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Economic Values and CO_2 Simulation on the Application of LPG for Public Fleets in Magelang, Indonesia: Executive Data to Support the Clean City Program

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Abstract

The implementation of the ASEAN Clean Tourist City Standard caused restlessness among public fleet operators and the Department of Transportation of Magelang City. Therefore, this article presents the prediction of economic value and environmental benefits of public fleet in Magelang that will be converted from gasoline to LPG. Investment feasibility parameters, such as Break Event Point (BEP), Net Present Value (NPV), Internal Rate of Return (IRR), and Payback Period (PBP) are presented through three financing scenarios compared with the current gasoline price at the fuel station, RON 88 and RON 90. Simulation results indicate that investment is feasible with the government providing fiscal incentives through the procurement of converter kits. The wages of the public fleet crew under Minimum Wage City will rise by 30 % and 70 % to switch from gasoline RON 88 and gasoline RON 90, respectively. Meanwhile, environmental benefits are also expected to improve, with CO_2 emission reduction of 320.46 tons/year or about 11 % of gasoline usage. These two benefits (economics and environmental) are expected to support the clean city program in Magelang City, Indonesia.

Keywords

public fleet, conversion to LPG, crew wages, environmental benefit

1 Introduction

Eco-friendly vehicles have become a requirement in the ASEAN Clean Tourist City Standard issued by the ASEAN Secretariat in January 2016. The objective of implementing this standard is to provide environmental sustainability guarantees and to provide convenient services for both domestic and international tourists in the cities in ASEAN (The ASEAN Secretariat, 2016). It is hoped that tourism contributes to the regional economic development and has an impact on improving living standards on a wider scale. Previously, the Global Fuel Economy Initiative (GFEI) has also targeted the reduction of exhaust emissions through fossil fuel reduction for the transportation sector by 50 % in 2050, including the ASEAN region (Fabian, 2010; GFEI, 2010).

Magelang is a service city visited by millions of tourists because it is integrated with the tourist area of Borobudur Temple, which is a historical building and one of the wonders of the world. Borobudur is not only a place of worship for Buddhists, but its presence has had social and economic impacts in Magelang, Central Java, and Yogyakarta provinces in Indonesia (Soekmono, 2005). In 2006, there was anxiety from the UNESCO World Heritage Committee on the sustainability of Borobudur tourism due to poor local tourism support and management (Nagaoka, 2011). Magelang is also famous for Military City, which has the biggest National Military Academy in Indonesia.

On the other hand, in the last decade, city branding has become a trend to guide city development (Kavaratzis and Ashworth, 2005). In the government mission of Magelang City 2016-2021, one of its flagship programs is 'safe, healthy, and sustainable city development', which includes the

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Fig. 1 Existing condition of the public fleet in Magelang City, Indonesia: (a) Fleet status and (b) Pertamina's Fuel station (SEO) that sells LPG called VIGAS

arrangement and modernization of public fleets integrated with tourist, commercial, educational, and residential areas. Until 2018, Magelang city is served by 12 city transport lines and several buffer lines, as well as fuel station that sells LPG called VIGAS. The existing conditions of the public fleet are presented in Fig. 1 and the landscape of Magelang city and Borobudur tourism area is presented in Fig. 2. The distance from the city center to Borobudur is ±11 km. However, its load factor is low, which has caused the decrease in the income of public transport business operators. The problem identified was the age of the vehicles, which decreased users' interest. As a result, there is a serious gap between the quality of public transport service and consumer expectations.

In recent years, the presence of online transportation systems based on Android, such as Go-Jek and Grab-Car, have also been one of the causes of the low load factor of conventional transportation. Employers and operators of conventional transportation feel disadvantaged by the presence of online transport. Although in reality, the presence of online transport provides new jobs for the community. Moreover, online transport has also provided new ways of transacting in the city, such as food purchases, massage services, cleaning, and other services (Natadjaja and Setyawan, 2016; Nurhidayah and Alkarim, 2017). Some communities have also given a positive assessment of online transport in terms of convenience, timeliness, and service (Silalahi et al., 2017). For now and in the future, the government must take a new approach, so that online transportation can synergize with conventional transportation, without anyone being harmed (Azzuhri and Mada, 2018).

Electric Vehicles (EV) and Fuel Cells (FC) have indeed been shown to provide better environmental impact than conventional gasoline or diesel vehicles. However, EV and

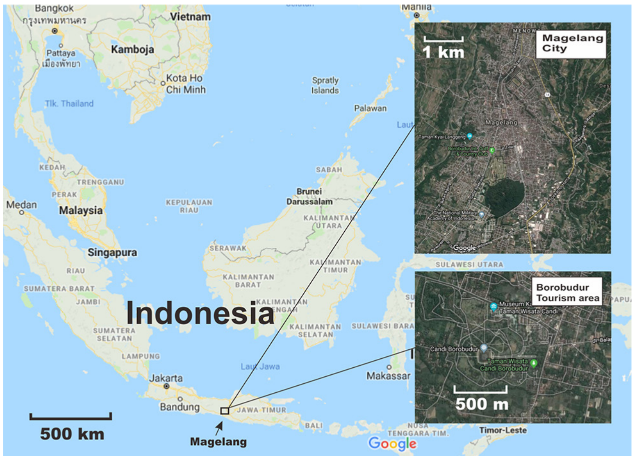

Fig. 2 Landscape of Magelang City and Borobudur tourism area

FC prices are still several times the price of commercial gasoline for the same power capacity (Messagie et al., 2013). EV implementation also requires a huge investment to build electricity infrastructure for accessible charging, which competes with electricity needs for other sectors (Karmaker et al., 2018; Weldon et al., 2018). The old vehicle retirement program then replaces it with new technologies. The Multi Port Injection (MPI) engine and Compressed Natural Gas (CNG) fuel use may be effective solutions to improve air quality and improve customer service (Deendarlianto et al., 2017). However, old vehicle retirement programs are not easy to implement as long as the owner of the fleet is a small company or even a private ownership. As a solution, replacing gasoline by LPG becomes a realistic option because to operate a vehicle with LPG can be done by adding converter kits on an engine with slight modifications (Werpy et al., 2010).

The trend of LPG fuel usage for Light-Duty Vehicles has been reported and updated annually by the World

LPG Association (WLPGA). In the last two decades, the number of LPG vehicles was reported to be more than 9.4 million in 2003 (World LPG Association, 2005) and rose sharply to 17.4 million in 2010 (World LPG Association, 2012). Then in 2014, it reached 25 million (World LPG Association, 2015) and the last in 2016 is reported to have reached more than 27 million (World LPG Association, 2016). Korea, Japan, Thailand, India, and Turkey are examples of countries in Asia that have successfully promoted LPG as a substitute for gasoline, either through conversion or as a package on a new car (OEM). Meanwhile, the growth of LPG vehicles in Indonesia is still not significant, although it started in the 1980s (Mahendra et al., 2013). Until 2014, vehicles using LPG were not more than 6000 units (Mahendra et al., 2014). Indonesia is lagging behind in the development of LPG vehicles, but in the medium- and long-term, LPG is still a viable option because of a simpler infrastructure than CNG (Melikoglu, 2014; Raslavičius et al., 2014).

