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Abstract

Domestic natural gas utilization in Indonesia suffers from lack of proper infrastructure and high transportation costs. The government might benefit from detailed estimation of demand to anticipate potentially fast-growing natural gas utilization in the future. Using Global Trade Analysis Project - Energy (GTAP-E) model simulation, this paper attempts to present a long-run estimation of natural gas demand in manufacturing sector for year 2025, 2030, and 2035. Chemical industry will remain the largest user of natural gas, followed by electricity, basic metal, and metal industry. To meet these demand, domestic production of natural gas should increase by 36.7 percent and 99.49 percent in 2025 and 2035, respectively. It brings us to the urge of massive investments in natural gas production and distribution.

Keywords: *natural gas, GTAP-E Model, energy demand*

JEL Code: Q41, Q47

1. Introduction

Natural gas plays a vital role in Indonesia's energy sector, both currently and in the future. Although Indonesia does not belong to world's largest holders of natural gas reserves—it holds only 1,5 percent of total world's proven resources in 2016 (BP 2017)—natural gas reserves in Indonesia is considerably large, estimated at around 144,06 TSCF. The Ministry of Energy and Mineral Resources (MEMR) estimated that largest reserve is being held in Natuna Island (49.87 TSCF), followed by Papua (19.03 TSCF), and Maluku (16.73 TSCF). This estimated numbers have not taken into account larger reserves from coal bed methane (453 TSCF) and shale gas (574 TSCF). In 2016, it is estimated that the annual production of natural gas is 6.752 MMSCFD (MEMR 2016b).

Natural gas is also predicted to be a major energy source in upcoming years, caused by increasing reserve availability, industrial demand growth, and global switch from coal (BP Energy

Economics 2018). Aside from large amount of reserves, natural gas has the advantage of yielding relatively less carbon emission compared to oil. Natural gas is targeted by the government of Indonesia to occupy larger portion in nation-wide energy source, according to 2014 National Energy Policy. It is expected to meet 22 percent and 24 percent of total energy utilization by 2025 and 2030, respectively. However, optimal domestic utilization of the energy source has been facing various challenges and hindrances, both from economic and non-economic factors.

Table 1. Main Users of Natural Gas in 2015 in Indonesia

Users		Amount BSCF	Percentage %
Domestic		1,448.72	49.14
	Fertilizer	238.06	8.07
	Refinery	39.53	1.34
	Petrochemical	31.55	1.07
	Condensation	7.85	0.27
	LPG (Liquefied Petroleum Gas)	24.80	0.84
	PT. PGN (National Gas Company)	229.50	7.78
	PT. PLN (State Electricity Company)	305.48	10.35
	PT. Krakatau Steel	3.57	0.12
	Other industries	246.40	8.36
	City Gas	0.21	0.01
	Own-use	214.31	7.27
	Transportation/BBG	1.40	0.05
	Local LNG	106.06	3.60
Export		1,226.40	41.60
	Feed for LNG Refinery	919.72	31.19
	LPG (Liquefied Petroleum Gas)	-	-
	Pipeline Gas	306.68	10.40
Losses	Gas lift & gas reinjection	273.40	9.27
Total		**2,948.36**	**100,00**

Source: Ministry of Energy and Mineral Resources (2017)

Domestic natural gas market in Indonesia is considered to be fragmented. Distance between natural gas resource and its users, as well as inadequate distribution infrastructure poses hindrance for higher domestic gas utilization (Purwanto et al. 2016). The problem is exacerbated by inability for industries to afford end-user natural gas price, as natural gas pipeline usage fee tends to be costly. Ministry of Industry (MoI) recounted a trend of shift towards other fossil-based energy due to high end-user price of natural gas (MoI 2018). The table below illustrates main users of natural gas in 2015 in Indonesia.

Electricity generation is the largest natural gas users in Indonesia. PT. PLN, the State Electricity Company, consumed around 10 percent from a total of 2,948.36 *Billion Standard Cubic Feet* (BSCF) nation-wide production in 2015. Fertilizer industry follows behind electricity sector as the largest user of natural gas. In 2015, around 40.4 percent of natural gas sales made by PT. PGN were for electricity generation purpose. To alleviate sub-optimal domestic utilization of natural gas, the government should solve bottlenecks in natural gas pipeline infrastructure. Energy planning has been becoming more imperative, with integrated approach and consideration of linkage between macroeconomic conditions with energy demand being an important factor in formulation of energy planning. Energy sector cannot be isolated from its underlying economic interaction; therefore, energy planning, pricing, and management should be seen from integrated approach (Munasinghe 1990). After detailed per-sector natural gas development plan and allocation have been obtained, then the government can proceed into providing adequate infrastructures for natural gas distribution. Priorities thus can be given to largest natural gas users.

