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The Effect of Government Regulation on Coal as Export Commodities and Downstream Effort through Coal Liquefaction (Systems Dynamic Modelling Approach)

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Abstract

On one hand, coal is still treated as an export commodity. On the other hand, the government is expecting additional value from the coal sector, among other, through coal liquefaction. The role of the government has been demonstrated through regulation, but there have been no concrete results to realize the downstream effort of coal. To find out to what extent is the optimum coal composition between the coal exported as commodity and coal used for liquefaction, it is analyzed by systems dynamic modeling method in several scenarios. The results show that there are several scenarios that suitable as Government alternative by fine-tuning the royalty instrument and the portion of state revenue. Scenario II could plausibly be the best proposal that is to seek coal for downstream effort through liquefaction in order to liquefy the coal by 50%, while still allocating the remaining portion for the sale of coal as a commodity. This is reinforced because factually there is portion of coal as a commodity being sold domestically as fuel of power plant (PLTU). In Scenario II, coal liquefaction begins to provide a positive cumulative cash flow difference to the baseline after assuming a pre-set condition of royalty at 0% and the state revenue portion in the range of 60% - 80%. The imposition of a royalty of 5% can still be maintained, provided that it remains collaborated with a decrease in the portion of state revenue. This is because the decline in the portion of state revenue is very significant in increasing the cumulative cash flow of coal liquefaction. The state revenue portion can be installed in the range of 60% - 70% on the grounds that this coal liquefaction activity is a process of increasing the value-added that has an impact on the economy.

I. INTRODUCTION

Indonesia's coal production grew at an average rate of 12% per year, while domestic coal consumption averaged 2% per year. Although coal prices started to decline since mid-2012, coal production and exports continue to grow at least until the end of 2013 as shown in Figure 1. In 2016, the decline in coal prices began to impact the realization of production and exports even though the figure is still quite high compared to 2012. It is estimated that the effect of coal price will be more significant on the realization of production and export in 2017.

The domestic coal sales tonnage, purely utilize coal directly as fuel for steam power plants. Insofar, increasing coal value-added as raw material, whether in the form of coal quality improvement, coal liquefaction, coal gasification or other forms, have not been developed into the business plant scale (Tomek, 2000). Some research and development are still concentrated on the lab scale, pilot plant, and demo plant. This is due to the situation from the beginning, which deemed as business as usual that still treats coal as a commodity and puts coal as one of the mainstays of non-oil and gas exports so far (IEA, IEF, IMF, & OPEC, 2011).

Another reason provided is the high cost of coal processing technology in several conditions and the economic value of processing method (gasification and liquefaction) which influenced by external factors such as oil and gas commodity prices (Khedhiri & Muhammad, 2008). However, in the meantime, development related to the increase of coal value-added has been going on, including the development for coal liquefaction (Baffes & Gardner, 2003).

For instance, development of coal liquefaction technology in other countries, the one performed by China Shenhua Coal Liquefaction Co. Ltd. with coal input at 5000 kcal/kg gross as received (gar) of 2.1 million ton/year. Oil product produced from this liquefaction process is 845,2 thousand tons/year.

PT Adaro Indonesia as one of the largest coal companies in Indonesia and with substantial coal reserves has the potential to be developed in the downstream direction through coal liquefaction. Table 1.1 shows the sales in tonnage of PT Adaro Indonesia from 2012 to 2016 with the revenue (profit/loss) of the company varying according to the price of coal development.

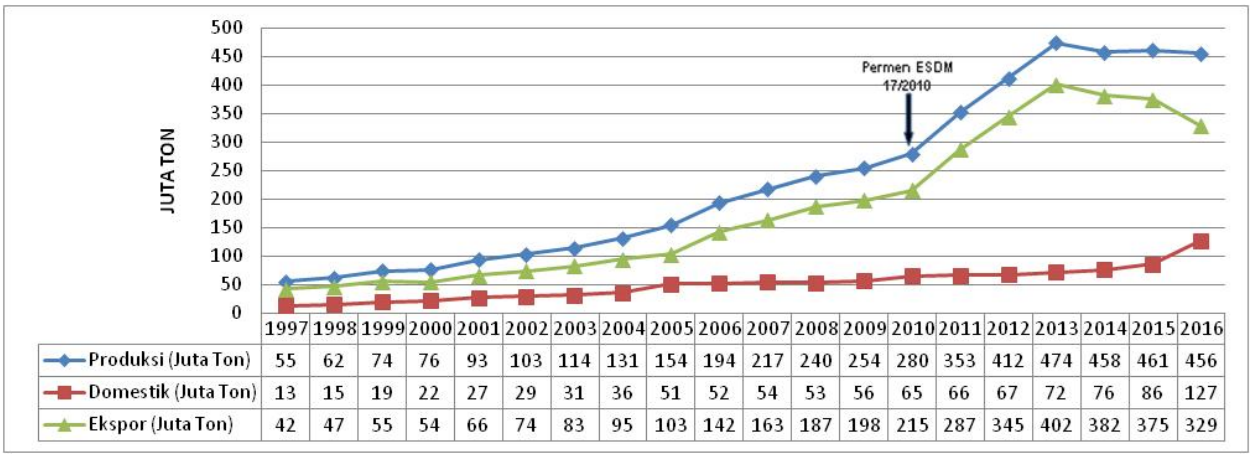
Table 1.
Tonnage of Sales and Actual Profit/Loss (P/(L)) of PT Adaro Indonesia Year 2012 - 2016

Year	Tonnage Sales	Coal Prices	Actual P/(L)
2012	47,249,604.00	70.51	407,829,451.00
2013	52,167,692.00	57.21	228,268,019.82
2014	56,087,821.00	54.31	161,384,968.00
2015	56,000,000.00	42.65	49,946,463.00
2016	54,061,537.00	40.99	10,218,116.00

Source: PT Adaro, 2017

PT Adaro Indonesia's coal reserves are still quite large, at 2.2 billion tons of coal by the year 2016. Considering an average of coal calories at 5000 gar, which is approximately equal to the coal calories used for coal liquefaction by China Shenhua Coal Liquefaction Co. Ltd., Downstreaming effort through coal liquefaction in PT Adaro Indonesia can be done by referring to the Chinese coal liquefaction technology Shenhua Coal Liquefaction Co. Ltd.