In Indonesia, infrastructure and government policies related to fiscal and regulatory incentives are constraints in campaigns of LPG application. Fiscal incentives include sales tax and conversion costs, provision of converter kits, vehicle registration costs, and tax breaks. Regulatory incentives include policies requiring all public fleet and vehicles owned by government offices equipped with converter kits and applying strict exhaust emission standards (Abdini and Rahmat, 2013). Meanwhile, governments in many countries that have successfully applied LPG have different reasons, such as economy, environment, energy security, and others. However, based on the WLPGA report, there is a role that the government plays in the success of this conversion program.

LPG for vehicles has several advantages, including being cheaper than gasoline today, lower emissions and toxic compounds, and has all the key properties as fuel, especially for fleet vehicles. Although there are some weaknesses, including the cost may rise with demand, limited supply, and no energy security (Bielaczyc et al., 2016). LPG vehicles have been shown to produce lower emission content than gasoline operating modes, both in urban cycle and extra-urban driving cycle (Shankar and Monahan, 2011). On the other hand, as long as LPG is fed to the engine as a vapor phase, it will negatively affect the power (Masi and Gobbato, 2012). Cause, the volumetric efficiency of LPG is lower than gasoline, although LPG heat values are higher than gasoline (Gumus, 2011). Several methods have been used to fix this problem, but the ignition timing adjustment and the intake system improvement are the most commonly applied methods (Cinar et al., 2016; Kim et al., 2014; Lawankar and Dhamande, 2012).

To date, there are two main types of LPG kits available commercially, namely vapor and liquid LPG kits. Vapor LPG kits consist of Converter and Mixer (CM) and Vapor Phase Injection (VPI). Then, liquid LPG kits consist of Liquid Phase Injection (LPI), and Liquid Phase Direct Injection (LPDI) (World LPG Association, 2016). CM LPG kits are the first generation of conversion devices from gasoline to LPG which are similar to carburettor systems. LPG enters the machine through a vacuum arrangement by the mixer. VPI LPG kits use converters, such as first generation, but the gas is taken out of the converter at a set pressure. Then, the gas is mixed into the air stream at the intake manifold by injectors electronically controlled. LPI LPG kits do not use a converter; liquid fuel is directly supplied to fuel rails, such as the gasoline injection system. Lastly, LPDI LPG kits are the most sophisticated systems today. LPDI uses high pressure pumps and injectors to inject liquid LPG into the engine at compression step and it is generally installed on OEM LPG vehicles. The typical characteristics of each system is described in detail by Raslavičius et al. (2014), although with slightly different terms.

Therefore, this article presents a techno-economic analysis and predicted CO_2 emission reduction with vapor LPG kits application on the public fleet. Two types of vapor LP kits are the most widely applied to almost all existing vehicle technologies in Indonesia, in the hope of being able to present executive data that can be used as a consideration for government and public fleet operators to jointly create a fair policy.

2 Methodology

2.1 Modeling of Economic Value and Comparison of CO_2 Emissions

In general, there are three types of costs to be considered by car owners before converting to LPG, including capital costs as initial investment, maintenance costs, and fuel costs as operational costs (Liu et al., 1997). In this study, the capital costs are a conversion cost, not the cost of buying an LPG vehicle manufactured by a car manufacturer called OEM. Engine oil contamination by carbon in LPG vehicles is less than gasoline, so oil change time may take longer to lower maintenance costs (Bosch, 2010). Because of the energy content of LPG per liter in fuel station is equal to gasoline per liter (liter of gasoline equivalent or GGE), the distance per liter of LPG can be assumed to be the same as the distance per liter of gasoline (Abdini and Rahmat, 2013).

In the present study, an economic analysis and comparison of CO_2 emissions are discussed in more detail based on data obtained from the Department of Transportation of Magelang City. Thirteen public transport lines are analyzed collectively and independently based on vehicle mileage and annual operational costs. Currently, there are 2 variants of gasoline that are used by public transport, namely RON 88 (premium) and RON 90 (pertalite). Although, recently, RON 88 was difficult to obtain from the fuel station due to supply restrictions from the government.

As mentioned before, there are 4 types of LPG kits that can be used to convert gasoline to LPG, but only CM LPG kits are acceptable easily by the public fleet in Magelang due to the consideration of existing vehicle technology (carburettor and injection based). Furthermore, the potential for CO_2 emission reduction is discussed based on data obtained from the review literature, as one of the considerations of policymaking related to environmental aspects. Flow path economic analysis and CO_2 emission are presented in Fig 3.

2.2 Economic Parameters

2.2.1 Break Even Point (BEP)

BEP analysis is used to determine the distance that a vehicle must travel after converting to LPG to cover costs incurred as a result of a conversion. In this case, the initial investment also considers the cost of engine standardization. As is known, pre-inspection is required before the car can be converted, including engine noise, fuel and oil leaks, and emissions so that technical requirements are met. Since almost all of the vehicles available as the object of this study have exceeded 60,000 km of mileage, the conversion cost must consider the cost of engine standardization through engine overhaul to meet technical requirements (Propane Education and Research Council, 2011; 2012). Then, all the conversion costs are compared to public fleet operational costs with gasoline RON 88 and RON 90. BEP distance is calculated using Eq. (1).

$$BEP = \frac{I_0}{\left(RC_g - RC_L\right)} \tag{1}$$

2.2.2 Budgeting Decision

To assess the feasibility of conversion investment programs, this study uses NPV, IRR, Payback Period, then continued with a sensitivity analysis of possible cost changes. NPV is proceeds discounted based on investment cost, whereas IRR is the interest rate that will make the present value of expected proceeds will be accepted. This program is considered feasible if NPV > 0 and IRR is greater than bank interest. By monthly profit calculated with cash inflow minus cash outflow $\left(Ci_1 - Co_1 = \pi_1\right)$, NPV is calculated using Eq. (2).