This paper aims to provide a long-run estimation of natural gas demand in Indonesian manufacturing sector. The contribution of this paper is twofold: (1) to provide an insight into efficient allocation of natural gas uses in Indonesia, and (2) to present an alternative method for natural gas demand forecasting using a computable general equilibrium model. The rest of this paper is organized as follows. Part 2 describes literature review. Part 3 represents methodology. Part 4 shows results. Finally, conclusions are in Part 5.

2. Literature review

Studies related to energy demand analysis have been extensively conducted. Interests in the topic started to rise in 1970s when oil shock affected global economic condition (Munasinghe 1990; Andersen, Nilsen, and Tveteras 2011). Energy demand is highly influenced by economic forces that underlie them. Macro level analyses may be conducted to evaluate relationship of energy consumption to population and level of economic activity, supported by analysis at sectoral level to further evaluate specific characteristics of each sectors. In this regard, computable general equilibrium models may be used to consider interactions affecting growth, energy trade, and energy prices (Bhatia 1987).

Suganthi and Samuel (2011) provided a summary of several models that have been previously incorporated to estimate energy demand. These models include: (1) time series models, (2) regression models, (3) econometric models, (4) decomposition models, (5) Unit-root test and cointegration models, (6) ARIMA models, (7) expert systems and ANN models, (8) Grey prediction, (9) Input-output models, (10) generic algorithm/fuzzy logic/neuro fuzzy, (11) integrated models such as Bayesian VAR, and (12) bottom-up models such as MARKAL/TIMES. Energy prediction is deemed to be vital due to it allows for optimal energy utilization both in terms of availability, quality, and environmental effects.

Models previously incorporated in industrial energy demand estimation are (1) econometric models, (2) end-use accounting, (3) input-output approach, and (4) process analysis (Bhattacharyya and Timilsina 2009). However, these approaches have been used to estimate total energy demand, treating various energy sources as substitute to each other. Estimation of natural gas demand for disaggregated manufacturing sector, however, has not been conducted extensively.

Previous studies on the issue took the case of European manufacturing sector. Chemical and petrochemical industries have been (and will remain) the largest users of natural gas, in addition to its energy-intensive nature. Own-price elasticity was found to be inelastic, both in short-run and long-run. There is also a prevalent positive relationship between energy intensity and own-price elasticity of natural gas demand, indicating that energy-intensive industries tend to be more responsive to change in energy price (Andersen, Nilsen, and Tveteras 2011).

The MEMR periodically publishes the Indonesian Natural Gas Balance (*Neraca Gas Indonesia*) which provides a prediction of future energy demand and supply (MEMR 2016a). The balance obtains future natural gas demand by collecting data for contracted and committed demand, as well as estimating potential demand. However, it does not provide further detailed per-sector demand estimation for manufacturing industry, as it is only grouped into electricity, manufacturing, household, and transportation uses. The lack for per-sector demand for manufacturing necessitates a detailed estimation of natural gas demand.

3. Methodology

To obtain an estimation of future natural gas utilization, this study conducts a simulation using GTAP-E (Global Trade Analysis Project – Energy Environmental Version) Model and database. GTAP-E is a computable general equilibrium model of global economy. The model is constructed as an adaptation from the standard GTAP model developed by Center for Global Trade Analysis, Purdue University, Indiana, United States (T. Hertel 1997) to form a CGE model containing energy and environmental modeling (Burniaux and Truong 2002; McDougall and

Golub 2007). GTAP-E database version 9 with baseline year 2011 is used in simulation. Aggregation scheme used is outlined in the Appendix.

CGE model is a system of equations which depicts an economy as a whole along with interactions between its components (Burfisher 2011,2). These mathematical equations can be used to analyze the impact of a policy by introducing a shock into the model's exogenous variable. The resulting changes in endogenous variables can be interpreted as the impact of a specified policy or any other exogenous factor. CGE model is superior when compared to other partial equilibrium analysis such as econometric models due to its ability to capture inter-market and inter-regional linkages (Hosoe, Gasawa, and Hashimoto 2010, 2-3). Taking into account such linkages is important as energy demand is derived from demand for firms' output (Berndt and Wood 1975).