Due to the description of the coal price policy and to the extent to which coal being conditioned as a commodity (coal exports) and coal as a source of domestic energy as well as raw materials in order to increase value-added (for instance coal liquefaction) (Engle, 2003). There is a condition related to the



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Produksi (Juta Ton)	55	62	74	76	93	103	114	131	154	194	217	240	254	280	353	412	474	458	461	456
Domestik (Juta Ton)	13	15	19	22	27	29	31	36	51	52	54	53	56	65	66	67	72	76	86	127
Ekspor (Juta Ton)	42	47	55	54	66	74	83	95	103	142	163	187	198	215	287	345	402	382	375	329

Source: MERM, 2017
Figure 1. Realization of Production, Export and Domestic Sales of Indonesian Coal

value of coal as a non-renewable natural resource either before coal price regulation or after coal price regulation (Barrett, 2008).

Previously there was a tendency for coal to be exploited as a commodity with inconcrete results to realize the downstreaming effort of coal. The publication of coal pricing policy reflects that there has been an attempt to add value to a mere coal. However, further exertion shall be given in terms of how to increase its value-added in the context of coal downstream effort (Asmara, et all, 2011).

Hence, an analysis is needed to see the effect of regulation including coal price policy to determine the extent of the coal's economic value as an export commodity (Aizenman & Pinto, 2004, p. 13). Subsequently, to determine the extent of influence of the regulation to the coal's economic value in order to increase added value through coal liquefaction (MERM, 2014). Henceforth, it shall reveal the urgency of the existence of the regulation and possibly determine whether the spirit has been appropriate or need to be changed to follow the recent developments (Akira, 2013).

In recent times, the coal exploitation in Indonesia tends to be oriented to coal as a commodity, in regards to the coal become directly exported without having any value added process. Only a small portion has been utilized in its derivative form. The role of the Government has been demonstrated through regulation in order to have additional value from the coal sector, but there have been no concrete results for the realization of coal downstream effort (Blanchard & Galí, 2007).

The research question based on the aforementioned formulation of the problem is to what extent that the coal is needed as an export commodity and to what degree the coal will be used for the liquefaction that being analyzed using several scenarios. The projection of the settlement of the problem shall determine the optimum composition between coal to be exported and the coal to be used for liquefaction.

II. Method

This research was conducted by using secondary data obtained from government agency source namely Ministry of Energy and Mineral Resources. The data collection is conducted through observation, brainstorming, and documentation related to the research topic being raised.

The research focus was conducted in DKI Jakarta Province with observation time in 2017. Various secondary data that being required were mostly obtained using literature study.

The acquired data are: 1) The Reserves Data, Actual Production and Realization of Coal Sales of PT Adaro Indonesia 2012 – 2016; 2) The PT Adaro Indonesia's average coal price data in 2012-2016 with coal sales specification of 5000 kcal/kg gross as received (gar); 3) Financial Report of PT Adaro Indonesia Year of 2012 – 2016; 4) Liquid Coal Technology Development Plan Data between China Shenhua Coal LiquefactioCo. Ltd. with West Virginia University, with details of: Plant cost estimate: USD 800 million

a. Coal input estimate: 2.1 million Ton/Year
b. Yield of oil product: 845,200 Ton/Year
c. Estimate production cost: USD 24/bbl
d. The result of oil product composition is Diesel 591,900 tons/year, Naptha 174,500 tons /year, LPG 70,500 tons/year, and liquid ammonia 8,300 tons/year

A. Research Method and Data Analysis

The research method conducted in this research is quantitative-descriptive method that is explained as a form of research based on data collected during the systematic study regarding the facts and properties of the object under study by combining the relationships among the variables involved in it, then interpreted by theories and literatures related to coal pricing policies, coal reserves, production plans, and coal sales plans, by example of coal liquefaction projects and simulations through dynamic systems. This method aims to provide a fairly clear picture of the problem being researched.

Method for processing and analyzing the data is using system dynamics modeling approach since it involves variables with different dimensions that amongst each other are related either directly or indirectly, and having dynamic nature that is constantly changing.

B. The Initial Condition of the Model

In general, the model is divided into 3 sub-models, namely sub-model of mining business aspect, economic value sub-model for scenario of coal as a commodity, and sub-model of economic value analysis for scenario of coal liquefaction.

The conceptualization of the system conducted by describing the causal loop diagram and the stock and flow diagram. Causal loop diagrams are organized on the basis of identified variables. This causal diagram is created by linking the interrelationships between variables as reflected in Figure 2.

Based on Figure 2, there are two main close loops. The first close loop describes the actual reserves as a source of mining production to obtain the coal tonnage which by the influence of the coal price resulting in coal export value and profit. Profit is used as a source of new exploration activities that

