Study of domestic coal-based dimethyl ether (DME) utilization to reduce LPG import

Annisa Muliahati[1,*], *Eva Fathul Karamah*[2], and *Ika Kaifiah*[3]

[1]Gas Management, Chemical Engineering Indonesia University, Depok, Indonesia
[2]Chemical Engineering, Indonesia University, Depok, Indonesia
[3]PPPMGB Lemigas, South Jakarta, Indonesia

Abstract.
This study evaluates the utilization of domestic coal-based dimethyl ether (DME) to substitute 15% of the total household sector demand of LPG import projected to year 2040 and the impact to the saving of state budget. Maximum LPG-DME blending in this study is 85% - 15% weight. DME-LPG mixture price at depot will be calculated based on DME FOB price at production plant, shipping cost, mixing and handling cost. The result of the research shows that DME-LPG mixture price and the import LPG price at each depot are 391 USD/MT and 620 USD/MT at Depot Tanjung Priok, 390 USD/MT and 620 USD/MT at Depot Eretan, 396 USD/MT and 622 USD/MT at Depot Tanjung Perak, 397 USD/MT and 622 USD/MT at Depot Gresik, and 401 USD/MT and 624 USD/MT at Depot Semarang. The substitution of LPG import with domestic coal-based DME results the saving of state budget about 388 million USD (IDR 5,332 billion). It concludes that the utilization of domestic coal-based DME is economically feasible to reduce the import of LPG per metric ton (MT), obtain the saving for state budget, and help the government to decrease the dependency of import LPG to maintain the national energy security.

1 Introduction

Since 2015, LPG demand in Indonesia reached 7.5 million TOE (tonne of oil equivalent) meanwhile the existing national production only 2.9 million TOE. Therefore, in 2016 the LPG import reached 67% of total national demand and the amount of state budget about 2,647 million USD (IDR 36,367 billion). It is necessary to find alternative energy that can help the government to reduce the burden of LPG import that impact on state budget saving. One of the alternative energy to substitute LPG import is Dimethyl Ether (DME).

DME has similar characteristics to LPG. DME can be produced from coal, natural gas, and biomass. However, the production of DME from coal provides the lowest production cost [1]. Indonesia as the second highest coal exporter country in the world contributes 28% of world's need [4]. Ironically, from the total national coal production in 2015, more than 75% was exported to other countries [8]. In fact, with total reserves of domestic coal per year 32.3 billion metric tons (MT) and the average coal demand growth of 6% per year, the reserves can be produced up to 40 years. So, the DME production from domestic coal can be sustained. Therefore, this study will evaluate the feasibility of coal-based DME utilization to reduce LPG import in Indonesia. This utilization will not only optimize the use of domestic coal but also overcome the growing LPG demand.

1.1 Characteristic of DME

The largest market of DME is as blend fuel with LPG for the residential cooking and heating, particularly in China [3]. This is related to the fact that DME can be blended with LPG up to 15% weight and would not require any modification either in the existing distribution infrastructure or in the users' appliances [7].

From some studies it is known that DME is an alternative fuel that can be used as a mixture for other fuels or even as pure DME [2]. Here is a comparison between DME and LPG in Table 1.

Table 1. Physical Properties & Characteristics of DME Compare to Other Fuels

Characteristics	DME	LPG
Formula	CH3OCH3	C3H8
Boiling Point (°C)	-25	-42
Liquid Density (kg/m3)	0.66	0.49
Viscosity, 40°C (cP)	0.18	0.1
Cetane Number	55 - 60	5
Auto Ignition Temp. (°C)	235	470
Lower Heating Value (MJ/kg)	28.8	46

Based on the table, it can be seen that DME has similar characteristics to LPG but has a lower heating value than LPG. In this study will be evaluated the feasibility of DME-LPG as a mixture to substitute LPG import.