In this study, natural gas demand is being forecast by assuming that the economy is moving in a predetermined direction. The direction is specified by introducing a shock into factor endowment, economic growth, and total factor productivity variables, which represents the trajectory of the economy during a specified period. It follows exogenous forecast method to obtain long-run estimation from static CGE model (Walmsley 1998). The dummy variable *rordelta* is set as 0 to allow for fixed current account balance, thus represent long-run condition where investment adjust to maintain a fixed capital stock.

The resulting simulation result is thus regarded as a static comparative treatment of an otherwise time-dependent situation. Investment and saving is a time-dependent aspect of the economy as savings require time before it can be incorporated into investment that affects production. The treatment assumes that capital stock changes according to a specified amount, as defined by an arbitrary number obtained from macroeconomic projection. The projection is obtained from EconMAP 2050 Database (Fouré, Bénassy-Quéré, and Fontagné 2012, 2013). The following is the assumptions as obtained from EconMAP 2050 Database.

Table 2. Assumptions Used in the Simulation

Variable	Predicted Change (%)	
	Indonesia	Rest-of-the-World
Database Update 2011-2018		
Total Factor Productivity	5.5	7.9
Capital Endowment	39.3	20.8
Labor Endowment	10.6	7.5
Population	7.2	6.9
GDP	38.7	18.0
2018-2025		
Total Factor Productivity	7.4	14.5
Capital Endowment	27.7	28.6
Labor Endowment	13.3	7.2
Population	7.9	7.9
GDP	35.1	24.9
2018-2030		
Total Factor Productivity	12.2	23.9
Capital Endowment	45.6	49.3
Labor Endowment	20.6	11.6
Population	12.3	12.4
GDP	60.1	43.5
2018-2035		
Total Factor Productivity	17.3	34.2
Capital Endowment	65.0	72.4
Labor Endowment	26.4	15.9
Population	16.1	16.6
GDP	75.3	64.9

Note: all values are in percentage change (cumulative)
Source: EconMAP 2050 Database, *Authors' calculation*.

The first few lines in the table are assumptions that are used to obtain 2018 condition from the GTAP-E Database, as the database only contains year 2011 as its base year. After the 2018 data is obtained, simulations are conducted for year 2025, 2030, and 2035 by using year 2018 data as its baseline. The corresponding GTAP variable for each assumption are *qo("Capital")* for

Capital Endowment, *qo("Labor")* for labor endowment, *pop* for population, and *qgdp* for GDP. By default, GDP is set as an endogenous variable, therefore, in this simulation; the closure has been modified by endogenizing an exogenous variable *afall* (total factor productivity) to replace the previously endogenous *qgdp* variable.

GTAP model records all transactions in monetary value, therefore, to estimate the demanded natural gas quantity; assumption of gas price of US$ 5.17/MMBTU is used. The price is obtained from average value of United States natural gas price from 2015-2017. As GTAP model records quantity change in percentage values, the price is used only to convert monetary purchases of natural gas in year 2018 only.

4. Results and Discussion

Demand for natural gas (in MMBTU) from manufacturing sector is presented in Table 3 below. The largest user of natural gas is predicted to be chemical industries, followed by basic metal and metal-based industries. The demand from chemical industry sector is predicted to be 1,003 million MMBTU in 2025 and expanded up to 1,320 million MMBTU in 2035. The amount is equal to 37.78 percent and 49.72 percent of total natural gas demand in 2025 and 2035, respectively. This is not surprising, considering that in chemical industry, natural gas is utilized both as energy source and feedstock. The result is in line with conditions in Europe (Andersen, Nilsen, and Tveteras 2011).

Table 3. Estimation of Natural Gas Demand for Manufacturing Industry

Industry Category	Natural Gas Demand (Million MMBTU) 2025	2030	2035
Food and Beverages	31.40	33.74	37.28
Tobacco Products	5.59	6.15	6.92
Textile and Apparel Products	7.40	8.61	9.87
Leather Products	0.49	0.55	0.64
Wood Products	2.78	3.10	3.58
Paper Products, publishing	22.88	25.11	27.80
Chemical, rubber, plastic products	1,003.52	1,177.28	1,320.78
Non-Ferrous Metal	20.33	24.28	28.93
Basic metal industries	196.06	224.87	268.14
Metal products and electronic equipment	83.41	96.05	110.10
Machinery and equipment	8.41	9.81	11.53
Motor vehicles and parts, transport equipment	13.75	15.88	18.55
Other manufacturing	51.77	59.54	67.61
Total Manufacturing Industry	1,447.79	1,684.98	1,911.73
Electricity	777.91	918.85	1,084.21