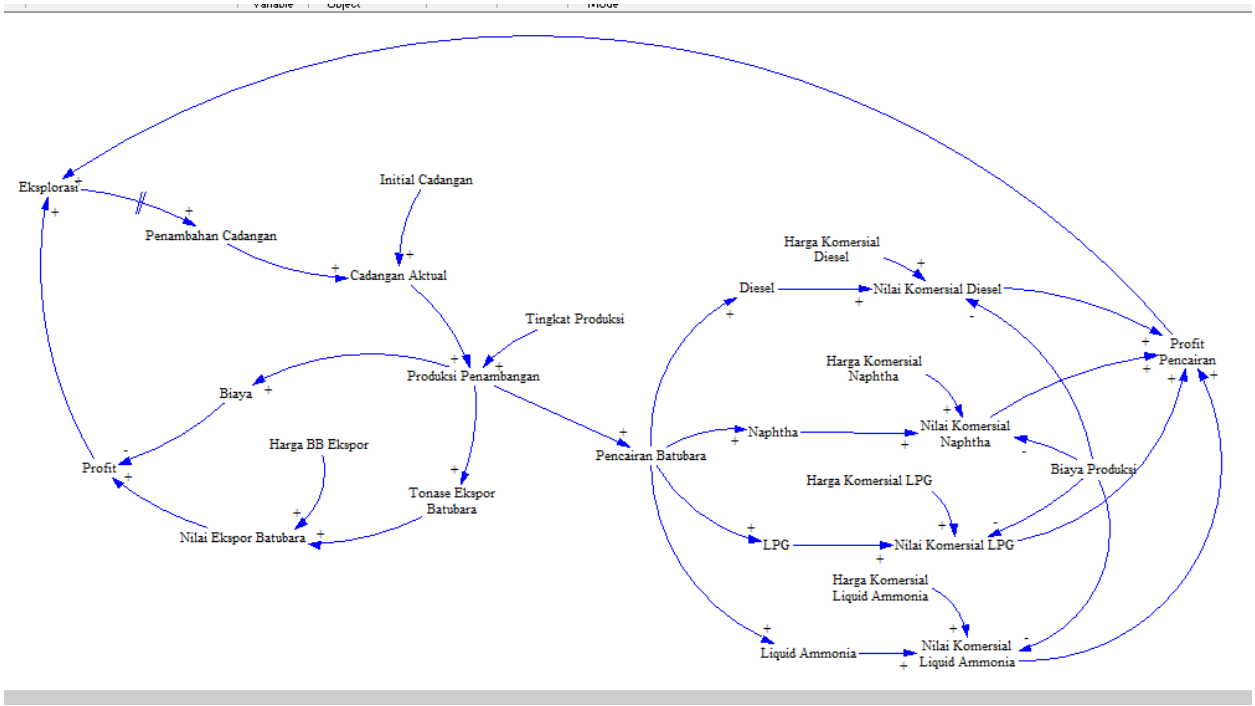


Figure 2. Causal Loop Diagram

over time will lead to additional reserves that will eventually affect actual reserves.

The second close loop describes the actual reserves as a source of mining production to obtain coal liquefaction tonnage. Hence, the commercial value of liquefaction products and liquefaction profits could be obtained. Alike to the first close loop, this liquefaction profit will be related to actual exploration and reserve activities.

From the causal loop diagram, several assumptions can be proposed, which among others are:

a) The value of coal exports will increase as export tonnage increase and coal prices increase.
b) Commercial value of coal liquefaction results will increase when liquefaction tonnage and commercial price of liquefaction increase.
c) Profit will increase when the value of exports increase, but otherwise will decrease when there are addition of mining costs. The same is true on the resulting value of the liquefaction and its production cost, upon the liquefaction profit.
d) The addition of profit (exports or liquefies) will result in the addition of cummulative export cash flows and coal liquefaction, which evetually increase the activities for advanced exploration.

Stock and flow diagram as a phase of model formulation is based on causal loop diagram in Figure 3.2 with the main variables are reserves, cumulative cash flow (cum. Cf) of export and cum. cf. of liquefaction The main variables are described as stock, while the other variables are as rate, auxiliary and constant as identified in Table 2.

Table 2.
Main Variables In The Model

No.	Variable	Unit	Type
1.	Reserves	ton	*Stock*
2.	Mining Production	ton/year	*Rate*
3.	*Cum. Cf of Coal Export*	USD	*Stock*
4.	Export Cash flow	USD/year	*Rate*
5.	*Cum. cf of Coal Liquefaction*	USD	*Stock*
6.	*Liquefaction Cash flow*	USD/year	*Rate*
7.	Other Variables		*auxiliary* dan *constant*

The depiction of the stock and flow diagram of the model including the relationships among variables that have been identified are observable in Figure 3.

C. Model Verification

Model verification conducted to check for errors in the model and to ensure that the model works in accordance with the logic of the system object. Verification is performed by checking the formulation and checking the unit of the variable in the model.

