Journal of Namibian Studies, 34(2023): 1604–1625 ISSN: 2197-5523 (online)

The Impact Assessment of Coal Gasification Initiative to Indonesian National and Regional Economy

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Abstract

This study aims to assess the impact of the Coal-Gasification Initiative to Indonesian national and also regional economy. As part of national energy policy, the Initiative can help meet the high demands for Indonesian gas energy. The study adopts Input-Output (I-O) simulation model to analyze Indonesian National Input Output (I-O) database and Interregional Input Output (IRIO) database of 34 provinces. The simulations show that the Initiatiave will bring significantly positive implications in national and provincial levels, starting from construction project, production set up, up to initial production stages. More specifically, it results the increase in economic output, growth, labor compensation, business surplus, and tax revenues in those levels. The province where the pioneering gasification industry is located and the seven neighboring provinces which are part of the urea fertilizer, polypropylene, and dimethyl ether production network can benefit much more significant impact than the other 26 provinces out of the network. The successful initiative can relieve the growth burden out of Java Island and promote equitable and sustainable development. In terms of financing hurdle, with proper fiscal incentives, it can attract domestic and international financing.

Keywords: Regional Economy, Coal Gasification, I-O and IRIO, Fiscal Incentives, Domestic and International Financing

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1. INTRODUCTION

Indonesian coal mines produce different types of coal based on their caloric value, ranging from low to medium, high, and very high. Higher-calorie coal typically commands a higher market price. Of all the coal extracted in Indonesia, 29% is low-calorie, 64% is medium-calorie, and only 7% is high-calorie or very high-calorie. Indonesia's coal reserves are dominated by medium-calorie coal, which accounts for over half of the country's national coal reserves (Mossner, 2016).

High-calorie and very-high-calorie coal are the flagship export commodities for coal producers due to their high prices in the world market. The Government is encouraging coal miners to use the gasification process to increase the value of low-calorie coal (Ragimun and Rosjadi, 2020). Gasification is a process that converts coal from a solid form to a gaseous form, making it usable in many industries and for household needs (Suganal et al., 2021).

From a macro perspective, the output of the coal-gasification process can help Indonesia meet the high demands for national gas energy, reduce dependence on gas imports, stabilize foreign exchange demand, increase government income, create jobs, and boost national economic growth (Caineng et al., 2019).

Coal-gasification technology continues to develop, and several countries including the US, China, Japan, and South Korea, have launched coal-gasification initiatives (Ragimun and Rosjadi, 2020). The Integrated Gasification Combined Cycle (IGCC) is a highly efficient technology that can convert coal into synthesis gas (syngas) and other products while also reducing emissions of dangerous pollutants (Porter et al., 2015; Breeze, 2019). The IGCC technology is superior to the coal processing methods. It can separate coal impurities and convert them into main and by-products, such as ammonia and methanol, which are reusable. Many consider the IGCC aligns with global emission reduction initiatives (Higman and Burgt, 2008), (Höök and Aleklett, 2010).

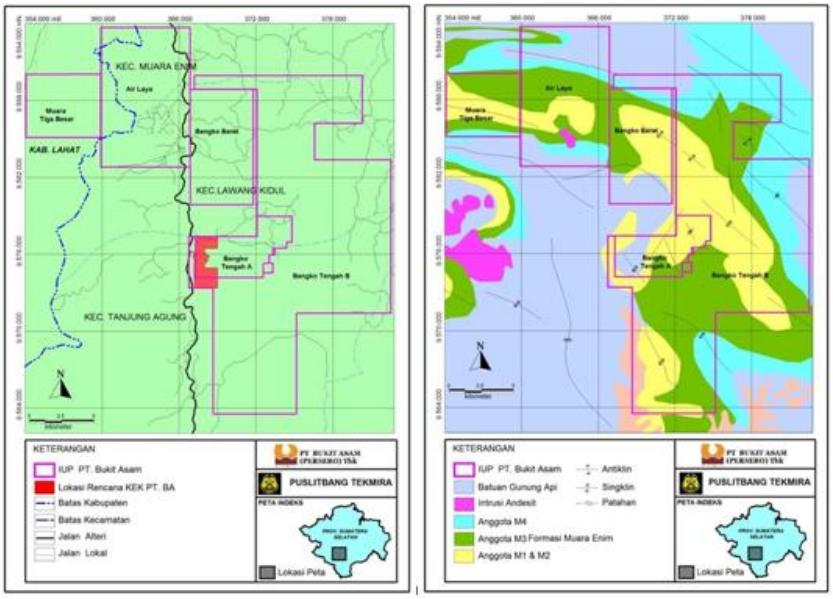
PT Bukit Asam (PTBA) is an Indonesian large coal miner and a state-owned enterprise interested in expanding into the coal gasification firm, along with other companies. The PTBA Mining Special Economic Zone is located in Muara Enim Regency, South Sumatera Province, Indonesia (see the map in Figure 1).

However, this Coal Gasification Initiative requires a significant upfront investment for construction, estimated at US$5.8 billion (Umah, 2019), or Rp 81.2 trillion, at a Rp 14,000 per dollar exchange rate at the time the construction project began in January 2022. To start this new business, as a state-owned enterprise and its high risk business exposure, PTBA will need full government support first. After its

operation begins, then PTBA will need to collaborate with other companies interested in the output of coal-gasification projects.