* Corresponding author: annisamuliahati@gmail.com

1.2 DME-LPG Mixture

The research that assess the amount of fuel consumption need for the burner test, has been done by PPPTMGB Lemigas by modifying burner which is generally used in household sector. It is given the same burning load and the result showed that the average amount of LPG consumption about 0.24 kg while the average amount of DME consumption about 0.35 kg [1]. Therefore, the equivalence of DME and LPG fuels from the test results on the modified burner is 1.5 which means that 1 kg of LPG is equivalent to 1.5 kg DME. This value becomes a reference in the economic calculation analysis.
Meanwhile, the specification for DME as household and industrial fuel in Indonesia is regulated in Decree of The Director General of Oil and Gas Number 990.K/10/DJM.S/2013, as follows in Table 2.

Table 2. The Specification for DME as Household and Industrial Fuel in Indonesia

Characteristics	Units	Limitation		Test Method ASTM
		Min	Max	
Specific Gravity 60/60 oF		Reported		D 1657/ D2598
Vapour Pressure @100 oF	psig		145	D 1267
Weathering Test @36oF	%vol	95		D 1837
Copper Corrosion	1 hour/100 oF		No.1	D 1838
Total Sulphur	Grains/100 cuft		15	D 2784
Water Content		No Free Water		Visual
Composition - CH3OCH3 - CH3OH - Others (*light ends*)	% vol	100	 0.4 0.1	D 2163
Ethyl atau Butyl Mercaptan	ml/1000 AG		50	Calculated

1.3 DME Demand for Household Sector in 2040

The limitation of this study is the amount of DME that will be evaluated to substitute LPG imports is 15% of the total imported LPG demand in 2040. Because the maximum amount of DME that can be blended with LPG is only 15% weight (85% weight LPG) without any modification to the existing household sectors' facilities. The LPG demand forecasting in 2040 is calculated based on Indonesia Energy Outlook (IEO) 2016 data in business as usual (BAU) scenario with increasing LPG demand 2% per year. LPG import demand forecasting in 2040 is 8,442,253 MT. Based on this study limitation, therefore the amount of DME demand in 2040 is 1,899,507 MT. Then it will be evaluated to assess the feasibility of substituting LPG import with the domestic coal-based DME and state budget saving that can be obtained from the substitution.

1.4 DME Distribution Scheme

The DME distribution scheme follows the existing LPG distribution scheme. This can be applied because they have the same characteristics. Moreover, LPG has a higher saturated vapor pressure than DME so the equipment designed for LPG can also be used for DME.

The DME distribution scheme analysed in this study is limited to the shipment from the DME plant in East Kalimantan to the depots, as described by the figure below.

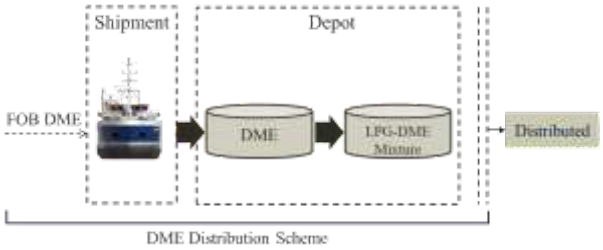

Fig. 1. DME Distribution Scheme from DME Plant to Depots

This scheme is applied for DME distribution from DME plant to each depots. Based on the previous study [7], the selected depots in this study are depots which regularly receive imported LPG and already have blending facilities to mix propane and butane. Those depots are Tanjung Priok Depot, Eretan Depot, Tanjung Perak Depot, Gresik Depot, and Semarang Depot.

2 Economic Analysis for DME-LPG Mixture for Household Sector

2.1 Coal-based DME FOB Price Calculation

The coal-based DME FOB price referred to the previous study based on the methodology used by Phillips et al (2007) with minimum selling fuel price (MSFP) at 10% IRR [1]. In this study, coal-based DME plant is assumed to be located in East Kalimantan closed to the location of coal sources as the raw material. The calculation components of the coal-based DME FOB price are total investment cost (CAPEX), raw material efficiency, utility cost, raw material price, and electricity selling price as a DME plant by-product.

CAPEX calculation of DME plant based on direct synthesis process (direct DME synthesis) used in NKK corp. Japan (2003) for plant capacity 2,500 MT/day required CAPEX 480 million USD. As to know the current price due to price escalation, the correction of price in 2003 with price index of Chemical Engineering Plant Cost Index (CEPCI) calculated using equation (1) as follows:

$$Ex = Ey\frac{Nx}{Ny} \quad \text{… Eq. (1)}$$

where,
Ex : Price Year X
Ey : Price Year Y
Nx : Price Index Year X
Ny : Price Index Year Y

and the result obtained from this equation is as shown in Table 3.