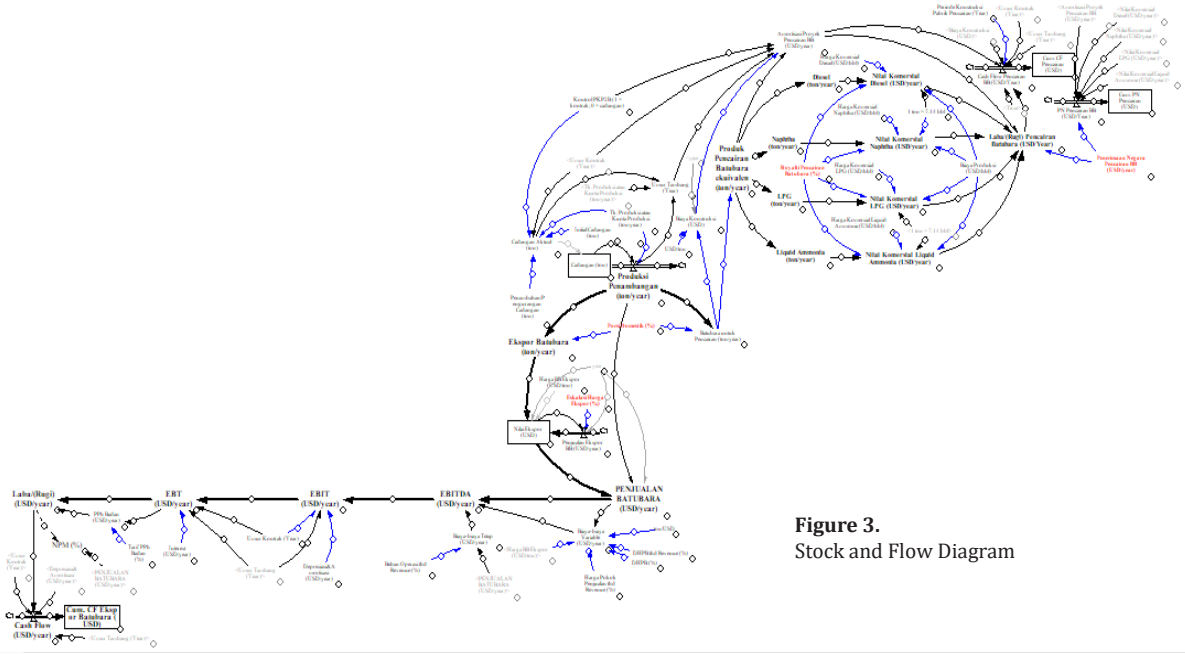


Figure 3.
Stock and Flow Diagram

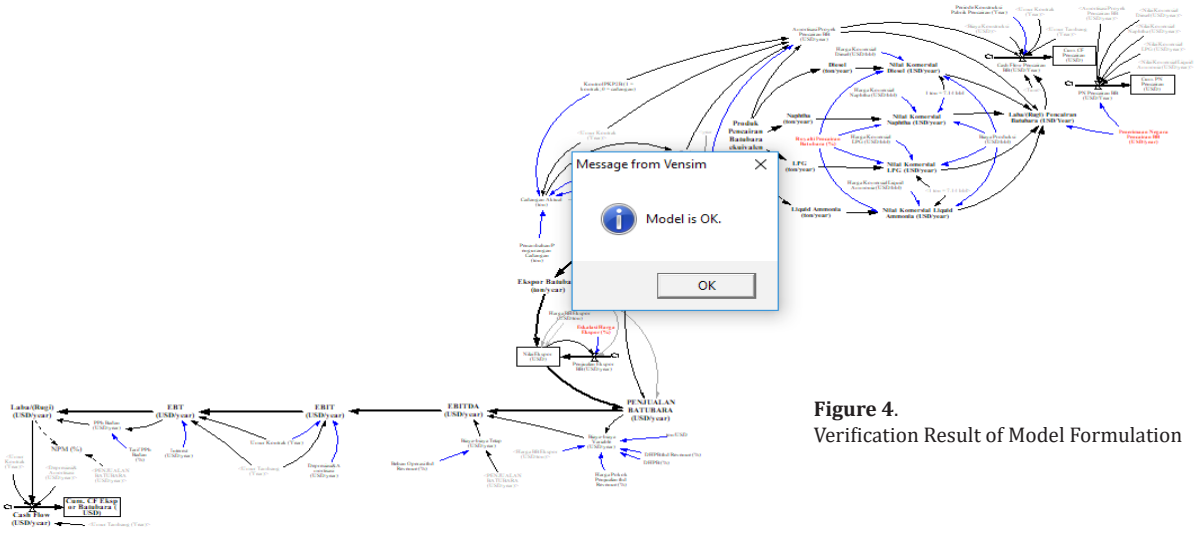


Figure 4.
Verification Result of Model Formulation

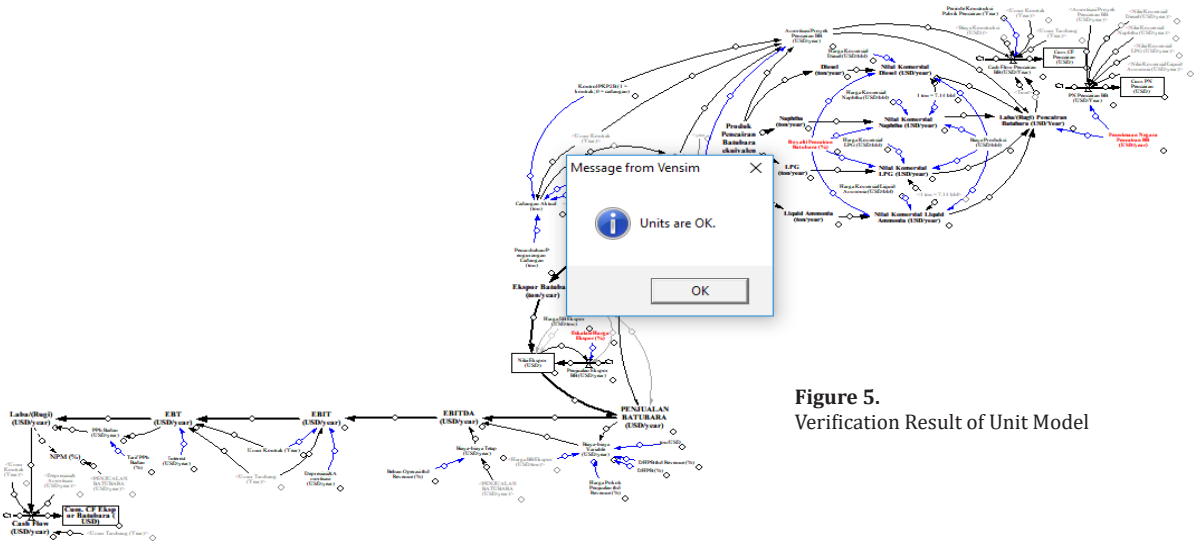


Figure 5.
Verification Result of Unit Model

In case of non-existence of error in the model, the model has been verified. Based on the results of simulation checking through check model and units check, therefore can be concluded that the model is running well without error in the formulation (Figure 3.4) or error in the unit (Figure 3.5).

D. Model Validation

Model validation is performed to ensure that the model meets the purpose of modeling and represents the current system. Quantitatively, the model is evaluated by performance validity test, carry out by comparing the mean and standard deviation on the actual system with the average and standard deviation on the simulation result.

Testing is performed based on percent error from actual data rate and simulation output with equation as follows:

$$E = |S - A| / A$$

Annotation,
E = rate of error
A = Actual Data
S = Simulasion Output

Model is deemed as valid if $E \leq\leq 0{,}05$

From the presented model, it is possible to validate the sub-model of economic value analysis for the scenario of coal as a commodity considering the condition in this sub-model is the condition of busines as usual that coal has been cultivated directly as an export commodity. For the purposes of validity test, the actual data of prior 5 (five) years will be the comparison to the simulation results output data.

Table 3.
Data Comparison of P/L Simulation compare to Actual P/L (USD)

Year	Tonnage Sales	Coal Price	L/R Actual	L/R Simulation
2012	47.249.604.00	70.51	407.829.451.00	410.936.000.00
2013	52.167.692.00	57.21	228.268.019.82	234.554.000.00
2014	56.087.821.00	54.31	161.384.968.00	212.703.000.00
2015	56.000.000.00	42.65	49.946.463.00	63.179.800.00
2016	54.061.537.00	40.99	10.218.116.00	41.913.800.00

Source : Processed data

These actual data are the data of profit or loss (P/L) of PT Adaro Indonesia's exports from 2012 to 2016 as a reflection of the sales tonnage and the average price of coal each year. The actual (P/L) values are simulated into the system, by conditioning all coal mining production sold annually as overall export tonnage according to actual conditions. Therefore, the (P/L) simulation can be obtained as shown in Table 3.2.