As a regulator and the shareholder of PTBA, the Indonesian Government decides to support this initiative, even if it needs to seek and allocate a significant amount of investment. Government has determined the project as one of National Strategic Projects, as stated in Presidential Decree Number 109 / 2020. With such initiative, it is expected that the Government benefits from increased economic activity, foreign reserve savings, and employment opportunities (Zhou, Liu and Zhou, 2015). This initiative is important to bridge the transition of Indonesian economic structure from currently high carbon to low carbon, more sustainable, prosperous and equitable economic structure.

Fig. 1. The coal gasification project location of PTBA in Lawang Kidul Subdistrict, Muara Enim Regency, South Sumatera Province, Indonesia. It is inside the PTBA Mining Special Economic Zone.



Source: Ministry of Energy and Mineral Resources and PTBA

This study aims to assess the impact of the Coal-Gasification Initiative as a pioneering industry to Indonesian national also regional economy. It is expected that the outcome of study can deliver robust impact assessment approach of Coal Gasification Initiative as a pioneering industry and also act as a basis for expansion decision to many other prospective areas of coal-gasification industries in Indonesia particularly, or elsewhere in the world.

2. RESEARCH METHODS

This paper primarily uses a quantitative research method. We apply the Wassily Leontief's work on Input-Output (I-O) approach to determine how much impact of the coal-gasification pioneering industry have on different sectors of the economy, at national and provincial levels. We adopt the Leontief I-O simulation model techniques to analyze Indonesian National Input Output database and Interregional Input Output database of 34 provinces.

We use the 2016 Indonesia's I-O Table database for national level, and the 2016 Indonesia's IRIO Table database for regional or provincial level. The databases are compiled and published by BPS (Indonesian Central Agency of Statistics), the national agency responsible in conducting nationwide surveys. The 2016 I-O Table and the 2016 IRIO Table database are the latest table database outcome which BPS officially published based on national and all 34 provinces surveys. The intermediate output matrix of the 2016 I-O Table consists of 34,225 data, from a 185 product x 185 product matrix. Meanwhile, that of the 2016 IRIO Table consists of 3,125,824 data, from a matrix with 52 industry in each of 34 provinces in the row side, and also 52 industry in each of 34 provinces in the column side. For other national and provincial economic data necessary for analysis, we also refer to relevant BPS official publication (www.bps.go.id).

The Leontief's I-O model can help estimate how demand shocks affect outputs, Gross Domestic Product (GDP), Gross Regional Domestic Product (GRDP), labor compensation, business surplus, and tax revenue. The model shows how products flow from one sector, called producers, to another sector, called consumers. These product flows are known as "transactions inter sectors " (Mancarella, 2014). While I-O Model applied on 2016 Indonesia's I-O Table database can estimate the impacts in various sectors in one region only, i.e. Indonesia, I-O Model applied on the 2016 IRIO Table database can estimate the impacts in many sectors in many regions (i.e. in detailed sectors of 34 provinces in Indonesia) (see Miller and Blair, 2009).

The I-O table database is a matrix that provides statistical information about the transactions of goods and services and how different economic sectors are connected in a specific area at a particular time. The matrix helps us see the economic impact of policies such as the coal-gasification initiative during a specific period, as explained by Wikarya (2015).

The I-O table database provides a complete view of specific sectors that significantly impact economic growth and are vulnerable to economic changes. The I-O table database is always balanced because the sum of sector outputs equals the sum of its inputs. The table

database has the same number of rows (Xj) as columns (Xi), creating an equal balance. This relationship can be expressed as follows:

$\sum_{j=1}^{i} X_{ij} + F_i = X_i$ for *i = 1, 2, …, n* …… (1)

and

$\sum_{i=1}^{j} X_{ij} + V_j = X_j$ for *j = 1, 2, …, n* …… (2)

Where:

X_{ij} = the number of outputs of sector i used as inputs by sector *j.*
F_i = the number of final demands for each sector *i.*
V_j = the number of primary inputs (gross value added) of sector *j.*
X_i = the sum of the outputs of sector *i.*
X_j = the sum of sector inputs *j.*

The simulation model approach for Indonesia's I-O Table Database is based on Input-Output Model for one region as follows

$X = (I - A)^{-1} . f$ …… (3)

where

X = output matrix (x_i^j)
I = identity matrix
A_s *= sector input coefficient matrix* (a_i^j)
F = final demand matrix (f_i^j)

$(I - A)^{-1}$ is a Leontiff matrix. The matrix is used to calculate and analyze the impact on Indonesia's economic output (X) due to demand shocks arranged in matrix F. For other impacts on Indonesia's GDP, Labor Compensation, Business Surplus and Tax Revenue, we need to adjust the above Input-Output Model as follows

$X = [(I - A)^{-1} . C]. f$ …… (4)

where

X = output matrix (x_i^j)
I = identity matrix
A_s *= sector input coefficient matrix* (a_i^j)
C = primary inputs coefficient matrix
F = final demand matrix (f_i^j)

The relevant primary inputs coefficient matrices (C) that we put in the model for the other impacts are the coefficient matrices of Gross Value Added, Labor Compensation, Business Surplus, and Tax Revenue.

The basic concepts of simulation model approach for Indonesia's I-O Table database above are still applied to the Indonesia's IRIO Table database. However, there should be some adjustments since the Indonesia's IRIO Table database includes not only sector interactions within one province (region), but also sector interactions among different provinces (regions).