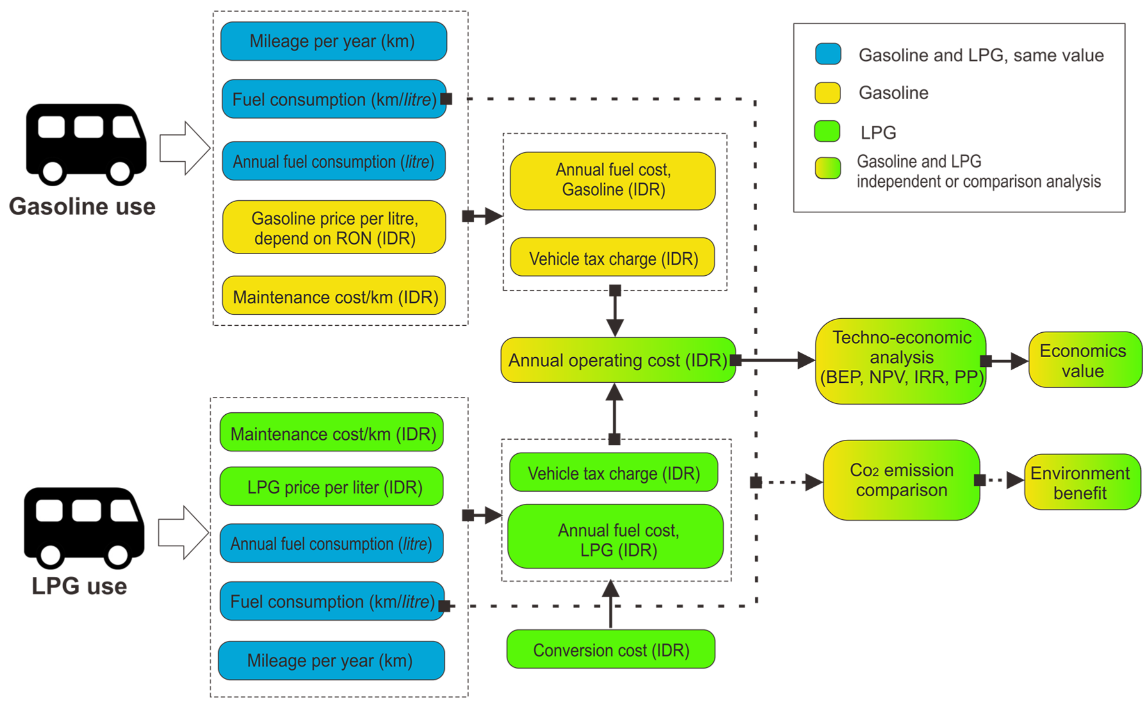

Fig. 3 Modelling of economics values and CO2 emission comparison

$$NPV = \pi + \frac{(\pi_1)}{(1+i)} + \frac{(\pi_2)}{(1+i)^2} + \ldots + \frac{(\pi_n)}{(1+i)^n} + \frac{S}{(1+i)^n} - I_0 \quad (2)$$

Assumed, the converter kits has a well-performing lifespan for 5 years with no salvage value and the monthly profit (π) and interest i are the same as long as the investment forecast (n period), NPV can be calculated by Eq. (3).

$$NPV = \left[\frac{\pi \times \left[1-(1+i)^{-n}\right]}{i} \right] - I_0 \quad (3)$$

Furthermore, the payback period is calculated to assess the period required to recover the investment cost with net cash flow (Eq. (4)). The faster the PP is achieved, the more promising this program is to implement. Finally, sensitivity analyses were conducted to anticipate changes in parameter values, including vehicle mileage per year and cost ratio of LPG to gasoline.

$$PP = \frac{I_0}{\pi} \quad (4)$$

2.2.3 Financing Scenario

In this study, the government could provide all the conversion costs or share with the public fleet owner. There are at least 3 financing components that can be shared; that is, conversion cost, engine standardization cost, and annual tax and inspection cost. Thus, there are three possible financing scenarios to be considered as presented in Table 1.

The total financing from the government (conversion cost, engine standardization cost, and annual tax and inspection costs) through a grant or social assistance program is not included in the simulation analysis, because the BEP and payback period will be zero, while the IRR becomes unpredictable. However, the scenario will be a comparison in the discussion. Although taxes and inspection costs are also small, this is interesting to study because the conversion cost is present at the beginning and the annual tax charge will affect the vehicle operating cost.

2.3 Comparison of CO_2 Emission

Emissions from LPG and gasoline vehicles compared to kg/year. In the previous study (Setiyo et al., 2016), emissions of gasoline and LPG vehicles have been compared but by stationary measurements that cannot be represented in this analysis. Therefore, the estimated CO_2 emissions from LPG vehicles in kg/year against emissions from gasoline vehicles will be calculated as in Eq. (5).

Table 1 Possible conversion financing scenarios

Cost type Scenario	Conversion cost	Engine standardization cost	Annual tax and inspection cost
Scenario 1	Government	Car owner	Government
Scenario 2	Government	Car owner	Car owner
Scenario 3	Car owner	Car owner	Government

$$CO_2 \text{ benefit of LPG car} = \frac{(CO_2 \text{ of gasoline car-}CO_2 \text{ of LPG car})}{CO_2 \text{ of gasoline car}} \times 100\ \% \quad (5)$$

3 Result and discussion

3.1 Public Fleet Operational Data

Annually, the Department of Transportation of Magelang City conducts surveys of vehicles, operational costs, and daily transactions of public transport for use as executive data. The results of the examination of all city routes in the last year are presented in Table 2.

From Table 2, it is found that only 90 % of the fleet operates daily, while the remaining 10 % does not operate. Oil maintenance cost is estimated from total traveled per year divided by 5,000 km as the standard oil replacement. The average fleet crew wages amounted to IDR 57,000. If one fleet consists of a driver and co-driver, then the total wage is divided for both. With 60 % / 40 %, daily average wage for driver and co-driver is IDR. 34,000 and IDR. 23,000, respectively. It is much smaller than Magelang City minimum wage standard of 1,580,000/month (IDR 53,000/day). Wages are obtained if the fleet uses gasoline RON 88 with a price at fuel station of IDR. 6,450 per liter. If the gasoline RON 88 supply is not available in the fuel station, the driver and co-driver wages are lower than they should be. If driver and co-driver wages are maintained, the deposit (mandatory cost submission) to the car owner will be reduced. This polemic is happening now in Magelang, which must be found a solution, immediately. Based on data from the Department of Transportation of Magelang City as shown in Table 2, further analysis of the cost calculations are presented in Table 3.

