Chapter 3

Methodology and Case Settings

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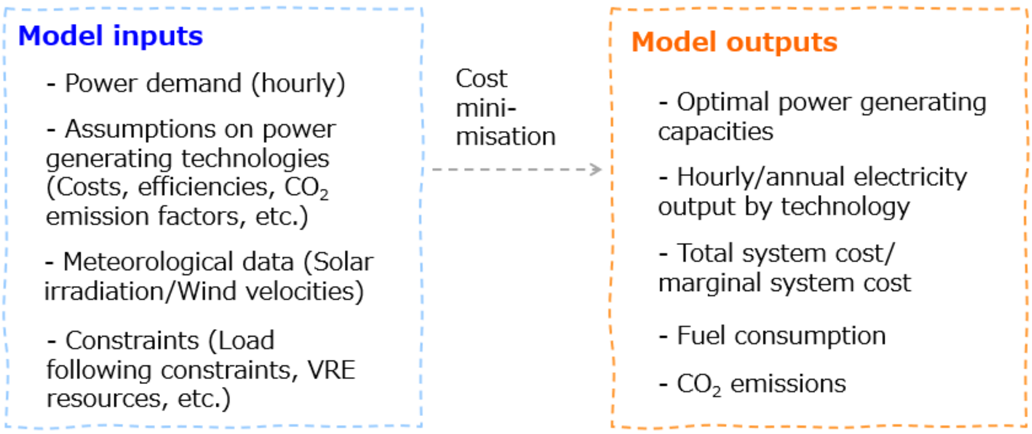
1. Optimal power generation mix model

Under the above conditions, in this study, we performed analysis by using an optimal power generation mix model that adopts a linear planning method developed by the University of Tokyo and the Institute of Energy Economics, Japan (IEEJ). Figure 3.1 shows an outline of the model.

The model simulates the optimal facility configuration and operation to minimise the total cost of the power system based on a time step of 8,760 hours per year for the eight targets areas. In this case, the cost includes the capital cost, converted to annual expenses, the operating cost of each power generation technology, the capital cost and operating cost of the power storage systems, and the capital cost of the transmission lines. In addition, if the amount of generated power exceeds the power demand when the solar photovoltaic (PV) and wind power generation is large, it is assumed to be possible to use any of the power-storage options, then use the stored power later or curtail output. Since the power-storage system is expensive, output curtailment is often selected. See previous studies (Komiyama and Fujii, 2017; Matsuo et al., 2020) for more details on the model, as well as Appendix A.

Figure 3.1. Overview of the optimal power generation mix model



VRE = variable renewable energy.
Source: Authors.

1.1. Case settings

In this study, model analysis of several cases was performed under various condition settings in order to estimate the optimal power generation mix in the target regions for 2040 and capture how trade flows change with different conditions, such as grid interconnection and changes in environmental policies. Table 3.1 shows the analysed cases (white boxes) in this study and the condition settings (grey boxes) for each case.

Table 3.1. Case settings list

Inter-connection capacity	Solar PV price	Externality	Nuclear Capacity	Carbon prices (USD/CO2-t)				High fuel prices	Differentia-ted Carbon price
				0	50	100	200		
Only existing	Base (2040)	Not included	Only in IDN	Base Case					
Existing + Planned expansion	Base (2040)	Not included	Only in IDN						
	2050								
Limitless	Base (2040)								
Existing + Planned expansion			Limitless						
		Included	Only in IDN						

IDN = Indonesia, PV = photovoltaic.
Source: Authors.

Regarding the interconnections, we assume two cases: one in which the only existing interconnections are utilised, and another in which future interconnection expansion plans are assumed as shown in Table 2-3. Cases in which the upper-limit restriction on interconnection capacity is relaxed is also implemented for reference.

In some cases, calculations have been performed with different carbon prices, ranging from US\$0/tCO_2 to US\$200/tCO_2. The carbon price literally increases the cost of the fuel unit price in proportion to the amount of CO_2 emitted through coal-fired thermal power generation and natural-gas thermal power generation; however, in terms of policy, the carbon price may be considered as an index that assumes not only a direct carbon tax but also indicates the strength of various measures for promoting low-carbon power sources or suppressing increases in thermal power generation.

In addition, the following five types of case analysis were also performed, setting special conditions.

- Thermal power lower limit case
- Low solar PV cost case
- High fuel price case
- Externality case
- Differentiated carbon price case
- Limitless nuclear case

In the thermal power lower limit case, lower limits are set for thermal power generation in some countries with large hydropower potentials. In the case of setting carbon prices, most of the electricity supply would be hydropower in some countries with high hydropower potential; however, this is not realistic given the current policies of each country and their energy security. Therefore, the lower limits of thermal power are set in some countries to get closer to a more realistic power generation mix.

In the low solar PV cost case, calculations were performed using a lower cost for solar PV in order to see the effect of more rapid cost declines.

In the high fuel price case, fossil fuel prices are assumed to be higher, following the assumptions by Kutani and Li (2014) as described in Chapter 2. In this case, renewable energy utilisation will be expanded without any carbon prices, and the interconnection lines between the areas will be utilised. The share of the gas-fired power portion in the total power generation mix of the regions will be reduced as gas-fired power generation will be less cost-competitive.

The externality case is a case in which the external costs of power generation – in particular, the effects of health damage due to thermal power generation – are internalised and included as part of the cost of generating power.

In the case of differentiated carbon pricing, carbon prices are not uniform across all countries; rather, high carbon prices are set in high-income countries and low carbon prices are set in low-income countries. In fact, considering the current situation in which high carbon prices have already been set in some advanced countries, higher carbon prices may also be imposed in ASEAN Member States in the future. In addition, the carbon price in the model can be considered as a proxy for indicating the strength of the CO_2 reduction measure; therefore, it can be considered as a case that simulates the case in which a stronger CO_2 reduction measure is taken in higher-income countries.

The unlimited nuclear case is that in which nuclear power generation can be introduced to an economical maximum by eliminating the construction constraints on nuclear power plants. In practice, building a nuclear power plant takes a long time and requires various procedures, such as local agreement. Therefore, this case should be considered as a hypothetical case that only takes economic efficiency into consideration.