The adjustments are based on the following equation of matrices [see Miller and Blair (2009) and Rum et al. (2022)]

$(1 - a_{ij}^{rr})\, x_i^r - \sum_{s=1}^{R-\{r\}} \sum_{j=1}^{n} a_{ij}^{rs}\ x_{ij}^{rs} = \sum_{s=1}^{R} \sum_{k=1}^{f} fd_{ik}^{rs}$ ..... (5)

where *R, n, f is number of provinces, sectors and final users.*

With the adjustments, for demand shocks on every *(r, s) ∈ R X S*, the impact on the output of sector *i* in province *r* (x_i^r) can be calculated based on the input coefficient data of inter-province industry transactions from sector *i* in province *r* to sector *j* in province *s* and inter-province final demand transactions from sector *i* in province *r* to final user *k* in province *s*.

3. LITERATURE REVIEW

The coal-gasification industry faces many challenges, including the need for a significant amount of investment. A study by Evatt et al., (2014) emphasizes the importance of investment in natural resource extraction businesses like coal. The United Nations (2017) suggests that policymakers and tax authorities should consider the benefits and improve program design, assessments, and administration to ensure tax efficiency, sustainable growth, and state income. Bowen, Christiadi and Deskins (2015) reported a decline in coal production and job losses in West Virginia, negatively impacting state tax revenues.

Several challenges and obstacles must be overcome when it comes to pioneering coal gasification industries. One of the biggest challenges is the upfront investment required. Zhou, Liu and Zhou (2015) identified financial challenges as one of the five inhibiting factors hindering industry development. However, other factors can also affect industries' investment decisions, including knowledge and technology, the scale of the economy, economic conditions, and social and political constraints.

Like the United States, Turkey also needs energy to promote national development through investment in coal energy. Acar, Kitson and Bridle (2015) highlight several challenges facing Turkey's electrical system, including increased public demand for electricity due to economic growth, resulting in greater energy use. The coal regime in Turkey has significant economic, social, and environmental burdens, as mentioned in the study. Acar, Kitson and Bridle (2015) also examine the cost of investing in coal in the form of subsidies, which causes a rise in external costs due to the impacts of coal exploitation on the environment and health.

The study of Atteridge, Aung and Nugroho (2018) focused on the international dynamics of coal production, potentially impacting future downstream production. Global coal production predicted that coal prices would remain uncertain, while the cost of renewable energy for power plants is becoming more competitive than coal-based electricity. On the other hand, there is a growing concern among

the international community about climate change. At national level, Indonesian Government is aware of disasters impact due to climate change on its national development sustainability. Thus, Government raises its commitments at international level and integrated programs and financing at national level in reducing its greenhouse gas emissions (Setiawan et al., 2021).

The study of Dippenaar (2018) on South Africa highlights the country's challenges in securing its electricity supply while reducing greenhouse gas emissions. Success in reducing greenhouse gas emissions can come from energy efficiency (EE) and renewable energy (RE) initiatives, as measured by the number of households and business sectors actively participating in these programs. The Government should include several tax incentives in the climate policy agenda to encourage EE and RE programs.

The Input-Output (I-O) Model

W. Leontief first developed the Input-Output (I-O) model in the late 1930s. He was awarded the Nobel prize for economic sciences in 1973 for his contributions to the model's development. One of the unique aspects of the Leontief model is its focus on inputs and outputs, while the term "interindustry analysis" is often used in his model, as noted by Sitepu and Sinaga (2006). The primary purpose of the input-output framework is to analyze the interdependence among industries in the economy, which makes it an essential tool for analyzing economic activities and predicting how changes in one sector can affect other sectors of the economy.

Leontief used a matrix to depict his Input-Output (I-O) table, shown in Table 1, and he divided it into four quadrants: quadrants I, II, III, and IV. Quadrant I of the I-O table shows the flow of goods and services produced and used by each sector in the economy, focusing on the distribution of goods and services for production purposes. This quadrant reflects the consumption of goods and services used for reproducing processes, whether as raw materials or intermediary inputs/goods, known as "intermediate transactions." It is important because it demonstrates the interdependence among sectors in production, highlighting the critical role of different sectors and how changes in one sector can affect others in the economy.

Table 1. Structure of the Input-Output Table

Output / Allocation / Input Structure	Sector	Intermediate Demand						Final Demand	Total Output
		1	2	.	.	.	n		
Intermediate Input	1	X_{11}	X_{12}	.	.	.	X_{1n}	F_1	X_1
	2	X_{21}	X_{22}	.	.	.	X_{2n}	F_2	X_2

	. . . N	. . . X_{n1}	. . . X_{n2}	. . . .	. . . .	. . . .	. . . X_{nn}	. . . F_n	. . . X_n
Primary Input		**V1**	**V2**	.	.	.	**Vn**		
Total Input		**X1**	**X2**	.	.	.	**Xn**		

Source: Sitepu and Sinaga (2006)

Quadrant I is described as follows:

Xij = output value of the production sector i used as input by the production sector j. The rows reflect the sales of the output, while the columns represent the input purchase.

Quadrant II of the Input-Output (I-O) table depicts the final demand, which is the consumption of goods and services for purposes other than production. This quadrant typically includes household consumption, Government expenditure, investment, and exports and imports. It shows the end use of goods and services and provides a comprehensive view of the economy's total output. By analyzing the final demand, economists can predict the impact of changes in consumption patterns or Government policies on the economy as a whole.

