Economic Research Institute for ASEAN and East Asia

Policy Brief

The Economic Consequences of Shifting Away From Nuclear Energy

- **GTAP Model, Database, and Extension**
- **Simulation Results**
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- Contact:
TEL: +62-21-5797-4460
FAX: +62-21-5797-4463

By Ken Itakura

In the aftermath of the devastating nuclear fallout in Japan, there has been a harsh debate surrounding the role of nuclear energy in electricity generation. A changing role will have economic consequences on production, consumption, and international trade. To quantity these effects, we implemented simulations with a global CGE model and database. The simulation results show that reductions in the use of nuclear for electric power generation may have profound negative impacts on the Japanese economy.

A nuclear accident at the Fukushima power plant changed the future direction of Japanese energy policy as well as Asian energy policy. These policies are integrated via technological, financial, and nuclear energy knowledge sharing activities within the region. The main objective of this policy brief is to shed some light on the following question: what would be the economic consequences of altering the source of power generation from nuclear to fossil fuels? This Japanese case study offers policy implications for both Japan and the region as a whole.

A global Computable General Equilibrium (CGE) model and its database are used to quantitatively estimate the effect of reducing the use of nuclear power in Japan through economic linkages and channels affecting industries and households across countries. Two sets of simulations were implemented: Simulation [A]: Reduce the electric power generated by nuclear in Japan; and Simulation [B]: Reduce the electric power generated by nuclear in Japan, while maintaining the overall generation level by substituting nuclear for fossil fuels.

Suppressing the use of nuclear power in simulation [A] will lead to a fall in supply of electricity, and I will examine how far economic activities in Japan would be curtailed. In simulation [B], electric power generation based on fossil fuels will fill the gap caused by the cut in nuclear. The extent to which substitution would mitigate the negative impacts on economic activities is considered.

• GTAP Model, Database, and Extension

A multi-sector multi-region CGE model is employed to evaluate the quantitative effect of shifting the electric power generation from nuclear to fossil fuels. The widely used platform for this type of CGE analysis is the Global Trade Analysis Project (GTAP) database and modeling framework (Hertel, 1997; McDougall, 2000; Narayanan and Walmsley, 2008). The GTAP database used in this paper is the version 7.1 database, which records all the domestic and international economic transaction flows for 57 industrial sectors across 112 countries / regions in the world, benchmarked in 2004.

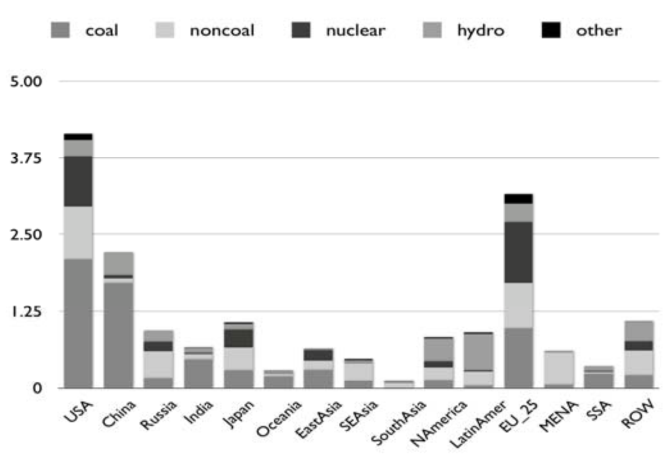
The electricity sector in the GTAP database can be viewed as an aggregate of different power generation types so that it is possible to disaggregate the original electricity sector into sub-sectors of fossil fuels, nuclear, and others. As electrical supply services are produced from both domestic and imported intermediates as well as primary factor inputs, these production inputs need to be split into sub-sectors. A similar split of database is required for electrical service supply in households' consumption, other industry's intermediate use, and international trade.

The software SplitCom (Horridge, 2005) along with the additional data information from IEA (2008), EIA (2008), and Japanese input-output tables for 2005 (SB, 2009) are used to disaggregate the electricity sector. Splitting the electricity sector in GTAP v.7.1 database into sub-sectors has been performed for 112 countries, and the splitting results are shown in Figure 2 for selected countries. There is considerable regional variation in the overall level of electric power generation, with the US, China, and EU_25 having the highest levels. The size of coal-based power generation in China is almost equivalent to the US, but its share in the overall generation is much larger. Following the US and EU_25, the use of nuclear power is most significant in Japan.