3.2 Vehicle Running Cost and BEP

Vehicle running costs and BEP are calculated using Eq. (1) by the parameter values are given in Table. 3. Furthermore, the calculation results are compared with some developing countries in Asia that presented in Fig. 4 (a) and Fig. 4 (b). In this study, we focused on comparing conditions in Indonesia with several developing countries in Asia, as a

Table 2 Public fleet data, operational cost, and daily transaction

Public Fleet data and specification														
Component	Unit 1						Line							
		2	3	4	5	6	7	8	9	10	11	12	13*	
1. Number of fleets registered	Unit	29	36	35	37	19	28	30	30	28	38	10	15	29
2. The number of fleets operates daily	Unit/day	27	33	32	35	17	25	28	28	25	35	8	13	25
3. Daily operation (average)	km/day	171	140	155	186	140	124	124	155	109	155	93	93	155
4. Year production	year	1998	1999	1999	2001	1998	1998	1996	1999	1996	2000	1998	1998	1996
Operational cost data (x thousand)														
Component	Unit 1						Line							
		2	3	4	5	6	7	8	9	10	11	12	13*	
1. Vehicle tax cost	IDR/year	200	200	200	200	200	200	200	200	200	200	200	200	200
2. Organization fee	IDR/year	36	36	36	36	36	36	36	36	36	36	36	36	36
3. Vehicle inspection costs	IDR/year	80	80	80	80	80	80	80	80	80	80	80	80	80
4. Fuel cost (gasoline)	IDR/day	110	90	100	120	90	80	80	100	70	100	60	60	100
5. Oil maintenance Cost	IDR/year	1992	1630	1811	2173	1630	1449	1449	1811	1268	1811	1087	1087	1811
6. Cleaning and washing cost	IDR/year	3650	3650	3650	3650	3650	3650	3650	3650	3650	3650	3650	3650	3650
Daily transaction (x thousand)														
Component	Unit 1						Line							
		2	3	4	5	6	7	8	9	10	11	12	13*	
1. Daily gross transaction	IDR/day	160	150	150	160	110	110	110	140	100	160	90	80	110
2. Deposit (submission to car owner)	IDR/day	90	80	80	90	60	60	60	80	50	90	50	40	60
3. Driver's wages	IDR/day	70	70	70	70	50	50	50	60	50	70	40	40	50

*Line 13 is the buffer line of Magelang-Borobudur (temple tourist area)

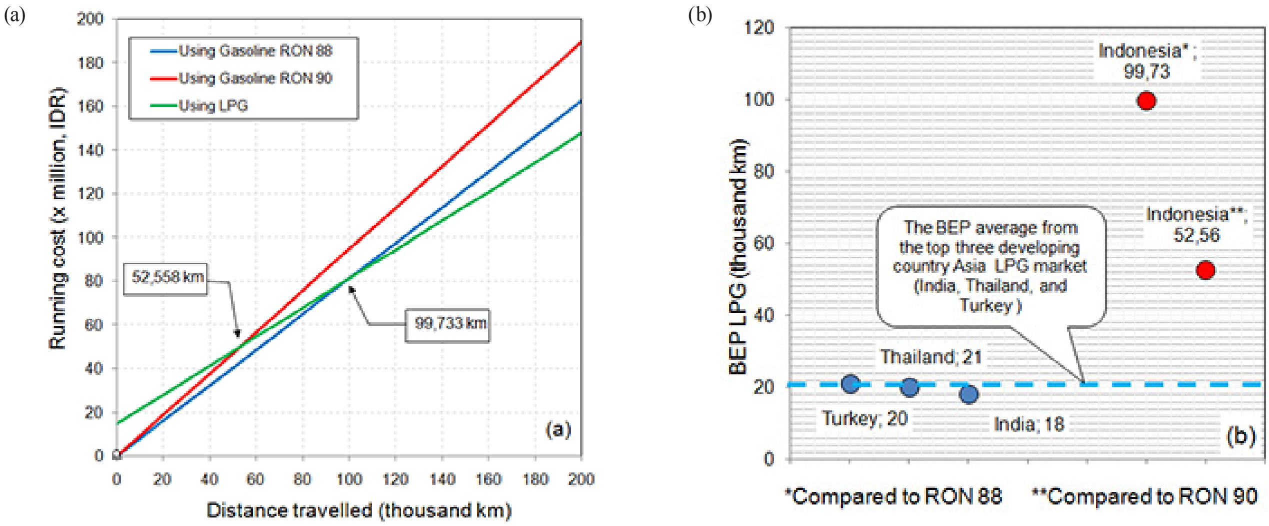

Fig. 4 (a) Distance traveled, running cost, and BEP LPG vehicle compared to gasoline operation: Predicting in Indonesia; (b) BEP LPG vehicle compared to gasoline operation: Comparison to the developing countries in Asia

fair comparison. Meanwhile, BEP for developed countries in detail has been explained in the WLPGA annual report.

In India, converting gasoline to LPG will get the BEP at a distance of 18,000 km. To promote LPG, the Indian government imposed a different fuel sales tax, 14.5 % for LPG and 27 % for gasoline. The conversion cost in India is also relatively low, estimated at 25,000 rupees (about Rp 5,225,943). In Thailand, although there is an increase in the price of all fuels, LPG prices remain quite low compared to the price of gasoline so that the BEP distance is

Table 3 Operational data of gasoline and LPG-fueled vehicles

Parameters	Amount	Formula
Vehicle mileage per year, km	50,495	vm
Fuel consumption, km/*l*	10	Fc
Annual fuel consumption, *liter*	5,049	$Fc_a = \frac{vm}{Fc}$
Gasoline RON 88 price/liter, IDR	6,450	C_{g88}
Gasoline RON 90 price/liter, IDR	7,800	C_{g90}
LPG price/liter equivalent to gasoline, IDR	5,100	C_L
Annual fuel cost for gasoline RON 88, IDR	32,569,231	$C_{g88,a} = Fc_a \times C_{g88}$
Annual fuel cost for gasoline RON 90, IDR	39,386,047	$C_{g90,a} = Fc_a \times C_{g90}$
Annual fuel cost for LPG, IDR	25,752,415	$C_{L,a} = Fc_a \times C_L$
Annual saving LPG to gasoline RON 88, IDR	6,816,816	$\pi_{g88-L} = C_{g88,a} - C_{L,a}$
Annual saving LPG to gasoline RON 90, IDR	13,633,631	$\pi_{g90-L} = C_{g90,a} - C_{L,a}$
Cost for LPG kits, IDR	10,000,000	C_{ck}
Cost for engine standardization, IDR	5,000,000	C_{es}
Oil maintenance cost for gasoline per km, IDR	32	C_{og}
Oil maintenance cost for LPG per km, IDR	23	C_{oL}
Oil maintenance cost for gasoline per year, IDR	1,615,838	$C_{og,a} = C_{og} \times vm$
Oil maintenance cost for LPG per year, IDR	1,154,170	$C_{oL,a} = C_{oL} \times vm$
Spare part and washing cost per year, IDR	6,650,000	C_{ck}
Annual vehicle tax, inspection, and membership cost, IDR	316,000	C_{ck}
Running cost /km for gasoline RON 88, IDR	815	$RC_{g88} = \frac{C_{g88}}{Fc} + \frac{C_{sw} + C_{tax}}{vm} + C_{og}$
Running cost /km for gasoline RON 90, IDR	950	$RC_{g90} = \frac{C_{g90}}{Fc} + \frac{C_{sw} + C_{tax}}{vm} + C_{og}$
Running cost /km for LPG with tax & inspection cost, IDR	671	$RC_{L,t} = \frac{C_L}{Fc} + \frac{C_{sw} + C_{tax}}{vm} + C_{oL}$
Running cost /km for LPG without tax & inspection cost, IDR	665	$RC_L = \frac{C_L}{Fc} + \frac{C_{sw}}{vm} + C_{oL}$

only 21000 km. The total conversion cost in Thailand is about 30,000 baht (IDR 13,156,720), 2.5 times that of India, but LPG prices are much lower than gasoline (35 %), making LPG vehicles quite promising in Thailand. In Turkey, conversion costs are also relatively low, about 2200 Lira (IDR 7,239,620). BEP distance in Turkey is reached at a distance of only 20000 km, which is comparable to India and Thailand (World LPG Association, 2017). As another explanation, differences in BEP in Indonesia to other developing countries in Asia are also influenced by fuel prices at the fuel station, as given in Fig. 5.