Leontief presented the Input-Output (I-O) table in a matrix format, where the rows show how a sector allocates or distributes its output to meet the intermediate and final demands of other economic sectors. Meanwhile, the columns represent the input used by each sector for their production activities. The matrix structure provides a clear and organized way to analyze the interdependence between sectors, where the output of one sector becomes the input of another. By looking at the rows and columns of the matrix, policymakers and economists can better understand the flow of goods and services throughout the economy and predict how changes in one sector may impact others.

Quadrant III in the I-O table shows the production sectors' primary inputs, which include production factors such as labor wages and salaries, the surplus of business added by depreciation, and net indirect taxes. The sum of these primary inputs contributes to the gross domestic product of a region. Quadrant IV, on the other hand, displays all primary inputs directly distributed to the final demand sectors. Although this quadrant is not the main focus of the matrix, it can be found in detail in the Sistem Neraca Social Ekonomi (SNSE) published by the Indonesia Statistic Agency or BPS (Badan Pusat Statistik, 2011).

The SNSE, published by the Indonesia Statistics Agency (BPS), is a matrix that summarizes social and economic variables, providing a

detailed overview of the Indonesian economic condition and the relationships between its variables at a specific time. It offers a complete picture of the country's economic performance, including indicators such as Gross Domestic Product (GDP) or Gross Regional Domestic Product (GRDP), income distribution, household income distribution, factorial income distribution, and household expenditure patterns. Using the SNSE, researchers can comprehensively understand Indonesia's economic situation and its regions (Badan Pusat Statistik, 2011).

4. DISCUSSION AND ANALYSIS

4.1 Development of the Coal Gasification Industry in Indonesia

Indonesia's coal gasification industry has significant growth potential, supported by concrete evidence of increasing coal prices over the past few years (see Figure 2) and high domestic energy demand.

Coal gasification has an excellent opportunity to grow as it aligns with the global trend toward clean energy. Moreover, the program is supported by the national trend of increasing energy demand (Yasin et al., 2021). The main product of gasification is synthesis gas or syngas; its main components consist of carbon monoxide (CO), hydrogen, carbon dioxide (CO2) and nitrogen. The syngas can then be further converted into clean downstream products such as methanol, dimethyl ether (DME), fertilizer, polypropylene and various other high-value products.

Fig 2. The Trend of Coal Price

Source: Ministry of Energy and Mineral Resources (2023)

for imported liquefied petroleum gas (LPG). To reduce its reliance on imported LPG, Indonesia needs to increase its domestic production. PTBA is one of several mining companies interested in diversifying into the coal gasification industry.

4.2 The Projected Impact of Coal Gasification Initiative to Local Economy

As a company located in the South Sumatra province, specifically the Muara Enim regency, PTBA's presence positively affects local employment. To demonstrate the changes brought about by the investment, the authors presented the outcome of I-O simulation of the Muara Enim regency economy if assumed the coal gasification production starts in 2022, a working collaboration among ESDM, Bappeda, and BPS Muara Enim. The results are as follows.

Table 2. The Estimated GRDP and the Size of Employment in Muara Enim Regency, South Sumatra Province with PTBA Investment in Coal Gasification (million rupiahs)

Sector Code Number	Sector	2017 Gross Regional Domestic Product	GRDP Growth (%)	2022 GRDP Projection	2022 GRDP Projection with PT BA Investment	Percentage of Change	Number of Labor Force Used
1	Agriculture	5,078,576	4.53	6,338,785	6,356,397	0.28%	619
2	Oil and Gas Mining	4,583,446	10.16	7,435,528	7,440,988	0.07%	4
3	Coal	16,802,114	10.16	27,257,346	66,392,782	143.58%	2,403
4	Mining and other quarrying	3,686,426	10.16	5,980,330	5,990,555	0.17%	9
5	Food Beverage and Tobacco Industry	2,023,364	4.06	2,469,180	2,469,294	0.00%	1
6	Wood, Rattan, and Bamboo Industry	81,929	4.06	99,981	100,047	0.07%	11
7	Paper, Printing, and Publishing Industry	3,750,964	4.06	4,577,429	4,578,852	0.03%	5
8	Chemical, Rubber, Plastic, and its Derrivative Product Industry	194,795	4.06	237,714	286,210	20.40%	306
9	Furniture Industry	2,810	4.06	3,429	3,429	0.00%	0
10	Other Industries	805,383	4.06	982,837	999,817	1.73%	285
11	Electricity, gas, and consumable water	78,419	15.58	161,726	164,992	2.02%	20
12	Building/Construction	2,818,133	7.74	4,090,616	4,111,812	0.52%	63
13	Wholesale and Retail	3,584,993	8.50	5,389,534	5,567,636	3.30%	398
14	Restaurant	224,176	8.42	335,887	337,176	0.38%	162
15	Hotel	27,287	8.42	40,885	40,962	0.19%	79
16	Road and Highway Transport	337,458	7.50	484,464	498,295	2.85%	223
17	Transportation Supporting Services	333,797	7.73	484,421	492,969	1.76%	139
18	Communication	322,727	13.41	605,431	608,063	0.43%	44
19	Banks, Financial Institution, and Government	298,206	8.57	449,906	469,991	4.46%	65
20	Corporate Services and Property Rent	518,199	7.73	752,034	809,682	7.67%	459
21	Other services	1,552,058	3.31	1,826,374	1,846,270	1.09%	283
TOTAL		47,105,259		70,003,838	109,566,217		5,578

Source: ESDM, Bappeda, BPS Muara Enim

The GRDP of Muara Enim before the coal gasification industry (2017) was Rp47.11 billion and is projected to increase to Rp70.01 billion in 2022. Suppose PTBA successfully executed the downstream

production in 2022, in that case, the GRDP is projected to increase more rapidly to Rp109.57 billion, which means the size of the economy will double over six years (2017-2022). Establishing the coal gasification industry in the Muara Enim regency of South Sumatra province is estimated to absorb 5,578 workers, a significant number for an area as large as Muara Enim.