Source: GTAP-E Model simulation output, processed (2018)

Table 4 shows natural gas demand for other economic sectors. Manufacturing industries will remain as the largest user of natural gas compared to other sectors. The subsequent largest significant user is the electricity sector, which is predicted to use 777 million MMBTU and 1,084.21 million MMBTU of natural gas in 2025 and 2035, respectively. The forecast is consistent with government of Indonesia’s effort of increasing natural gas utilization in power plants, as reflected in the national 35GW power expansion plan. Natural gas uses from electricity sector is predicted to take up 29.28 percent of total natural gas consumption in 2025, and will expand up to 40.81 percent by 2035. The prediction does not deviate very far from the Electricity Supply Planning (*Rencana Usaha Penyediaan Tenaga Listrik*, RUPTL) 2017-2026, which predicted natural gas requirement in 2025 to be 752 TBTU (PLN 2017).

Table 4. Estimation of Natural Gas Demand for All GTAP-E Sectors

Sector Name	2025	2030	2035
Agriculture	8,969.47	9,906.50	11,365.44
Coal	7,279.17	9,040.90	13,245.42
Crude oil	145,206,752.69	162,245,416.32	194,373,104.55
Gas	520,152,119.56	617,335,204.47	826,708,714.81
Refined Oil	565,033,222.60	657,837,751.00	713,292,052.16
Electricity	777,906,202.42	918,852,881.45	1,084,209,641.40
Manufacturing Industries	1,447,794,843.46	1,684,977,738.76	1,911,731,137.72
Water Utilities	11,510,292.66	13,199,638.72	15,190,685.69
Construction	6,583,394.60	8,021,221.62	9,602,416.46
Wholesale and Retail	41,985,663.12	50,323,477.72	59,877,917.17
Transportation and Warehousing	3,477,802.54	4,089,753.08	4,783,141.90
Information and Communication	1,231,709.26	1,392,605.57	1,615,822.25
Financial and Insurance Services	3,604,863.44	4,169,184.56	4,867,131.62
Corporate Services	2,081,493.41	2,427,779.37	2,874,960.46
Government Administration	22,630,097.70	27,486,946.04	32,359,791.91
Other services	7,235,369.42	8,430,945.04	9,749,256.20
Total	2,656,445,829.79	2,656,445,829.79	2,656,445,829.79

Note: All values are in MMBTU
Source: GTAP-E Model simulation output (2018); processed

Although the model reports values for natural gas use in crude oil and refined oil sector, it does not show any significance for analysis. The model relies on technology coefficient in input-output table to determine intermediate demand, therefore, these numbers correspond to own-use of natural gas in oil and gas sector, either attributable to processing purposes or losses in processing. The model, however, does not take into account dynamics in natural gas supply. In reality, supply tends to be constrained by availability of natural gas resources, as well as quality in pipeline or LNG transportation infrastructure. The model assumes that natural gas demand will automatically be met by equal amount of supply. Price adjusts according to quantity demanded and cost of production, which is dependent on intermediate input price as well as endowment goods' price. The model also fails to account for unconventional energy sources such as renewable energy. This drawback stems from the fact that CGE model can only represent real sectors of the economy.

Integrating renewable energy sources requires the energy to be represented in real measurements, an aspect that has not been considered in the GTAP-E model.

How much does Indonesia should produce its energy commodities to overcome the rise in demand? The simulation shows that in order to anticipate a rise in natural gas demand, national gas production should rise by 36.7 percent and 99.49 percent in 2025 and 2035, respectively. Table 4 below shows change in production quantity of natural gas in comparison with other energy commodities included within GTAP-E model. The Indonesian natural gas industry could use this number as an anchor to anticipate growing domestic natural gas demand in the long-term.

