Modeling Power Plant Expansion Problem in Indonesia: Evaluating Minimizing Cost and Minimizing CO_2 Emissions

Maxensius Tri Sambodo[1], Hozumi Morohosi[2], and Tatsuo Oyama[2]
[1] PhD candidate at National Graduate Institute for Policy Studies
[2] Professor at the National Graduate Institute for Policy Studies

Overview

Availability of power supply is one of basic elements to enhance economic competitiveness and to sustain long-term economic growth. However, underinvestment is one of the main obstacles of power sector in Indonesia (IEA, 2008). Since the economic crisis in 1997/98, the new installed capacity of *PT Perusahaan Listrik Negara* / National Electricity Company (PT.PLN) has showed decreasing rate of growth from 10.4% before the crisis to about 2.1 % after the crisis (Sambodo and Oyama, 2010). On the other hand, following concern on low carbon economy, we also need to promote green investment because this can avoid risks on 'carbon lock-in' the future. According to IEA (2009), there are three pillars to curb CO_2 emissions from the electricity sector: (i) significant improvements in energy efficiency of electricity end use; (ii) providing policy incentives such as through a price on CO_2 emissions or subsidies for promoting low carbon technology; (iii) enhancing research and development in low carbon generation technologies. This paper aims to construct the model of power expansion plant by considering two objective functions: (i) minimizing generating cost / objective I; and (ii) minimizing CO_2 emissions / objective II. In the analysis, we evaluate the two objectives in terms of CO_2 emissions intensity (ton CO_2/MWh), output diversification index, and average generating cost (Rp/kWh).

Methodology

We divide steps of analysis into four parts. First, we estimate the load duration curve (LDC) in 2006 at the national level. Then, we estimate the LDC between 2007 and 2019 based on annual growth of electricity consumption. We apply the autoregressive moving average (ARMA) model to forecast electricity consumption. Second, we forecast generating cost for steam, combine cycle, gas, diesel, geothermal, and hydro power plants base on the ARMA model and obtain upper and lower bound estimate at 5% critical level. Third, we estimate emissions intensity for each type of power plant by using the Intergovernmental Panel on Climate Change (IPCC) emissions default factors. Fourth, we use additional capacity information from PT. PLN' business plan 2010-2019. To obtain feasible solutions, simulations in linear programming are adjusted based on three strategies: (i) selecting the parameter for renewable energy preference; (ii) adjusting information on capacity availability factor; (iii) and changing primary energy supply availability. Further, we also simulate the system to conduct the demand side management (DSM) to fulfill: (i) at least 100% of demand; (ii) 95% of demand; and (iii) 90% of demand.

Preliminary results

1. In general, minimizing CO_2 emissions from the power sector is the matter of selecting output combination among the fossil fuel (steam, combine cycle, gas and diesel), because generating cost (Rp/kWh) from geothermal and hydro power is relatively low. However,

the major obstacle is how to increase availability factor of renewable energy. Growing electricity consumption leads to more demand on primary energy supply in the future. Thus, government needs to secure energy supply for power plant.

2. The DSM always can reduce emissions intensity under objective II, but it is not always the case of objective I. This is because although output can be lower with the DSM, the percentage decrease in output is higher than percentage decrease in CO_2 emissions. Thus, the DSM will be more effective to reduce emissions intensity, if output reductions are mostly come from high emissions intensity power plant, or alternatively, if government gives more space for renewable power plant to operate.
3. Pursuing objective II can increase diversification index of the system and with the DSM the diversification index will be higher that without the DSM. This is because objective II will give more chances for less carbon intensity power plant to operate. Thus the DSM can also give lead the system to be more balance and diversity in input use.
4. In terms of generating cost, objective II is more expensive than objective I because power plants with less emissions intensity have expensive generating cost. However, we may argue that by including substantial carbon tax objective I can be more expensive than objective II.
5. We can argue that the price difference between objective II and I is the premium or extra cost to minimize CO_2 emissions. The results shows that between 2006 and 2014, the extra cost (percentage change between objective II and I) increase from about 37% to about 107.4%. This is because we keep the share of non fossil fuel in primary energy supply relatively constant about 26.5%. However, between 2014 and 2019, we attempt to increase the share of non fossil primary supply for almost double. With this situation, the difference in the extra cost decrease to about 87.5%. This is due to a dramatic increase in the share of non fossil fuel in the system from about 14.7% between 2006 and 2014 to about 30% between 2015 and 2019.
6. The percentage change in price premium tends to increase as we implement the high requirement on the DSM. This is because the DSM means we give more space for steam power plant to increase production. Thus generating cost under objective I with DSM will be lower than without the DSM. On the other hand, under objective II, implementation of the DSM will increase the cost because the system will operate with more expensive generating cost.
7. Thus although the DSM policy is highly recommended as one of policy options to increase the electricity system performance, we need to reduce utilization of high carbon intensity during the implementation. As consequence, there will be incremental cost when we increase targets on the DSM.
8. We suggest that to pursue greening power system in the future, Indonesia needs to increase the share of less emissions intensity power plant and at the same time to implement the DSM policy.

References

International Energy Agency / IEA. (2008). *Energy Policy Review of Indonesia*, IEA: Paris.

International Energy Agency / IEA. (2009). *Sectoral Approaches in Electricity: Building Bridges to a Safe Climate*, IEA: Paris.

Sambodo, M.T., and Oyama, T. (2010). The Electricity Sector Before and After the Fast Track Program. *Economics and Finance in Indonesia*, 58, 285-308.