The I-O simulation demonstrates that the development of PTBA's coal gasification project has a positive and strategic impact on local economic development, including an increase in GRDP and employment.

4.3 The Impact Assessment of Construction Project of Coal Gasification Initiative to National Economy

To start the coal gasification industry, PTBA needs to build a specific gasification construction site with the estimated investment amount IDR 81.2 trillion. The Indonesia I-O model simulation shows that impact of the investment can generate an estimated total output of Rp483 trillion for the Indonesian economy, Rp84 trillion from coal and lignite sector and Rp399 trillion as indirect impact from other sectors. Furthermore, the simulation predicts that in total, GDP will increase Rp130 trillion, labor compensation will increase Rp24 trillion, the gross business surplus will increase Rp106 trillion, and indirect tax revenues will reach Rp664 billion (see Table 3).

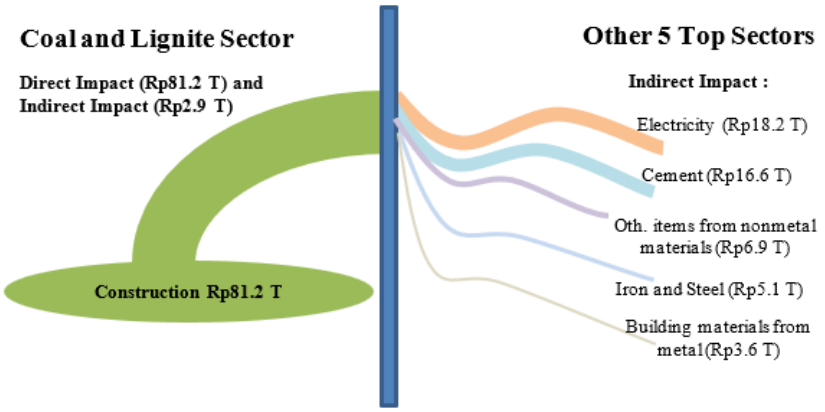
Table 3. The Potential Impact of Coal Gasification Construction on the National Economy (in Rp billions)

No.	Impact	Coal and Lignite Sector	Other Sectors (Indirect)	Total Potential Impact
1.	Output	84,180	398,725	482,905
2.	GDP	49,196	80,928	130,124
3.	Labor compensation	9,011	14,824	23,835
4.	Business Surplus	39,934	65,691	105,625
5.	Indirect Tax	251	413	664

Source : Authors' calculation

Several sectors are identified as main contributors in each impact (see Fig. 3). Six sectors contribute 28% out of the estimated total output of Rp483 trillion. Coal and lignite sector surely shares the most with 17%, Rp81.2 trillion from direct impact and Rp2.9 trillion from indirect impact. Other sectors out of coal and lignite sector share the indirect impact. The second top contributor is electricity, it shares 4% or Rp18.2 trillion. The other four top sectors share contribution as follows, cement 3% or Rp16.6 trillion, other items from nonmetal materials 1.4% or Rp6.9 trillion, iron and steel 1% or Rp5.1 trillion, and building materials from metal 0.7% or Rp3.6 trillion.

Fig. 3. Transmission of Impacts on National Sectoral Output from Gasification Construction Project Investment



Source: Authors' calculation

4.4 The Impact Assessment of Production Set Up of Coal Gasification Initiative on National Economy

After the construction project is completed, PTBA will proceed to the production stage. Based on a market review analyzing potential market demand, PTBA plans to produce three types of coal derivative products, those are urea fertilizer, polypropylene and DME.

Table 4. Production Set Up

Investment	Production			Total (USD mill.)	Total (IDR mill.)
	Fertilizer	Polypropylene	DME		
Capex (USD)	616,000,000	2,236,000,000	593,000,000	3,445	51,675,000

Note: in production set up, the conversion rate is assumed US$1 = IDR 15,000 to more reflect recent rate.

Source: PTBA's basic estimate; Authors' calculation

To carry out the production stage of these three products, PTBA allocates a number of capital expenditure for production set up expenses related with production equipment and supplies spending (see Table 4). For capital expenditure financing, companies commonly prefer to finance most or all of internally generated cash flows (Mielcarz, Osiichuk, and Behr, 2018). In this stage, the estimated value of second demand shock from the coal and lignite sector is IDR 51.68 trillion.