Table 5. Predicted Change in Energy Production

Change in Production Quantity (%)	2025	2030	2035
Coal	48.99	86.20	147.75
Crude Oil	23.18	38.15	50.12
Natural Gas	36.70	63.92	99.49
Refined Oil	44.94	77.73	85.24
Electricity	42.19	73.66	84.90

Note: all numbers are stated in terms of percentage change from year 2017 condition.
Source: GTAP-E simulation output (2018); processed

5. Conclusions

In order to become comprehensive and relevant to actual industrial needs, national energy planning should include estimation of per-sector manufacturing demand for natural gas. The issue of comprehensive planning becomes central in the case of Indonesia where market for natural gas is heavily fragmented. Construction of LNG delivery infrastructure is both costly and time consuming; therefore, the government should anticipate growing natural gas demand beforehand. It is hoped that through comprehensive and detailed planning, infrastructure planning can provide optimum impact and support for industrial growth.

This paper attempts to provide an estimation of business-as-usual demand for natural gas with detailed per-sector estimation for manufacturing industry. Chemical industry (including fertilizer and petrochemical) will remain the largest user of natural gas, followed by electricity, basic metal, and metal industries. In order to meet the growing demand of natural gas, current production capacity should be increased by 36.7 percent by 2025 and by 99.49 percent by 2035. This amount will only be in effect, however, with adequate infrastructure linking natural gas production site with industrial areas.

However, the paper still suffers from drawbacks. It does not take into account the existence of unconventional energy sources such as renewable energy. Further, the simulation assumes that no government intervention is present, yielding an estimation representing business-as-usual condition. In reality, however, natural gas utilization will also depend on government's energy mix policies, as well as other institutional factors. Therefore, the results should be considered only as a baseline for future potential natural gas demand. More estimation that is realistic could be obtained through end-use accounting approach.

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Appendix. Sector Aggregation Scheme

GTAP Sector Code	Disaggregated Sectors	Group Code	Remarks
Pdr	Paddy rice		
Wht	Wheat		
Gro	Cereal grains, not elsewhere classified (n.e.c)		
v_f	Vegetables, fruit, nuts		
Osd	Oil seeds		
c_b	Sugar cane, sugar beet		
Pfb	Plant-based fibers		
Ocr	Crops n.e.c		
Ctl	Cattle, sheep, goats, gorses		
Oap	Animal products, n.e.c		
Rmk	Raw milk		
Wol	Wool, silk-worm cocoons		
Frs	Forestry		
Fsh	Fishing	AgrFF	Agriculture
Coa	Coal	Coal	Coal
Oil	Oil	Oil	Crude Oil
Gas	Gas	Gas	Coal
Cmt	Meat, cattle, sheep, goats, horse		
Omt	Meat products, n.e.c.		
Vol	Vegetable oils and fats		
Mil	Dairy products		
Pcr	Processed rice		
Sgr	Sugar		
ofd	Food products, n.e.c.	ProcFood	Food and Beverages
b_t	Beverages and tobacco products	Tobacco	Tobacco Products
tex	Textiles		
wap	Wearing apparel	TextWapp	Textile and Apparel
lea	Leather products	LeaProd	Leather Products
lum	Wood products	WoodProd	Wood Products
ppp	Paper products, publishing	PaperProd	Paper Products, Publishing
p_c	Petroleum, coal products	Oil_pcts	Refined Oil
crp	Chemical, rubber, plastic products	ChemProd	Chemical, rubber, plastic products
omn	Minerals, n.e.c		
nmm	Mineral products n.e.c.		
i_s	Ferrous metals	BasicMetal	Basic Metal Industris
nfm	Metals n.e.c.	NFMProd	Non-Ferrous Metal
ele	Electronic equipment		
fmp	Metal products	MetalElec	Metal Products and electronic equipment
mvh	Motor vehicles and parts		
otn	Transport equipment n.e.c.	MotorTrans	Motor vehicles and parts, transport equipment
ome	Machinery and equipment n.e.c.	MacProd	Machinery and equipment
omf	Manufactures n.e.c.	OthManuf	Other manufacturing
ely	Electricity	Electricity	Electricity
gdt	Gas manufacture, distribution	Gas	Gas
wtr	Water	Water	Water Utilities
cns	Construction	Cons	Construction
trd	Trade	Trade	Wholesale and Retail
otp	Transport n.e.c.		
wtp	Sea transport	Transport	Transportation and Warehousing

atp	Air transport		
cmn	Communication	Comm	Information and Communication
ofi	Financial services n.e.c.		
isr	Insurance	FinServ	Financial and Insurance Services
obs	Business services n.e.c.	BusServ	Corporate Services
osg	Public administration/defense/health/education	PubAdm	Government Administration
ros	Recreation and other services		
dwe	Dwellings	RecOth	Other services

Source: Authors' Specification