Table 3. DME Plant CAPEX Estimation Year 2017

Plant Capacity (MT/day)	Year	Index	CAPEX (million USD)
2,500	2003	402	480
8,700	2017	574	1,448

From the table it is known that the DME plant with capacity of 8,700 MT/day in 2017 has CAPEX 1,448 million USD.

Another parameter for the FOB DME price is the efficiency of the feedstock. The efficiency of raw materials shows how much the coal needed to produce DME, where efficiency will depend on the thermal efficiency of a process or known as cold gas efficiency. Referring to CCUJ (Central for Coal Utilization) and JIE (Japan Institute Energy), DME production from coal has an efficiency 60% or 46 MMBTU/MT DME. Besides, utility costs such as water, electricity and other costs required in producing DME also affect the FOB DME price. Utility costs will depend on the type of DME synthesis process. For DME production process according to CCUJ data (2003) is 5.3 USD/MT DME. Using equation (1) due to the price correction of 2003 to 2017 obtained 7.6 USD/MT DME.

The coal price as raw material also affects the price of coal-based DME FOB price. Raw material price refers to Coal Reference Price (Harga Batubara Acuan) for December 2017 is 94.04 USD/MT [5] or equivalent to 4.65 USD / MMBTU with the assumption that 1 ton of coal is equivalent to 20,224,900 BTU. Meanwhile, the sale of electricity as a by-product of the DME plant is obtained due to the low gas efficiency of the coal gasification process only about 60%. Therefore, the remaining heat released can be utilized to generate electricity through turbine gas. The assumptions used are thermal efficiency of turbine gas 35%, heat rate 10,000 BTU/KWh, and capacity factor 75%. The calculation uses the equation as follows.

$$KWh = \frac{Mf \times LHV \times \eta}{HR} \times Cf \quad \text{… Eq. (2)}$$

where,
KWh : amount of KWh generated by Generator
Mf : amount of fuel (MT)
LHV : lower heating value (Kcal/Kg)
HR : heat rate (BTU/KWh)
η : thermal efficience (%)
Cf : capacity factor (%)

by using equation (2) the result obtained that the amount of power generated from the DME production process from coal is 483 KWh/MT DME.

The data and assumptions used to calculate the FOB DME price are as shown in Table 4.

Table 4. Data and Assumptions for DME FOB Price Calculation

No.	Data and Assumptions	
1	Project Lifetime	20 years
2	Construction Phase	
	- Phase 1	25%
	- Phase 2	35%
	- Phase 3	40%
3	Operation in A Year	333 days
4	Interest Rate Loan	12%
5	Income Tax	30%
6	Discount Factor	10%
7	% Weight DME	15%
8	Scale Factor	60%
9	CEPCI 2017	574
10	CEPCI 2003	402
11	HHV DME	6,900 Kcal/Kg
12	HHV Coal	5,100 Kcal/Kg
13	Load Factor	
	- Year 1st	90%
	- Year 2nd	95%
	- Year 3rd	100%
14	Coal Price	4.65 USD/MMBTU
15	Production Capacity	8,700 MT/day
16	CAPEX	1,448 million USD
17	OPEX	
	- Raw Materials	46 MMBTU/ton DME
	- Utility Cost	8 USD/ton DME
	- Electricity Production	480 KWh/ton DME
	- Maintenance Cost	3% CAPEX
	- Administration Cost, etc.	0.5% CAPEX

Based on these data and assumptions, using Discounted Cash Flow method, the coal-based DME FOB price at IRR 10% is 327 USD/MT.

2.2 Shipping Fee Calculation

Generally, the classification of vessel types used to transport refined products is based on the ability of vessel to sail through certain shipping lines and the maximum capacity of products that can be loaded in the vessel. One of the most common system in the world for vessel type classification is AFRA (Average Freight Rate Assessment). The classification is based on the deadweight tonnage of the vessel. Whereas, the vessels' maximum capacity can be calculated by 90% deadweight tonnage depending on the density of each product. AFRA Scale for ship classification is depicted in Figure 2.