Table 5. The Potential Impact of Coal Gasification Production Set Up Investment on the National Economy (in Rp billions)

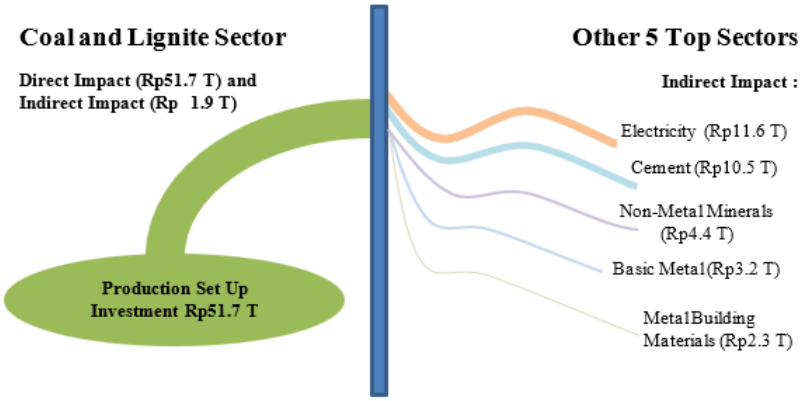
No.	Impact	Coal and Lignite Sector	Other Sectors (Indirect)	Total Potential Impact
1.	Output	53,571	253,745	307,317

2.	GDP	31,308	51,502	82,810
3.	Labor compensation	5,735	9,434	15,169
4.	Business Surplus	25,414	41,805	67,219
5.	Indirect Tax	160	263	422

Source : Authors'calculation

The second demand shock in the Indonesia's I-O model simulation results that the potential output impact of production set up investment in the gasification industry for Indonesian economy is Rp307 trillion. In more details, Rp54 trillion from coal and lignite sector and Rp253 trillion as indirect impact from other sectors. The demand shock will generate increases in GDP Rp83 trillion, labor compensation Rp15 trillion, the gross business surplus Rp67 trillion, and indirect tax revenues Rp422 billion (see Table 5).

Fig. 4. Transmission of Impacts on National Sectoral Output from Production Set Up Investment



Source: Authors' calculation

As shown in Fig. 4, several sectors play role as main contributors. They contribute 28% out of the estimated total output of Rp307 trillion. Coal and lignite sector still claim the most with 17%, Rp52 trillion from direct impact and Rp2 trillion from indirect impact.

Some other sectors also share the indirect impact: electricity accounts 4% or Rp12 trillion, then cement accounts 3.4% or Rp11 trillion, other items from nonmetal materials accounts 1.4 % or Rp4.4 trillion, basic metal accounts 1 % or Rp3.2 trillion, and metal building materials accounts 0.7 % or Rp2.3 trillion.

4.5 The Impact Assessment of Initial Production of Coal Gasification Initiative to Multi-Province Economy

The above three coal gasification products can be substitutes for similar products produced in Indonesia from different raw materials. The domestic market condition of higher demand than supply for

these three products (urea fertilizer, polypropylene and DME) has caused Indonesia's dependence on imports from abroad.

Farmers use urea fertilizer to provide nutrition for paddy fields, fields and plantations, while polypropylene is a kind of raw material various plastic products and containers for food and others. DME is a substitute for LPG (liquefied petroleum gas) fuel, and DME supply highly depends on imports in recent years.

To place the demand shocks of those three products right in the I-O Model Simulation on IRIO Table Database, we need to identify the suitable sector for each product in the Database. We identify that urea fertilizer is a production input for Chemical, Pharmaceutical and Traditional Medicine industries; polypropylene is a production input for Rubber and Plastic Industries, while DME is a production input for Gas Procurement and Ice Production industries.

Table 6. Initial Production Plan

Investment	Production			Total (USD mill.)	Total (IDR mill.)
	Fertilizer	Polypropylene	DME		
Initial Production Target (tonnes), A	570,000	450,000	400,000		
Opex	USD 135.35	USD 497.4	USD 198.53		
Cost of Goods Sold per tonnes (USD per tonnes), B	253	1,450	393		
Cost of Goods Sold (C) = A * B	144,210,000	652,500,000	157,200,000		
IDR Mill.	2,163,150	9,787,500	2,358,000		14,308,650
Total				4,398.91	65,983,650

Note: in initial production, the conversion rate is assumed US$1 = IDR 15,000 to more reflect recent rate.

Source: PTBA's basic estimate; authors' calculation

For the initial production, PTBA is going to produce 570,000 tonnes of urea fertilizer, 450,000 tonnes of polypropylene, and 400,000 tonnes of DME. The values of cost of goods sold for each product are shown in the Table 6.

After production set up, PTBA is ready for initial production plan execution as shown in Table 6. The third demand shock comes from the following three industrial sectors: (1) Chemical, Pharmaceutical and Traditional Medicine for urea fertilizer demand; (2) Rubber and Plastic Products for polypropylene demand; and (3) Gas Procurement and Ice Production for DME demand. Each of PTBA's demand shock output values from the three sectors are first, IDR 2,163 trillion in Chemical, Pharmaceutical and Traditional Medicine sector; second, IDR 9,788 trillion in Rubber and Plastic Products; and third, IDR 2,358 trillion in Gas Procurement and Ice Production sector.

To distribute the provinces of origin of the three demand shocks, we conduct an investigation into the capacity of the three industrial sectors to fullfil these demand shocks. We observe the economic structure of the South Sumatra province and other surrounding provinces. Several provinces that have the potential to become origins of demand shocks are divided into four groups (see Table 7).