This calculation of validation produces the standard of error of 0.01 which is still less than or equal to 0.05, consequently the model are appropriate to be deemed as valid in order to analyze the coal exploitation especially in PT Adaro Indonesia.

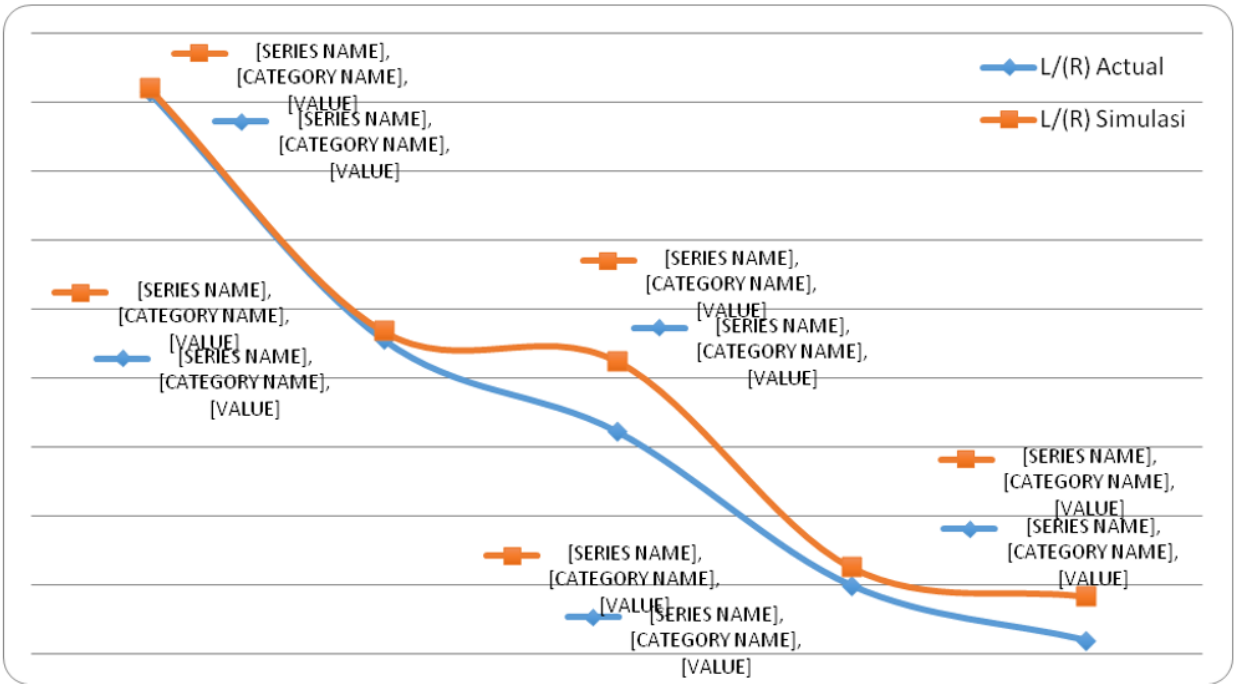


Figure 6. Graphic of Data Comparison of P/L Simulation compare to Actual P/L (USD)

III. Result and Discussion

The coal liquefaction project carried out by China Shenhua Coal Liquefaction with coal input of 2.1 million tons resulted in the liquefaction product as much as 843 thousand tons/year. Production and sales of PT Adaro Indonesia in 2016 amounted to 54 million tonnes of coal which by business as usual manner become commodity of export and directly used as fuel of PLTU for the domestic purpose. Scenario I assumes that PT Adaro allocates the same portion of China Shenhua 2.1 million tons (approximately 3.88%) of the total 54 million tons of production for coal liquefaction portion. Scenario II tries to see the economic aspect comparison between coal export and liquefaction coal in larger tonnage portions, while scenario III tries to see what if coal production tonnage is allocated entirely for coal liquefaction.

Table 4.
Baseline Scenario (No Portion of Coal for Liquefaction)

BASELINE SCENARIO	
Coal for Liquefaction (ton/year)	0
Construction Cost (USD)	0
Cum. CF of Coal Export (USD)	5.77E+09
Cum. CF Liquefaction (USD)	0
Coal Export (ton/year)	5.41E+07
The Mine life (Year)	40

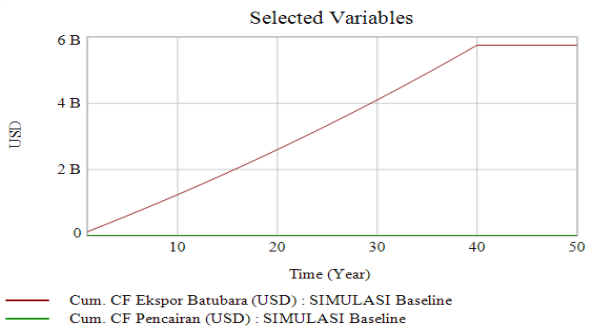


Figure 7. Baseline Scenario

The condition of PT Adaro Indonesia in business as usual manner is the condition in the baseline scenario, which is a scenario with no coal portion used for liquefaction. The baseline scenario is shown in Table 4.1 listing all coal tonnage sold directly as a commodity and for 40 years of the mine life producing Cum CF.of sales of coal amounting USD 5.77 Billion.

Scenario I presents various sub-scenarios for changes in government regulation instruments, namely the change in royalty figures and state revenue components. Meanwhile, coal price escalation is assumed to remain at 1%. Referred to the World Bank research stating that the price escalation is 1% annually. The simulation results of Scenario I are summarized in Table 4.

