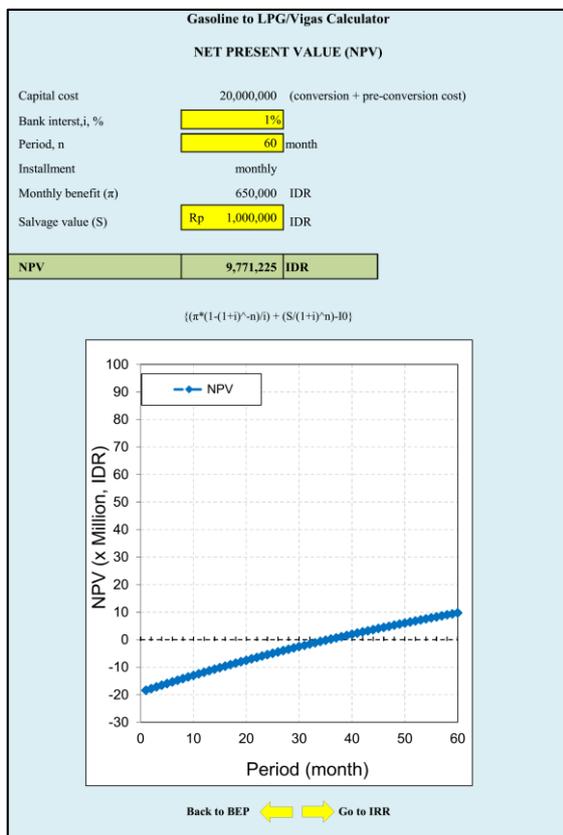


Figure 4. Net Present Value (NPV) sheet

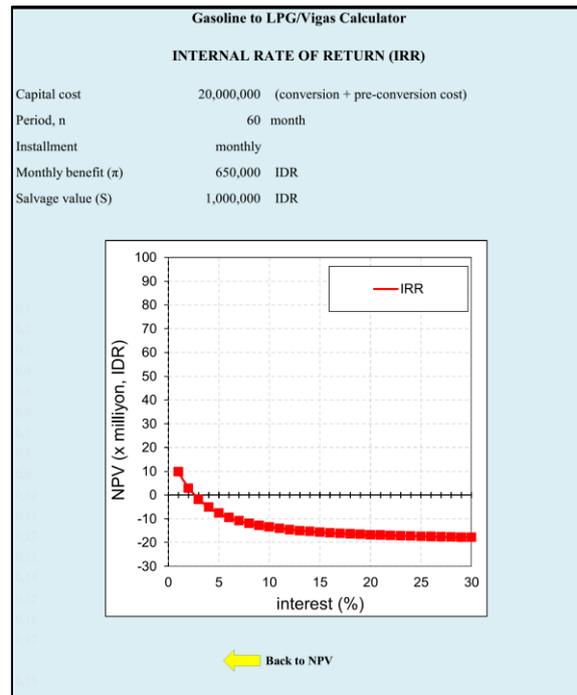


Figure 5. Internal Rate of Return (IRR) sheet

The results of this study can also be used by stakeholders in order to succeed in emission reduction and clean air programs. To promote LPG / Vigas as an alternative fuel, the government can provide incentives, both fiscal and non-fiscal, as practiced in several countries [18], [19]. Fiscal incentives can be provided by tax breaks and LPG price subsidies, while non-fiscal incentives can be realized as strict regulations on emissions, requiring official vehicles to switch to LPG, and other regulations related to clean air projects. However, even though sometimes LPG prices are less competitive, the environmental effects of LPG-fueled vehicles are better than gasoline vehicles, through proper conversion [20], [21].

4. Conclusion

This calculator can help for quick decision making in planning conversion from gasoline to LPG or to other alternative fuels such as CNG. The effect of changes in input parameters can directly know the output, in the form of numbers and graphs. This calculator can be used by public transport entrepreneurs, private vehicle owners, as well as local governments as supporting tools to make decisions. An investment is considered feasible if $NPV > 0$, $IRR > i$, and $PP < n$. Of course,

these parameters still have to consider risk factors if there is a change in the input parameters. In the near future, this calculator will be developed into an Android-based application, which is expected to be one form of down streaming and commercializing research products.

Acknowledgement

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