Table 7. The Capacity of Three Industrial Sectors in South Sumatra Province and Surrounding Provinces Related to The Third Demand Shocks

Group	Provinces	Sectoral Output (IDR Mill.)		
		Chemical, Pharmaceutical and Traditional Medicine	Rubber and Plastic Products	Gas Procurement and Ice Production
Group 1	South Sumatera	23,338,199	4,537,428	665,728
Group 2	Bengkulu	410	357,802	4,277
	Jambi	289,771	1,793,306	30,683
	Lampung	2,457,317	6,025,541	426,743
Group 3	Riau	20,628,534	1,463,587	524,378
	North Sumatra	438,863	11,431,792	618,361
Group 4	West Java	68,763,093	19,194,019	16,506,454
	Banten	16,825,118	31,007,268	7,254,865

Source: compiled from 2016 IRIO Table Database BPS

The first group is the province of South Sumatra itself; then group two are the three closest neighboring provinces, namely Bengkulu, Jambi, and Lampung. Furthermore, the third group is Riau and North Sumatra. These provinces are the neighboring provinces which are separated by the three closest neighboring provinces above and still located in the island of Sumatra. The fourth group is Banten and West Java. Those provinces are located in the island of Java, just separated by the Sunda Strait and not far from Lampung province.

Furthermore, we distribute properly on each group above by determining each weight based on : (1) the capacity of industrial sectors in each province, and (2) the distance between the industry (with demand shock) and PTBA (which provides production input for the industry). The first group is the closest, so its industrial sector has the most priority for the relevant demand shock. We give 0.5 as the coefficient of weight (it means we assume that the maximum capacity to produce is only 50 percent of sector values in 2016 IRIO Table Database). If the first group can not absorb all demand shock, then the rest of demand shock is distributed to the second group. The second group is also given a coefficient of weight 0.5.

If again, the first and second group can not absorb all the relevant demand shock, then the rest of demand shock is distributed to the third group. Since the distance is farther, we then set a less coefficient of weight 0.4 (under assumption that the maximum capacity to produce is only 40 percent of sector values in 2016 IRIO Table Database).

Furthermore, if the first, second, and third group can not absorb all the relevant demand shock, then the remaining demand shock is distributed to the fourth or last group. The fourth group is the last priority since it is the farthest and involve the most complex route and the most expensive costs. The distribution result is shown in Table 8.

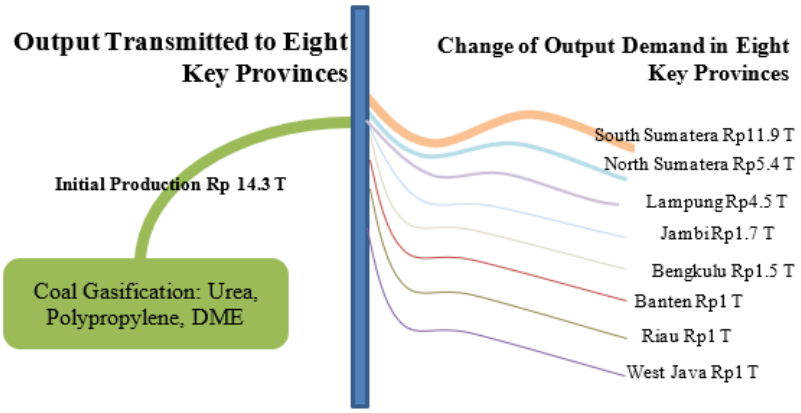
Table 8. The Distribution of Third Demand Shock

Group	Provinces	Distribution of Third Demand Shock (IDR Mill.)			TOTAL DEMAND SHOCK
		Chemical, Pharmaceutical and Traditional Medicine	Rubber and Plastic Products	Gas Procurement and Ice Production	
Group 1	South Sumatera	2,163,150	2,268,714	332,864	4,764,728
Group 2	Bengkulu	-	178,901	2,139	181,040
	Jambi	-	896,653	15,342	911,995
	Lampung	-	3,012,771	213,372	3,226,143
Group 3	Riau	-	585,435	209,751	795,186
	North Sumatra	-	2,845,027	247,344	3,092,371
Group 4	West Java	-	-	668,594	668,594
	Banten	-	-	668,594	668,594
TOTAL DEMAND SHOCK		2,163,150	9,787,500	2,358,000	14,308,650

Source: Authors' calculation

We then assessed the economic impact of PTBA's initial production plan activities in South Sumatra and also its transmission to other provinces outside South Sumatra by adopting I-O Model on 2016 Indonesia IRIO Table Database as previously explained in Research Method section. The simulation model result is shown below in Fig. 5.

Fig.5 Change of Output Demand from Initial Production in Eight Key Provinces



Source: Authors' calculation

As shown in Fig.5, PTBA's initial production of IDR 14.3 trillion provides a total transmission impact of the increasing output IDR 31.7 trillion in eight provinces. South Sumatra becomes the province which has the biggest increase in output, IDR 11.9 trillion or 38 percent of the total output, followed by North Sumatra IDR 5.4 trillion (17%) and Lampung IDR 4.5 trillion (14%). Meanwhile, neighboring provinces with small production capacity and other provinces with large industrial areas on the island of Java still get a small transmission impact under IDR 2 trillion.