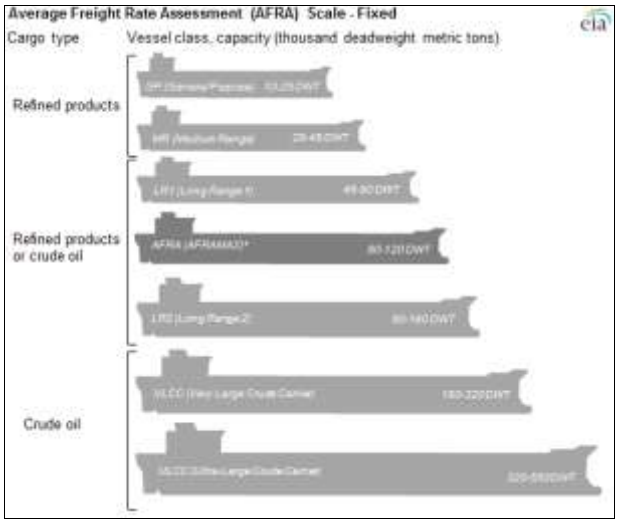

Fig. 2. AFRA Scale for Ship Classifications based on Load Capacity (deadweight metric tons)
source: https://www.eia.gov/todayinenergy/detail.php?id=17991

Based on the Figure 2, it can be seen that the vessel with the deadweight tonnage (dwt) below 25 dwt can be classified as small vessel with the maximum capacity up to 22.5 dwt. And the DME shipment from DME plant to the depots is sufficient with the small vessel.

Table 5. Shipping Fee Calculation from DME Plant to Each Depot Locations

Description	A	B	C	D	E
Vessel Speed (nm/hour)	11	11	11	11	11
Depot Throughput (MT/day)	1,676	1,822	874	801	583
Distance (nm)	943	769	534	594	792
Voyage (day)	3.57	2.91	2.02	2.25	3
Vessel Loading-Unloading:					
- Docked (hour)	3	3	3	3	3
- Connecting Hosts (hour)	0.5	0.5	0.5	0.5	0.5
- Cargo Calculation (hour)	2	2	2	2	2
- Cargo Pumping (hour)	12.78	13.89	6.67	6.11	4.44
- Disconnecting Hosts (hour)	0.5	0.5	0.5	0.5	0.5
- Cargo & Ship Documentation (hour)	2	2	2	2	2
- ATD (Actual Time Departure) (hour)	0.5	0.5	0.5	0.5	0.5
- Berthing-Unberthing (hour)	1	1	1	1	1
RTD (Roundtrip Days)	**9**	**7**	**6**	**6**	**7**
Shipping Fee (USD/MT)	**12.68**	**12.18**	**16.50**	**16.96**	**19.41**

Note:
A : Depot Tanjung Priok
B : Depot Eretan
C : Depot Tanjung Perak
D : Depot Gresik
E : Depot Semarang

The shipping fee is calculated from the cost needed to transport DME from the plant to the location of each depots. Those depots are Tanjung Priok Depot, Eretan Depot, Tanjung Perak Depot, Gresik Depot, and Semarang Depot. The location of the DME plant is assumed in East Kalimantan closed to the source of coal as raw material. The shipping fee is calculated by the discounted cash flow method to get the minimum IRR 15%, and the result is as shown in Table 5.

According to the Table 5, the roundtrip days (RTD) of each vessels are the time takes to sail back and forth to the plant site and depot. Based on the RTD, the vessel rent cost to accommodate the throughput of each depot that should be transported by vessel in every metric ton (MT) of cargo is considered as a shipping fee. The result of shipping fee for each depots are 12.68 USD/MT Tanjung Priok Depot, 12.18 USD/MT Eretan Depot, 16.50 USD/MT Tanjung Perak Depot, 16.96 USD/MT Gresik Depot, and 19.41 USD/MT Semarang Depot.

2.3 Depot Fee Calculation

Currently, the imported LPG received at the depot in the existing distribution scheme are propane and butane, then they are blended at the depot. The price of imported LPG at depot then will be compared with the DME-LPG mixture price at depot. Besides coal-based DME FOB price, and shipping fee, another component in DME-LPG mixture price is depot fee. There are several parameters to calculate the depot fee, such as investment cost (CAPEX) and operating cost (OPEX) at the selected depots. The selected depots are depots that already have propane and butane blending facilities therefore the required CAPEX is only for the additional DME storage facilities.