Table 5.
Scenario I with 3.88% coal portion for liquefaction

SCENARIO I	I.a	I.b	I.c	I.d	I.e
Coal for Liquefaction (ton/year)	2.10E+06	2.10E+06	2.10E+06	2.10E+06	2.10E+06
Construction Cost (USD)	7.99E+08	7.99E+08	7.99E+08	7.99E+08	7.99E+08
Cum. CF of Coal Export (USD)	5.55E+09	5.55E+09	5.55E+09	5.55E+09	5.55E+09
Cum. CF of Liquefaction (USD)	1.41E+08	2.15E+08	1.22E+09	2.23E+09	3.23E+09
Coal Export (ton/year)	5.20E+07	5.20E+07	5.20E+07	5.20E+07	5.20E+07
The Mine life (Year)	40	40	40	40	40
BEP of Liquefaction Project (Year)	36	35	24	20	18

annotation :

I.a = royalty 5%; state revenue 90%; price escalation 1%
I.b = royalty 0%; state revenue 90%; price escalation 1%
I.c = royalty 0%; state revenue 80%; price escalation 1%
I.d = royalty 0%; state revenue 70%; price escalation 1%
I.e = royalty 0%; state revenue 60%; price escalation 1%

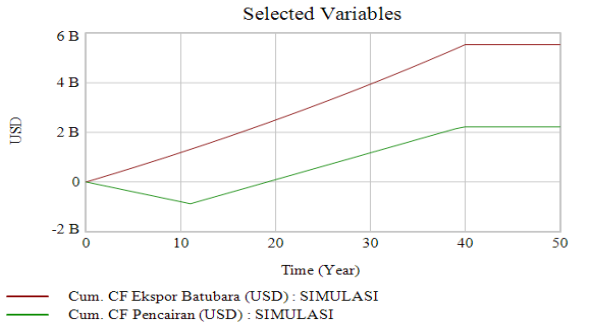


Figure 7. Scenario I.d with State Revenue become 70%

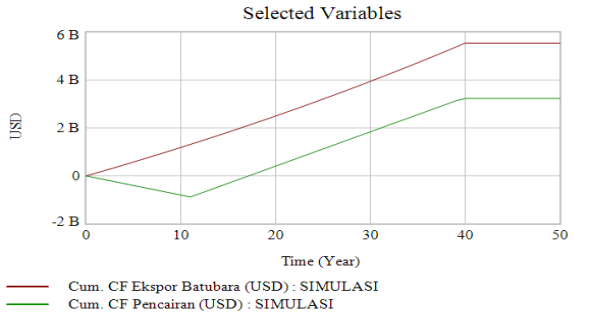


Figure 8. Scenario I.d with State Revenue become 60%

In Scenario I, the coal tonnage for the liquefaction is only slightly allocated which stands at 3.88%, it appears that on the existing Government regulation instrument (5% royalty, state revenue 90%, and escalation 1%) coal liquefaction project produces positive cum. cash flow but still smaller than cum. cash flow of coal export. Even though the royalties were made 0%, it does not significantly increase the cum. rate cash flow as shown in column I.b in Table 6. However, the economic value of coal liquefaction increased when simulated by reducing the component of state revenue. The greater the decrease, the greater the number of cum. cash flow, even though the tonnage allocated is only 3.88%. Scenario I concludes that sub-scenario I.e is the best option that gives the greatest cum. cash flow.

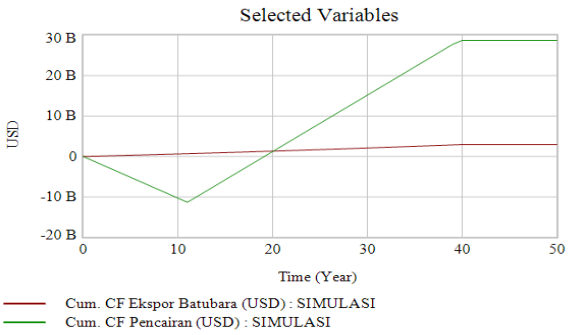


Figure 9. Scenario II.d with State Revenue become 70%

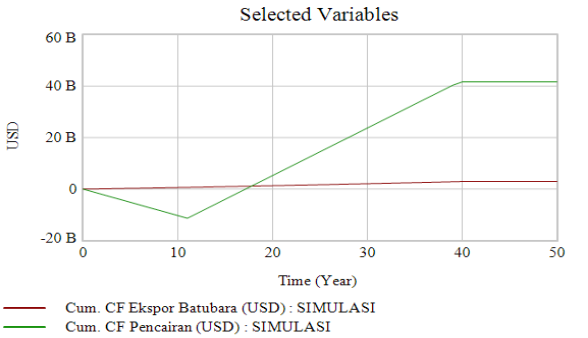


Figure 9. Scenario II.e with State Revenue become 60%

Table 6.
Scenario II with 50% portion of coal for liquefaction

SCENARIO II	II.a	II.b	II.c	II.d	II.e
Coal for Liquefaction (ton/year)	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07
Construction Cost (USD)	1.03E+10	1.03E+10	1.03E+10	1.03E+10	1.03E+10
Cum. CF of Coal Export (USD)	2.94E+09	2.94E+09	2.94E+09	2.94E+09	2.94E+09
Cum. CF of Liquefaction (USD)	1.81E+09	2.77E+09	1.57E+10	2.87E+10	4.17E+10
Coal Export (ton/year)	2.70E+07	2.70E+07	2.70E+07	2.70E+07	2.70E+07
The Mine life (Year)	40	40	40	40	40
BEP of Liquefaction Project (Year)	36	35	24	20	18

annotation :

I.a = royalty 5%; state revenue 90%; price escalation 1%

I.b = royalty 0%; state revenue 90%; price escalation 1%

I.c = royalty 0%; state revenue 80%; price escalation 1%

I.d = royalty 0%; state revenue 70%; price escalation 1%

I.e = royalty 0%; state revenue 60%; price escalation 1%

In Scenario II, it is seen that although the coal portion for liquefaction is already 50%, but state revenues remain at 90%, Then, cum. cash of coal liquefaction is smaller than cum. cash flow of coal export. The same thing happens when royalties are reduced to 0%, but state revenue remains 90%.

As illustrated in Table 6, the condition changes significantly when the state revenue portion is lowered to 80%. In this condition cum. cash flow of coal liquefaction is much greater than cum. cash flow of export. When the portion of state revenues is lowered again to 60%, obtained cum. cash flow of coal liquefaction becomes USD 41.7 billion, which is much larger than cum. cash flow of coal export amounting USD 2.9 billion over a period of 40 years or during the life of the mine. With the smallest portion of state revenue, sub-scenario II.e becomes the best in Scenario II.