From 2007 to 2011, the Indonesian government provided free of charge (including modifications to bi-fuel) more than 5000 converter kits for taxis and public fleet in several cities, such as Bogor, Surabaya, Palembang, and Jakarta. However, the program does not seem to have

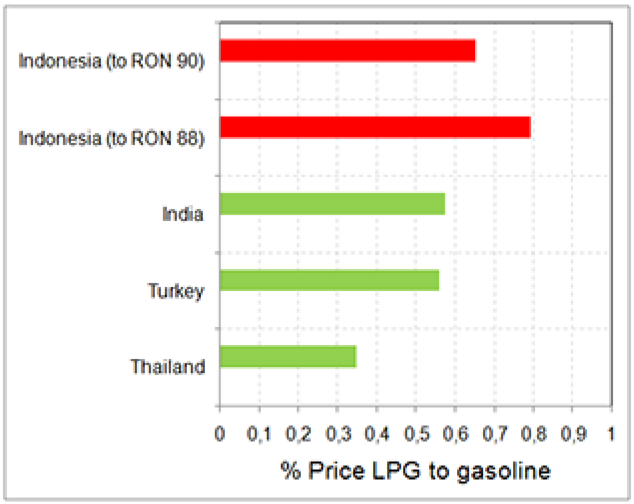

Fig. 5 Competition of LPG to gasoline prices in Indonesia compared to the top three LPG markets in developing countries in Asia

grown, seeing the trend of converter kit sales by private parties. One of the causes is the government's neglect of public transport, which encourages the use of gasoline because the price difference between LPG and gasoline makes it less profitable. This phenomenon also occurs in China, as reported by Leung (2011). In addition, the limitations of infrastructure, such as refueling sites and authorized maintenance center causes frustration to the drivers.

3.3 Investment Feasibility Analysis

In the present work, blic fleet from gasoline to LPG using effective interest rates per month. Investment feasibility is set for 60 months (5 years) with bank interest is assumed at 1 % per month, a fair rate in Indonesia. Based on financing scenarios given in Table 1, the NPV and IRR calculations are presented in Fig. 6.

Analyzing the three simulated scenarios, the gasoline to LPG conversion program in Magelang is promising for scenario 1 and scenario 2, where the government provides the grant for converter kits and exemption from tax charges. In fact, compared with gasoline RON 90 and the engine standardization charged to public fleet owners, they will benefit immediately before 5 months of operation. Vehicle owners can apply for loans to state-owned banks because IRR's resistance is much higher than the IRR calculated in this simulation. However, if using scenario 3, where conversion

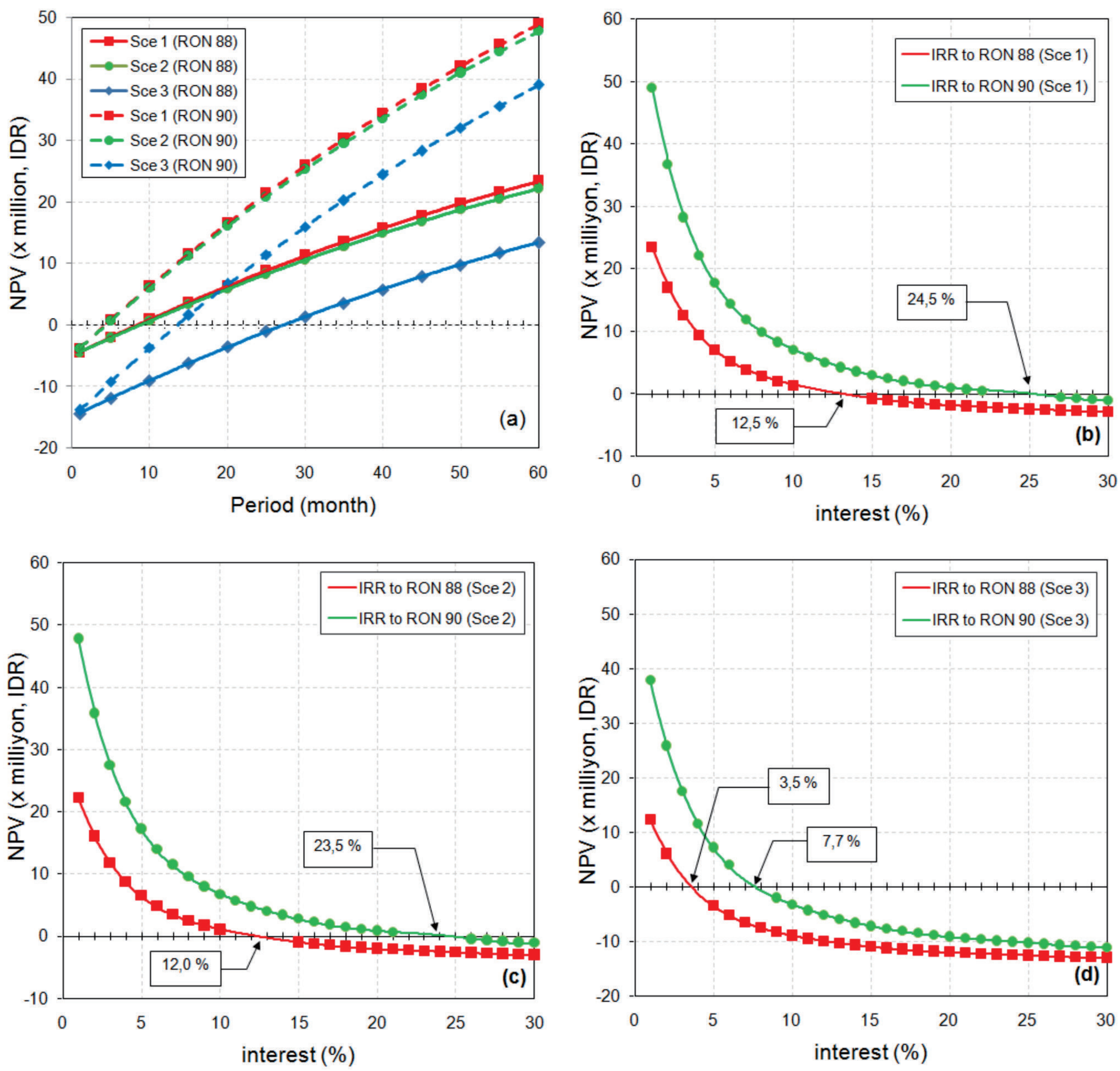

Fig. 6 NPV and IRR of LPG operation compared to gasoline RON 88 and RON 90 operation:
(a) NPV for 3 scenarios: (b). IRR scenario 1; (c) IRR scenario 2, and (d). IRR scenario 3

costs are borne by the owners of the public fleet, the program becomes unattractive to them.