The additional DME storage tank capacity in each depot can be calculated based on DME demand in 2040 and vessel RTD in distributing DME to each depots. The existing and additional DME storage capacities are as shown in Table 6.

Table 6. Existing Storage Facilities & Proposed Storage Facilities

Depot	Existing	Proposed
Tanjung Priok	**Capacity (MT)**	
	2 x 500	8 x 2,500
	2 x 750	
	4 x 1,500	
Total Capacity (MT)	**8,500**	**20,000**
Eretan	4 x 2,500	7 x 2,500
		2 x 2,000
Total Capacity (MT)	**10,000**	**21,500**
Tanjung Perak	4 x 1,500	3 x 2,500
	2 x 750	2 x 1,500
	2 x 750	
Total Capacity (MT)	**8,000**	**10,500**
Depot	**Existing**	**Proposed**
Gresik	4 x 2,500	3 x 2,500
		2 x 1,000
Total Capacity (MT)	**10,000**	**9,500**
Semarang	4 x 2,500	2 x 2,500
		2 x 1,000
Total Capacity (MT)	**10,000**	**7,000**

Based on the reference from Lemigas research [8], detailed assumptions and data in economic calculation are as shown in Table 7.

Table 7. Data and Assumptions for Depot Fee Calculation

No.	Data & Assumptions	
1	Project Lifetime	20 Years
2	Operation in A Year	330 Days
3	Loan Period	3 Years
4	Interest Rate Loan	12%
5	Investment Portion:	
	- Internal Equity	30%
	- Bank Loan	70%
6	Income Tax	25%
7	Discount Factor	10%
8	Scale Factor	60%
9	Exchange Rate of USD - IDR	IDR 13,740 / 1 USD
10	Investment Reference:	
	- Capacity	2,000 Ton
	- CAPEX (2018)	USD 6,231,004

Meanwhile, the operating and maintenance costs assumption used 5% CAPEX, and insurance costs 3% CAPEX. The depot fee is calculated by the discounted cash flow method to get the minimum IRR 15%, and the result is as shown in Table 8.

Table 8. Depot Fee Calculation

No.	Description	A	B	C	D	E
1	Total Storage Capacity (thousand MT)	20	21.5	10.5	9.5	7
2	CAPEX (million USD)	56.99	62.33	31.86	29.59	22.47
3	Operation & Maintenance Cost (million USD)	2.85	3.12	1.59	1.48	1.12
4	Inssurance Cost (million USD)	1.71	1.87	0.96	0.89	0.67
5	OPEX Escalation (million USD)	5%	5%	5%	5%	5%
6	Depot Fee (USD/MT)	28.64	28.83	30.68	31.07	32.46

According to the table, the depot fees at each depots are 28.64 USD/MT at Depot Tanjung Priok, 28.83 USD/MT at Depot Eretan, 30.68 USD/MT at Depot Tanjung Perak, 31.07 USD/MT at Depot Gresik, and 32.46 USD/MT at Depot Semarang.

3 State Budget Saving

The state budget saving is calculated by comparing the price between DME-LPG mixture and the LPG import at depot. The DME-LPG mixture price is generated from domestic coal utilization to be processed into DME to fulfil the household sector demand in 2040. Meanwhile the LPG import price depends on the propane and butane price at the delivery point (depot) in Indonesia. The DME-LPG mixture price consists of coal-based DME FOB price, shipping fee from the DME plant to each depots, depot fee for DME handling, and the current LPG depot handling fee. Currently, LPG depot fee is 300 IDR/MT or equivalent to 21.83 USD/MT. The calculation components of LPG import price at the depot as the delivery point are as shown in Table 9.