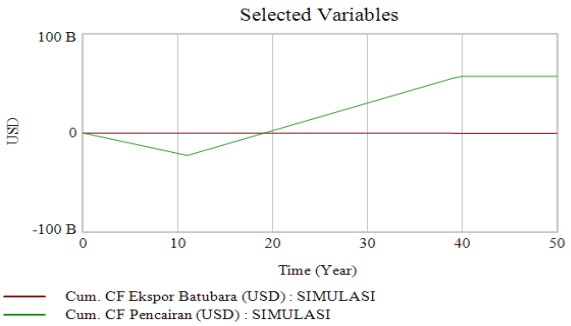


Figure 10. Scenario III.d with State Revenue becomes 70%

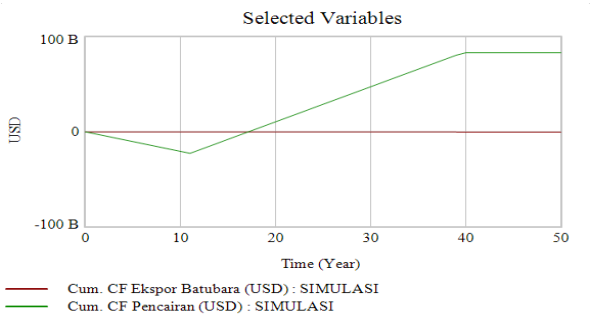


Figure 11. Scenario III.e with State Revenue becomes 60%

In scenario III, which is conditioned as 100% coal tonnage allocated entirely for coal liquefaction, it appears that sub-scenario III.c to III.e produces greater cum. cash flow than the other sub-scenario. However, sub-scenario III.a and III.b still provide positive cum. cash flow as shown in Table 4.4.

From the simulation description, it can be seen that the incentive from the side of the percentage reduction of the state revenue portion has a significant impact on the optimism of coal liquefaction business. The greater the decrease in the share of state revenue, the greater the cum. cash flow, thereby enlarging the economic values from coal liquefaction scenarios.

In Scenario I, it appears that in any sub-scenario (sub-scenario I.a to I.e) cum. cash flow of coal liquefaction is always smaller than cum. cash flow of coal export. In scenario II, cum. cash flow of coal liquefaction begins to show larger numbers

Table 7.
Scenario III with 100% portion of coal for liquefaction

SCENARIO III	III.a	III.b	III.c	III.d	III.e
Coal for Liquefaction (ton/year)	5.41E+07	5.41E+07	5.41E+07	5.41E+07	5.41E+07
Construction Cost (USD)	2.06E+10	2.06E+10	2.06E+10	2.06E+10	2.06E+10
Cum. CF of Coal Export (USD)	-2.25E+08	-2.25E+08	-2.25E+08	-2.25E+08	-2.25E+08
Cum. CF Liquefaction (USD)	3.63E+09	5.54E+09	3.15E+10	5.74E+10	8.34E+10
Coal Export (ton/year)	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
The Mine life (Year)	40	40	40	40	40
BEP of Liquefaction Project (Year)	36	35	24	20	18

annotation :

I.a = royalty 5%; state revenue 90%; price escalation 1%

I.b = royalty 0%; state revenue 90%; price escalation 1%

I.c = royalty 0%; state revenue 80%; price escalation 1%

I.d = royalty 0%; state revenue 70%; price escalation 1%

I.e = royalty 0%; state revenue 60%; price escalation 1%

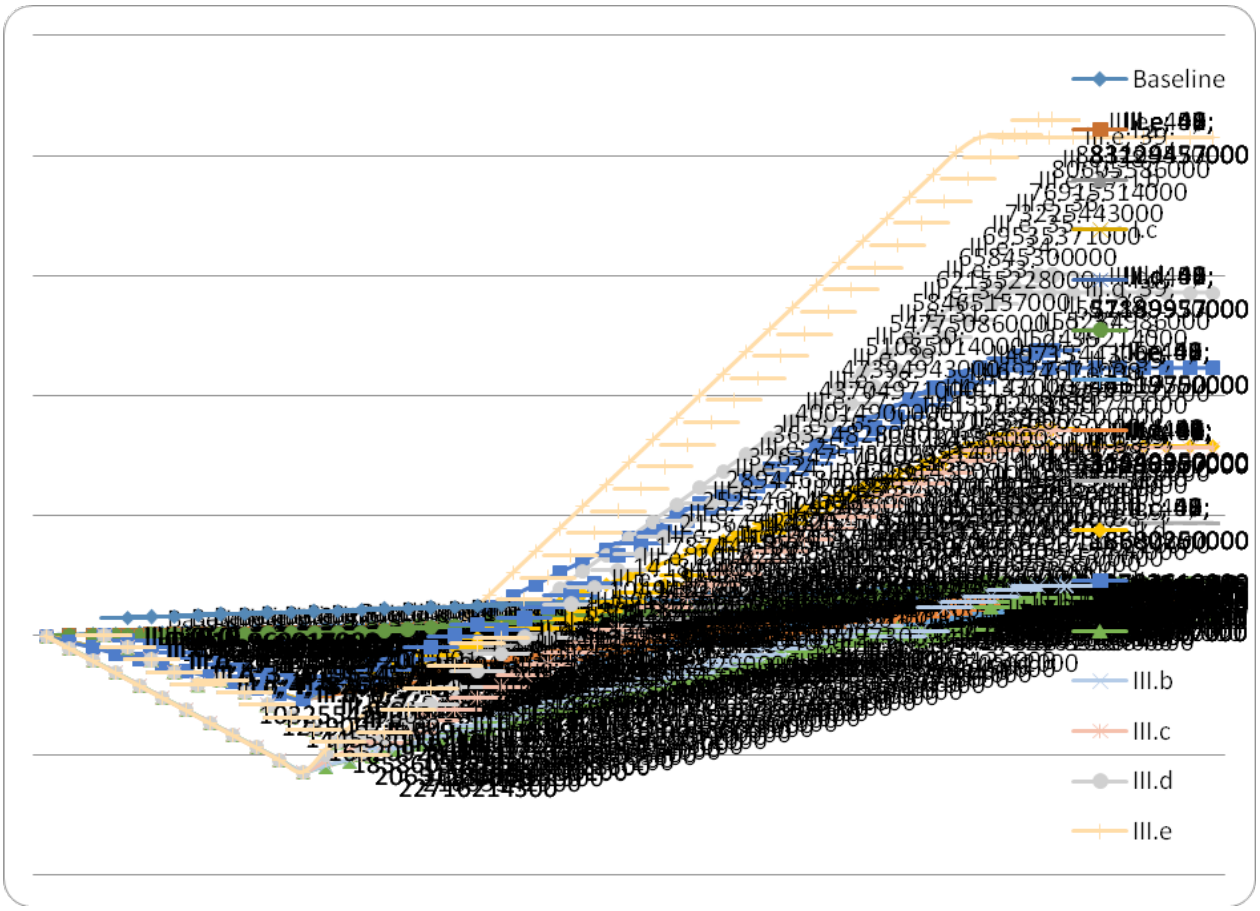


Figure 12. Difference of Cum. CF from Each Sub-Scenario Against the Baseline

which ranging from sub scenario II.c to II.e. while in scenario III, all sub-scenarios show the number of cum. cash flow of coal liquefaction which always greater considering the overall coal tonnage is used for liquefaction.