In addition to conversion costs, the more important consideration is the price difference between LPG and gasoline. The smaller the price ratio of LPG to gasoline, the owners of the public fleet will tend to be interested themselves to convert their vehicles, by looking at the promising NPV. The initial investment costs are not an obstacle if the government guarantees the continued use of LPG at a reasonable price. On the other hand, availability should also be guaranteed so that people do not return to use gasoline (Melikoglu, 2014). If these conditions are to be expected, the role of the socio-economic institution becomes important to provide socialization and convince the owners of public transport.

3.4 Payback Period

Three simulated financing scenarios yield different payback period characteristics. For scenario 1 and scenario 2, the government's conversion financing has similar characteristics due to the fact that the annual tax and inspection costs are relativity small. The owners of the public fleet will receive a payback period of 8 and 5 months in comparison with RON 88 and RON 90, respectively. However, for scenario 3, with conversion financing by vehicle owners, the payback period is prolonged: 24 and 13 months in comparison with RON 88 and RON 90, respectively. The payback illustration for the three financing scenarios is presented in Fig 7.

Furthermore, since the annual mileage for each route is different, payback periods can be simulated and compared independently, as shown in Fig. 8.

3.5 Sensitivity Analysis

Sensitivity analysis is used to measure changes in NPV if there are changes in key indicators affecting project appraisal. While scenario analysis is used to measure how much the expected value and the coefficient of variance of the project changes when faced with the probability of the condition in the future. The coefficient of variance is very important because it measures the overall risk of the project. The sensitivity analysis is based on three financing scenarios as set out in Table 1. However, since scenario 1 and scenario 2 have almost identical NPV characteristics, then this sensitivity analysis will compare scenario 1 and scenario 3. Fig. 9 shows the sensitivity analysis of two financing scenarios with different NPV characteristics. Based on sensitivity analysis, from two financing scenarios, conversion projects from gasoline to LPG are very sensitive to gasoline prices, both RON 88 and RON 90, and mileage per year, as presented in Table 4.

Based on the summary in Table 4, scenario 1 has the lower coefficient value than scenario 3. It means that scenario 1 has the lower risk level than scenario 3. Therefore, scenario 1 is more feasible economically.

3.6 Socio-Economic Benefit

The simulation results show that there is an increase in public transport crew wages after the vehicle is converted to LPG. When compared to gasoline RON 88, there is an increase of 37 % and when compared with gasoline RON 90, there is an increase of 70 % against existing wages. The choice of financing scenario will affect the time period but does not affect the amount, as presented in Fig. 10.

In this case, if the anxiety of the public fleet crew is due to competition with the online fleet, the Government of Magelang City may provide financing for conversion and engine standardization through a grant scheme or in collaboration with State-Owned Enterprises (SEO) through a CSR scheme. In this case, the owner of the public fleet does not spend anything. If this option is chosen, public fleet crews will receive benefits in the first month that they operate their vehicles with LPG. With the number of existing fleets, it is estimated that these benefits can have a good economic impact on more than 700 families of public fleet crews. If one family consists of four people, there will be at least more than 2800 people who will benefit from this conversion program. Learning from the LPG mega project for households in 2007, the Government of Indonesia has successfully converted kerosene into LPG through the Blue Sky program (Budya and Yasir Arofat, 2011; PT Pertamina, 2011). For now, the government can also adopt a similar strategy for economic and environmental reasons. In infrastructure, the government should also equip all the existing fuel stations in Magelang City and along the Magelang-Borobudur line with LPG dispensers, either owned by Pertamina (SEO) or privately owned.

Table 4 Summary of sensitivity analysis

	Expected Value	Standard Deviation	Coefficient of variation
Scenario 1	36.22	22.60	0.62
Scenario 3	26.22	20.17	0.77