Table 9. Component of LPG Import Price Calculation at Depot LPG

Calculation Factors	Value	
Propane Price (α)	525	USD/MT
Butane Price (β)	505	USD/ MT
Propane Composition (X)	42%	x Propane Price
Butane Composition (Y)	58%	x Butane Price
Contract Price (CP) Aramco	513	USD/ MT
Freight Cost	68.64	USD/ MT
Import Constant	1.88%	x CP Aramco

Components of the calculation if expressed in the equation are as follows.

$$CP\ Aramco = (X \times \alpha) + (Y \times \beta) \quad \text{…. Eq. (3)}$$

Having obtained the value of CP Aramco, the value goes into the following equation.

$$LPG\ Import\ Price = CP\ Aramco \times (1 + Import\ Constant) + Freight\ Cost \quad \text{… Eq. (4)}$$

Obtained from the calculation that the LPG import price is 591 USD/MT, and LPG import price at Depot will include theexisting LPG handling fee 21,83 USD/MT therefore the total LPG import price at each depots are 620 USD/MT at Depot Tanjung Priok, 620 USD/MT at Depot Eretan, 622 USD/MT at Depot Tanjung Perak, 622 USD/MT at Depot Gresik, 624 USD/MT Depot Semarang. This price becomes the reference to calculate the state budget saving compare with the economic price of DME-LPG mixture at depot. While the price of DME-LPG mixtures in each depots will depend on the distance of depot location from the DME plant that affects the number of additional DME storage tank facilities required. The comparison between LPG import and the DME-LPG mixture price at each depot are as shown in Table 10.

Table 10. Benefit Reduction of APBN Year 2040 from Each Depot

Description	Unit	A	B	C	D	E
DME FOB Price	USD/MT	327				
Shipping Fee	USD/MT	12.68	12.18	16.50	16.96	19.41
Depot Fee	USD/MT	28.64	28.83	30.68	31.07	32.46
Depot LPG Fee	USD/MT	21.83				
DME-LPG Mixture Price	USD/MT	391	390	396	397	401
LPG Import Price	USD/MT	591	591	591	591	591
Depot LPG Fee	USD/MT	21.83				
LPG Import Price at Depot	USD/MT	620	620	622	622	624
Saving	USD/MT	251	223	217	216	212
APBN Saving Year 2040	**Million USD/Year**	**123**	**121**	**56**	**51**	**37**

According to the table above, the comparison between LPG import price and DME-LPG mixture price result the state budget saving at Depot Tanjung Priok 123 million USD per year, at Depot Eretan 121 million USD per year, at Depot Tanjung Perak 56 million USD per year, at Depot Gresik 51 million USD per year, and at Depot Semarang 37 million USD per year. The total state budget saving can be seen in the Table 11 below.

Table 11. Total State Budget Saving in 2040

	Value	
APBN Saving Year 2040	5,332	Billion IDR/Year
	388	Million USD/Year

Based on the table above can be concluded that the utilization of coal-based DME to substitute LPG import in Indonesia can give total state budget saving for the government about 5,332 billion Rupiahs per year or equal to 388 million USD per year.

4 Sensitivity Analysis

4.1 Coal Price vs DME-LPG Mixture Price

The sensitivity analysis of coal price towards the DME-LPG mixture price will be evaluated by the change of coal price. There are 3 (three) variances of coal price, 94.04 USD/MT or equivalent to 4.65 USD/mmbtu (HBA December 2017), increasing up to 15% and decreasing up to 15% (the range of price change based on the historical data) and the result is as shown in Table 12.

It can be inferred from the tables that the increase of coal price 15% or equal to 108 USD/MT resulted the DME-LPG mixture price increasing 32 USD/MT. Meanwhile, the decrease 15% resulted the DME-LPG mixture price decreasing 32 USD/MT. Therefore, it can be concluded that by the change 1% of coal price will affect the change of DME-LPG mixture price 2.1 USD/MT.

Table 12. Sensitivity Analysis of Coal Price vs DME-LPG Mixture Price

Coal Price (USD/mmbtu)	DME-LPG Mixture Price (USD/MT)				
	A	B	C	D	E
3,95	359	358	364	365	369
4,65	391	390	396	397	401
5,11	423	422	429	429	433

4.2 CAPEX vs DME-LPG Mixture Price

The sensitivity analysis of CAPEX DME Storage towards the DME-LPG mixture price at each depots will be evaluated by changing the investment cost in 2 (two) variances, plus 25% and 50%. The result is as shown in Table 13.