If cum. cash flow of coal export is added with cum. Cash flow of coal liquefaction for each sub-scenario then subtracted with baseline scenario, therefore, the difference of cum. cash flow of each sub-scenario against the baseline will be obtained. The result will be seen as shown in Figure 4.8 which sub-scenario III.e, III.d, and II.e in sequence, respectively give the largest difference.

Table 8.
Difference of Cum. CF from Each Sub Scenario against the Baseline

sub scenario	Scenario	I	II	III
a		-7.84E+07	-1.01E+09	-2.36E+09
b		-4.45E+06	-5.73E+07	-4.57E+08
c		1.00E+09	1.29E+10	2.55E+10
d		2.01E+09	2.59E+10	5.14E+10
e		3.01E+09	3.89E+10	7.74E+10

In detail, the difference of cum. cash flow from each sub-scenario can be seen in Table 4.5. Sub-scenario a and b representing the royalty condition of 5% and 0% respectively but the portion of state revenue still remains, these always giving a negative difference. Positive differences begin to appear for sub-scenario c, d, and e (scenarios I, II and III), which in this state the portion of state revenues is reduced by 80%, 70%, and 60% respectively.

The selection of the best scenarios through mapping and modeling of each scenario, shall obviously show Scenario III and more specifically the sub-scenario III.e as the best option, which gives the largest cum. cash flow of coal liquefaction. However, in fact, there is some portion of coal as a commodity being sold domestically as fuel for domestic power plants within the range of 30%. Domestic steam power plants (PLTU) primarily still need coal for short or medium term until there is a policy to change the function of the boiler if it is technologically possible. Hence, the appropriate choice becomes Scenario II that addressing coal to a downstream effort in order to perform the coal liquefaction by 50%. While still allocating a portion of a coal for selling it as a commodity.

Scenario II is a wise choice considering the factual and business as usual conditions of the

company, especially for short-term conditions. In which the royalty rate for liquefaction shall only be given a mere 0%, considering the coal has gone through the process of increasing the added value, which inherently during the process has provided extensive added value to the economy. The imposition of a royalty of 5% can still be maintained, collaborated with a decrease in the portion of state revenue. Due to its very significant influence in increasing the cum. cash flow of coal liquefaction.

The state revenue portion of 90% received from PT Adaro Indonesia is an existing condition which is different from the coal companies in the IUP regime, currently, the state revenue portion of the IUP company is much lower than the stated figure. Thus, the proposed companion of scenario II is the share of state revenue at the rate of 60% - 70%, on the grounds that coal liquefaction is a process of increasing the added value that gives impact to the economy, while the other reason is considering 90% of it is the existing condition, due to the "nailed down" regulation as stated in the PKP2B contract.

In this modeling, the construction of a coal liquefaction plant is assumed to take 10 years by assuming that this coal liquefaction project starts from scratch in the sense of being start up from pilot scale, demo scale, up to business scale. If the liquefaction project is assumed to be 2 or 3 years, in the sense that the liquefaction project begins directly on business scale, then the project's economic model will give even greater cum. Cash flow, hereby, could increase the level of optimism that the project to increase the value added through coal liquefaction can be economical.

IV. Conclusion

In accordance to the discussion result, therefore it can be concluded that the best scenario selection is Scenario II, in which performing coal as downstream effort for liquefaction as much as 50% while allocating the remaining half portion for sales of coal as a commodity. It is underpinned by fact that some portion of coal as commodity happen to be sold domestically as fuel for domestic PLTU amounting to around 30%.

In Scenario II, coal liquefaction starts to provide a positive cumulative cash flow difference to the baseline after assuming pre-set condition of royalty at 0% and the state revenue portion in the range of 60% - 80%. The imposition of a royalty of 5% can still be maintained, collaborated with a decrease in the portion of state revenue. Due to its very significant influence in increasing the cum. cash flow of coal liquefaction.

Thus, the proposed portion of state revenue is at the rate of 60% - 70%, on the grounds that coal liquefaction is a process of increasing the value-added that gives impact to the economy, while the other reason is considering 90% of it is the existing condition, due to the "nailed down" regulation, while the portion at this IUP regime happens to be significantly less than 90%.

The recommendation from the result of this research is there is a necessity to complement the rules related to coal exploitation to coal liquefaction in this case related to a coal royalty arrangement in the framework of liquefaction. The existing rules only regulating the coal royalties if it is directly sold as a commodity, but there are no royalties set if coal has been converted to other product forms, either the result of liquefaction or gasification.

The coal exploitation scenario modeled on PT Adaro Indonesia assumes that coal as a single business entity, therefore the coal tonnage to be liquefied is the coal produced by its own mine. In other words, there is no need to purchase a coal as an input for coal liquefaction. In its development, there will be many companies that do not mine coal but will do the business only for coal liquefaction. The company shall purchase coal from other companies that producing coal. Hence, it is advisable to strictly regulate the coal price regulation especially coal price for purpose of increasing value-added. Coal price regulation for increasing value-added needs to be differentiated, while made the price lower than the price of coal as an export commodity. This is an encouragement for the achievement of business scale or economic scale in the context of coal downstream effort.

Recommendation for further research that there is a need to study the economics of coal liquefaction if the condition is set as a separate business entity. In other words, it is necessary to look at the extent to which the liquefaction economic value of coal liquefaction if the company that will liquefy the coal does not mine by themselves and should purchase coal from other companies that producing coal.

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