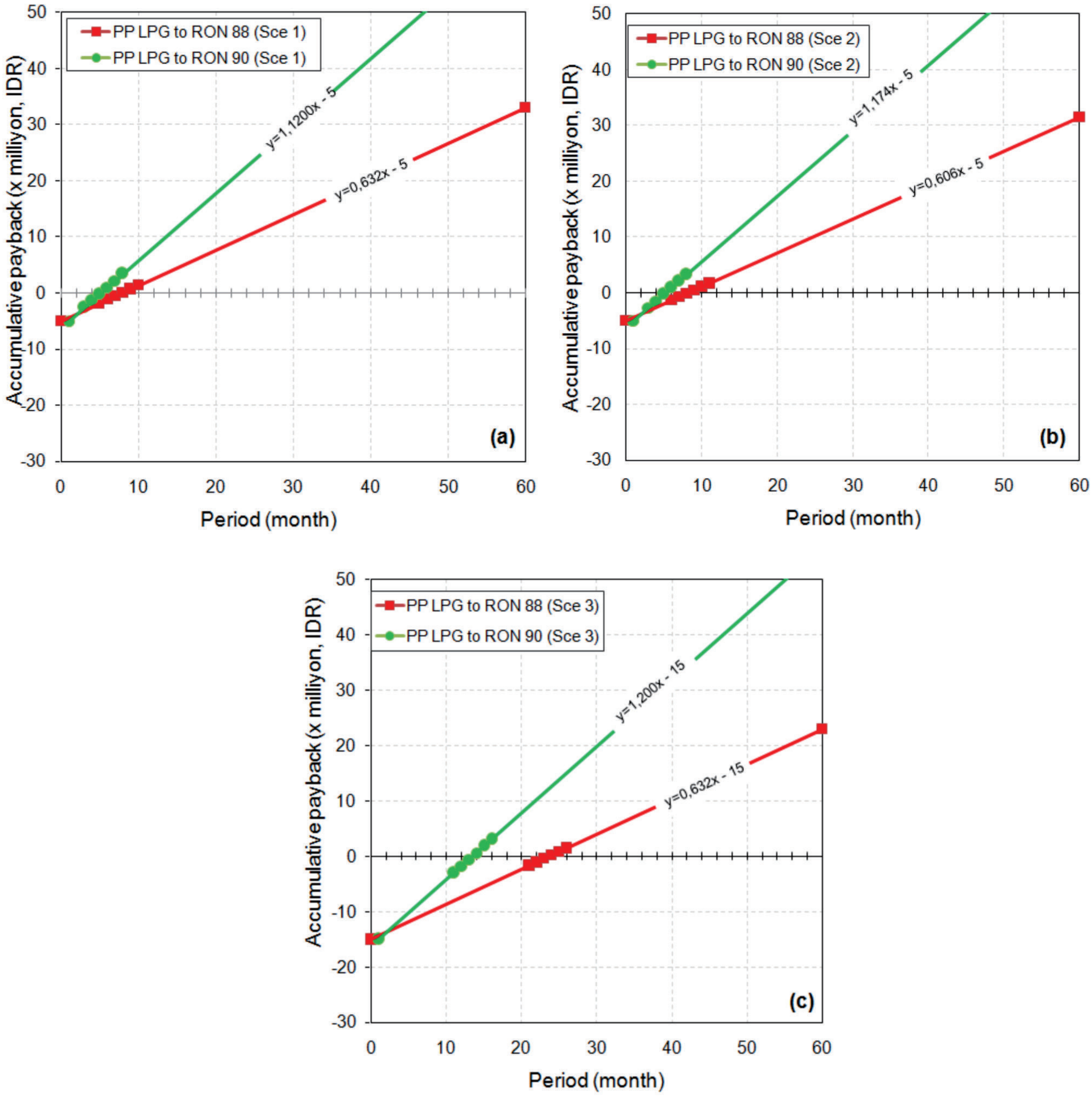

Fig. 7 Payback periods: (a) scenario 1, (b) scenario 2, and (c) scenario 3

3.7 Environmental Benefits

From the literature study, there are many reports on the emission comparison of vehicles fueled by LPG and gasoline (Alam et al., 2017; Bielaczyc et al., 2016; Lai et al., 2009; Lau et al., 2011; Tasic et al., 2011). However, in this study, we will use data reported by Jeuland and Montagne (2004) because it uses the New European Driving Cycle (NEDC) with a variety of samples. Based on their test results, gasoline and LPG vehicles produce nearly equivalent CO, HC and No_x emissions, with value of 1.03/1.094 for CO, 0.075/0.061 for HC, and 0.05/0.016 for No_x (in g/km). However, there are significant differences in CO_2 emissions, which is 171.2 g/km for gasoline use and 152.9 g/km for LPG use. From the data presented in Table 2, it is estimated that the public fleet in Magelang City covers a distance of 17,511,605 km per year. The resulting CO_2 emissions are estimated at 2,997.99 tons/year by gasoline and 2,677.52 tons/year by LPG. From these calculations, the use of LPG can reduce CO_2 about 320.46 tons/year or about 11 %.

4 Conclusion

Based on the simulation result, gasoline to LPG conversion program for the public fleet in Magelang city is feasible to be applied as a replacement for gasoline RON 88 and gasoline RON 90, through 3 types of financing

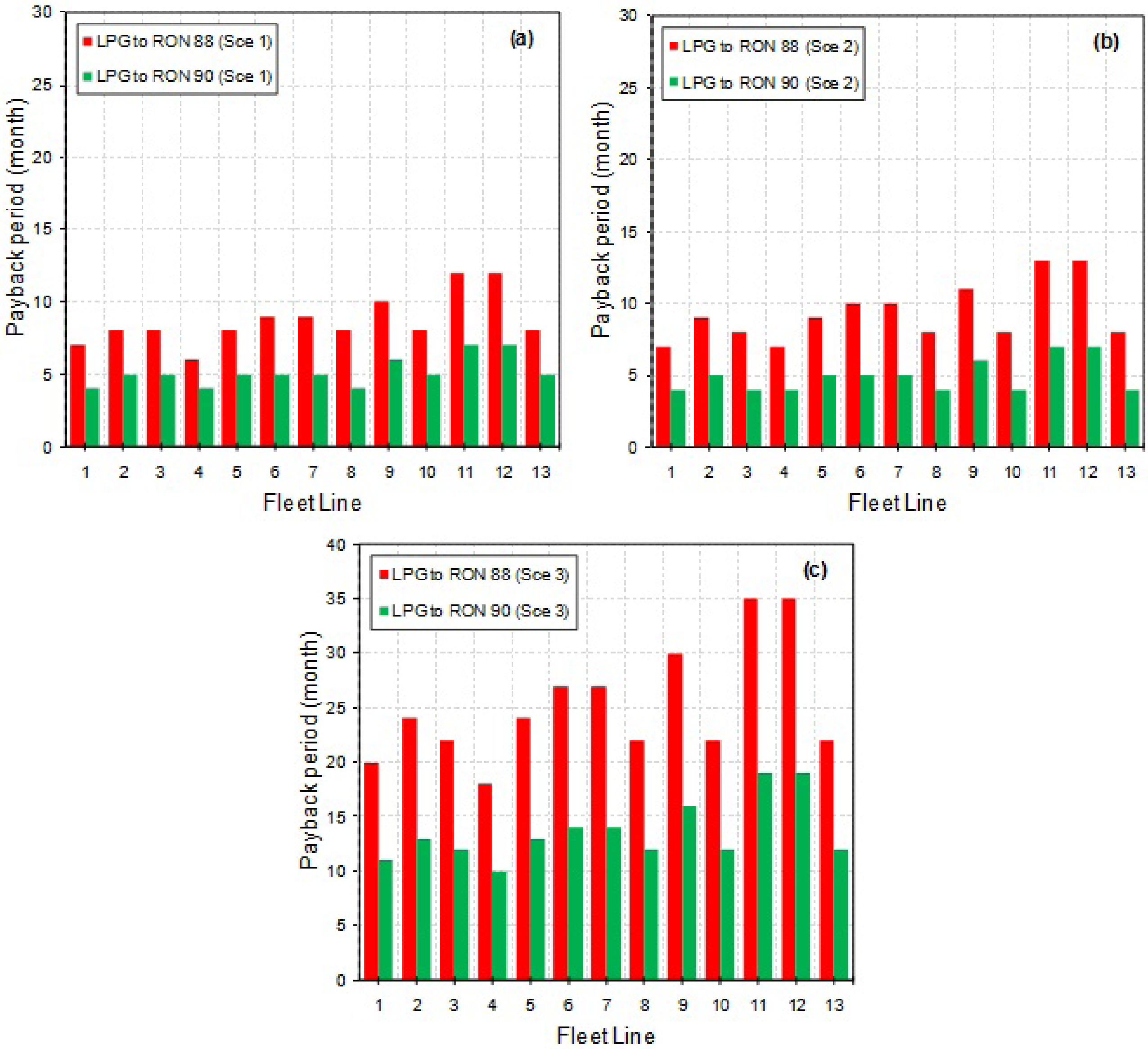

Fig. 8 Payback periods for 13 fleet-lines: (a) scenario 1, (b) scenario 2, and (c) scenario 3