Table 13. Sensitivity Analysis of CAPEX vs DME-LPG Mixture Price

Depot	CAPEX (Initial)		CAPEX 1 (+25%)		CAPEX 2 (+50%)	
	CAPEX Million (USD)	DME-LPG Mixture Price (USD/MT)	CAPEX Million (USD)	DME-LPG Mixture Price (USD/MT)	CAPEX Million (USD)	DME-LPG Mixture Price (USD/MT)
A	56,99	391	71,24	396	85,48	405
B	62,33	390	77,91	395	93,49	405
C	31,86	396	39,82	402	47,79	412
D	29,59	397	36,99	403	44,39	413
E	22,47	401	28,09	407	33,70	417

Based on the calculation, the increase of investment cost 25% and 50% resulted the increase of DME-LPG mixture price 9-11 USD/MT. It can be concluded, by the change 1% of CAPEX DME storage at each depot will affect the change of DME-LPG mixture price 0.37-0.42 USD/MT.

4.3 IRR vs DME-LPG Mixture Price

The sensitivity analysis of IRR towards the DME-LPG mixture price at each depots will be evaluated by changing the IRR in 2 (two) variances, plus 10% and 20%. The result is as shown in Table 14.

Table 14. Sensitivity Analysis of IRR vs DME-LPG Mixture Price

IRR	DME-LPG Mixture Price (USD/MT)				
	A	B	C	D	E
10%	386	385	391	392	396
15%	391	390	396	397	401
20%	396	395	402	403	407

According to the calculation for IRR 10% and 20%, the increase of DME-LPG mixture price is 5-6 USD/MT. It can be concluded, by the change 1% of IRR will affect the change of DME-LPG mixture price 1.1-1.2 USD/MT.

4.4 Sensitivity Analysis of Parameters Change towards The State Budget Saving

Based on the previous sub-section about the sensitivity analysis of some parameters towards the DME-LPG mixture price, in this section we would analysis those parameters' impact to the state budget saving for the DME demand in 2040. The parameters change is calculated per 1%, it means that 1% change of parameters will affect the increase or decrease of state budget in USD/year. The result of simulation is as shown in Table 15.

Table 15. Sensitivity Analysis of IRR vs DME-LPG Mixture Price

per 1% changing to these parameters:	DME-LPG Mixture Price (USD/MT)	State Budget Saving Increase/Decrease (USD/Year)
Coal Price ↑↓	2.1	3,988,965
CAPEX DME Storage ↑↓	0.37	702,818
	0.42	797,793
IRR Depot Fee ↑↓	1.1	2,089,458
	1.2	2,279,408

According to the table above, the coal price changes 1% resulted the increase or decrease state budget saving 3,988,965 USD/year. And the CAPEX DME storage changes 1% resulted the increase or decrease state budget saving 702,818 USD/year up to 797,793 USD/year. Meanwhile, the IRR depot fee changes 1% resulted the increase or decrease state budget saving 2,089,458 USD/year up to 2,279,408 USD/year. Figure 3 illustrates the sensitivity of those parameters toward the state budget saving.

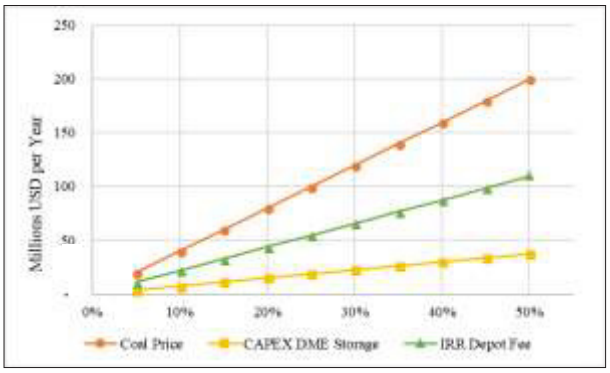

Fig. 3. Sensitivity Analysis of Parameters Change per Percentage towards The State Budget Saving in 2040

It can be concluded that the change of Coal Price will dominantly affect the state budget saving, then the second is IRR for Depot Fee calculation and the lowest impact to the state budget saving is the change of CAPEX DME Storage at depot.

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