Table 9. The Economic Impact at Provincial and National Level in Indonesia from Initial Production Plan of Coal Gasification Initiative (in % deviation from baseline)

Impact	South Sumatera	North Sumatera	Lampung	Jambi	Bengkulu	Riau	Banten	West Java	Oth. 26 Prov.	TOTAL NATIONAL
Output	1.57	0.47	0.94	0.70	1.60	0.10	0.08	0.03	0.02	0.13
Growth	0.92	0.28	0.63	0.41	1.01	0.08	0.11	0.03	0.02	0.09
Labor compensation	0.75	0.16	0.59	0.55	0.80	0.06	0.08	0.01	0.01	0.06
Business Surplus	1.01	0.32	0.63	0.29	1.13	0.09	0.13	0.05	0.02	0.10
Indirect Tax	2.24	1.12	1.83	1.47	2.67	0.23	0.01	0.002	0.01	0.08

Source: Authors' calculation

From Table 9, in terms of its impact on growth (from each provincial baseline), the PTBA's initial production has the biggest transmission impact on Bengkulu's economic growth (1.01%), followed by South

Sumatra (0.92%) and Lampung (0.63%). As an illustration, under assumption that the PTBA's initial production can start from date 1 January 2023, with Lampung's GRDP in 2022 (constant) of IDR 49.92 trillion as a baseline, there will be a potential increase in Lampung's GRDP amounted IDR 504 billion in year 2023. For North Sumatra, with a baseline GRDP in 2022 (constant) of IDR 343.48 trillion, its GRDP will potentially increase by IDR 3.16 trillion in 2023.

During initial production stage of Coal Gasification Initiative, South Sumatra province and its neighboring provinces (those are similarly situated in Sumatera Island in particular), gain a very significant impact in all economic indicators compared with the other 26 provinces out of the Initiative production network. Meanwhile, two neighboring provinces in Java Island still share a small piece of impact transmission due to the lack of Sumatera's production capacity.

As a matter of fact, the coal mining exploration spots in Indonesia are mostly located in provinces outside Java Island, the island which dominantly contributes national GDP. The Coal Gasification Initiative can draw some of Java Island's national economic growth burden to other provinces outside Java Island. It can also promote green economy, and equitable and sustainable development.

As the Government carry out the Coal Gasification Initiative starting from PTBA in South Sumatera province in Sumatera island, we can see that the province will be the largest beneficiary. South Sumatera's output is 79 times higher and its growth is 46 times better than the other 26 provinces out of the Initiative production network. Moreover, South Sumatera's labor compensation, business surplus, and indirect taxes are also 75 times, 51 times, and 224 times better respectively than the other 26 provinces.

West Java province – ranked the third biggest GDRP (2021) among 34 provices in Indonesia - is known for its big industry capacity. Despite West Java's much bigger GDRP size than the other 26 provinces in average, West Java still gains higher economic impact from the Gasification Industry Initiative than the other 26 provinces, despite its only small contribution in the Initiative production network.

5. Conclusions and Policy Recommendations

5.1 Conclusion

Indonesia's coal gasification industry is still not developed yet, so it has significant potential for development. The development program aligns with the Government's downstream policy aimed at increasing the economic value of natural resources, particularly minerals and coal. The Coal Gasification Initiative encourages energy firms to

convert coal into derivate products such as urea fertilizer, polypropylene, and DME.

Based on the discussion and analysis presented above, the authors conclude that the Coal Gasification Initiative brings positive impact for various sectors in Indonesian national economy and also in its 34 provincial economies, starting from construction project, production set up, up to initial production stages.

The adopted I-O model simulations show several benefits from the coal gasification investment in Indonesia both in national and provincial or regional levels, despite of relatively large investment needs for financing. It reinforces the PTBA and regency government study which shows a significant impact on local or regency level economic development.

More specifically, the I-O model simulations result the increase in economic output, growth, labor compensation, business surplus, and tax revenues in those three levels. The province where the gasification industry is located and the neighboring provinces which are part of the PTBA urea fertilizer, polypropylene, and DME production network can benefit much more significant economic impact than the other 26 provinces out of the Initiative production network.

The positive result from the assessment may encourage a shift in the mining business towards better business models that boost the national economy, maintain environmental sustainability, and promote bright energy future. The outputs of coal gasification can generate many business opportunities, including the possibility of turning the coal gasification products into export commodities. It will also reduce Indonesian dependency on imports and save more foreign reserves.

Indonesian government has appointed the PTBA to pioneer the gasification industry. As a pilot project in the industry, its success will attract other coal mining companies to run the business as well. This study can deliver a base reference for the impact magnitude if the Coal Gasification Initiative is expanded further to many other prospective areas in Indonesia. In this context, the Initiative and further expansion can help share the economic growth burden out of Java Island, while supporting green economy and equitable, sustainable development simulatenously. It is expected that it can also deliver another substantial reference for the impact magnitude of coal gasification program elsewhere in other countries.

5.2 Policy Recommendations

Indonesia's pioneering coal gasification industry faces high production costs and expensive technology. As a result, the Government must encourage energy companies to invest in the coal gasification sector. The argument is that the successful investment by pioneering

companies will attract further investment from similar firms. Thus, providing fiscal incentives can be a good policy recommendation in this case. With that support, it will be easier to attract domestic or international investors in the Initiative financing.

If the Government provide such incentives, it will have a multiplier effect on the Indonesian national, regional, and local economy. The incentives can be in the forms of tax incentives provision, royalty cuts, subsidies and other facilities. However, the Government must take prudential measures to avoid any misuse of those incentives.

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