scenarios. The value of NPV of LPG to RON 88 is IDR. 23.45, 22.27, and 13.45 for scenarios 1, 2, and 3, respectively. In fact, the NPV of LPG investments into gasoline RON 90 is more promising at IDR. 48.99, 47.80, and 38.99 for scenarios 1, 2, and 3, respectively. All investment scenarios are set at 60 months. Of course, these numbers will change if the investment parameters and running cost of the vehicle are changed. On the other hand, BEP in Indonesia is longer compared to three developing countries in Asia (Turkey, India, and Thailand) which have a successful experience of promoting LPG as an alternative to gasoline because the fuel price ratio in Indonesia is higher. The conversion program is predicted to be able to increase the public fleet crew's revenue by 37 % and 70 % to switch from gasoline RON 88 and gasoline RON 90, respectively. Environmental benefits are also expected to improve, with CO_2 emission reduction of 320.46 tons/year or about 11 % of gasoline usage. These two benefits (economics and environmental) are expected to support clean city program in Magelang. Consequently, the government must equip all existing fuel stations in Magelang City and along the Magelang-Borobudur Tourism Area with LPG dispensers. If this program is implemented, there is an additional demand for LPG of more than 1,800 kiloliters per year which must be provided by Pertamina to Magelang City.

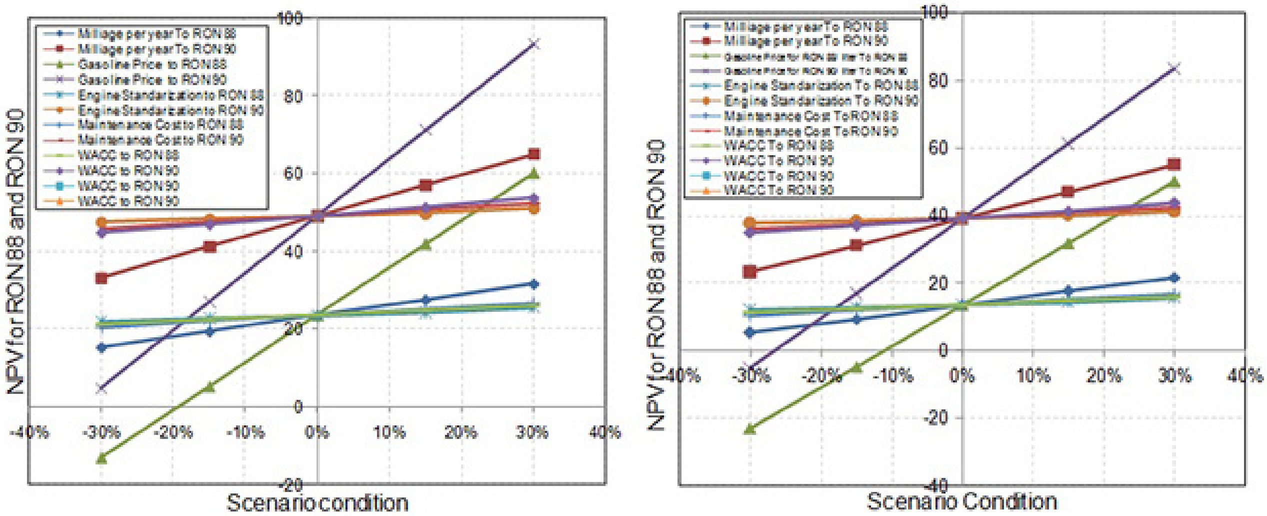

Fig. 9 Sensitivity analysis of the financing scenarios

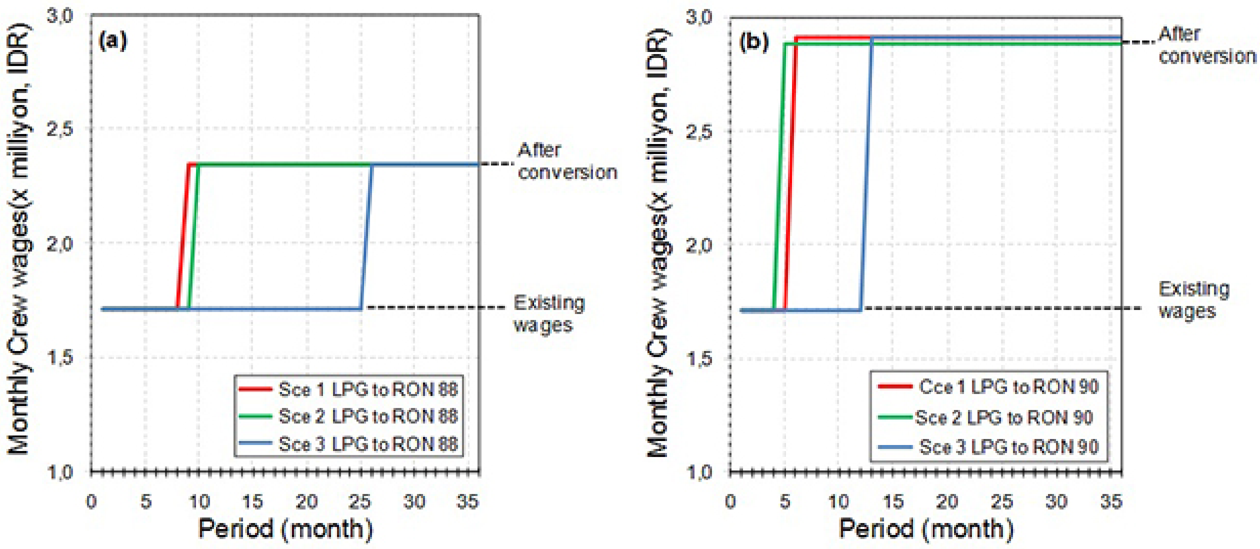

Fig. 10 Wage prediction of the public fleet crew: (a) LPG to gasoline RON 88 and (b) LPG to gasoline RON 90

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Nomenclature and Abbreviation

BEP	Break Even Point
C_i	Cash inflows
C_o	Cash outflows
i	Bank interest
I_0	Initial investment or capital costs
IRR	Internal Rate of Return
LPG	Liquified Petroleum Gas
n	Period
NPV	Nett Present Value
OEM	Original Equipment Manufacturer
PP	Payback period
RC_g	Running cost using gasoline per kilometer
RC_L	Running cost using LPG per kilometer
RON	Research Octane Number
S	Salvage values in the end of period
SEO	State-Owned Enterprises

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