Table 1 reports the share of power generation types in total production, computed for the EAS countries. Among EAS members, Japan and Korea rely substantially on nuclear, whereas China only utilizes nuclear to a minor degree. The use of fossil fuel predominates in power generation amongst EAS countries. The large number observed in Laos for other energy sources is mainly driven by hydro-electricity.

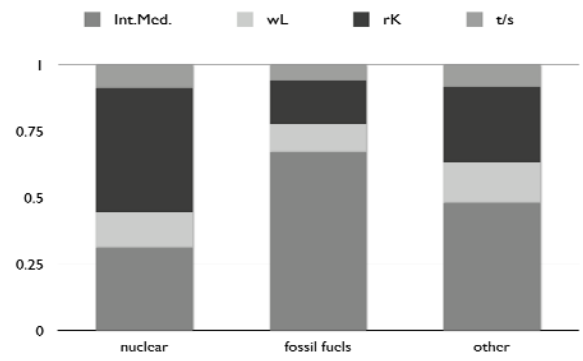
Figure 3 illustrates the cost structure of electric power generation by type in Japan, estimated from the input-output tables in 2005. Total generation cost breaks down into four categories: intermediate input cost (Int.Med), labor cost (wL), rental cost (rK), and tax or subsidy (t/s). It is clear that nuclear power generation has a large rental cost share whereas fossil fuel power generation relies heavily on intermediate inputs. These variations in the cost structure imply that different power generation types would have different impacts on the rest of economy after a shift in the mix of electricity generation.

Figure 2. Electric Power Generation by Type, 2004 (PWh)



Source: Author's estimates from IEA, EIA, SB.

Figure 3. Cost Structure of Electric Power Generation by Type in Japan



Source: Author's estimates from SB.

Table 1. Share of Electric Power Generation Type in EAS (%, 2004)

	Fossil	Nuclear	Other
Japan	62.6	26.5	11.0
Korea	63.0	35.7	1.3
China	81.5	2.3	16.2
Cambodia	96.3	0	3.7
Indonesia	86.4	0	13.6
Laos	3.2	0	96.8
Myanmar*	57.1	0	42.9
Malaysia	92.9	0	7.1
Philippines	66.3	0	33.7
Singapore	100.0	0	0
Thailand	93.0	0	7.0
VietNam	61.6	0	38.4

Source: Author's estimates from IEA, EIA, SB.

Note: * Weights are computed but not used in GTAP Database v7.1

- **Simulation Results**

The comparative static GTAP model and database version 7.1 are used to run simulations with the software GEMPACK (Harrison and Pearson, 1996) and RunGTAP (Horridge, 2008). Two sets of simulation experiments with four different levels of changes are implemented:

Simulation A1: Cut the use of nuclear in electric power generation by 5%

A2: Cut the use of nuclear in electric power generation by 10%

A3: Cut the use of nuclear in electric power generation by 15%

A4: Cut the use of nuclear in electric power generation by 20%

Simulation B1: A1 + increase the use of fossil fuels to substitute for nuclear

B2: A2 + increase the use of fossil fuels to substitute for nuclear

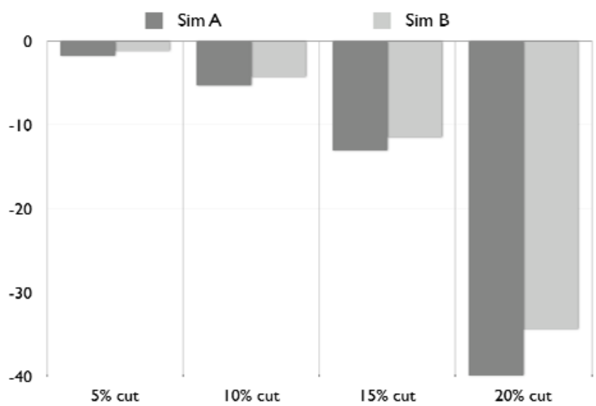
B3: A3 + increase the use of fossil fuels to substitute for nuclear

B4: A4 + increase the use of fossil fuels to substitute for nuclear.

In simulation A, reductions of the use of nuclear in Japan are simulated to varying degrees. In simulation B, fossil fuels substitutes for the reductions in nuclear generated electricity.[1]

A reduction in power generated from nuclear negatively affects real Japanese GDP. Figure 4 illustrates the negative impacts on real GDP in Japan. The deeper the cut in nuclear use for power generation, the larger the negative impact on real GDP. The substitution of fossil fuels for nuclear in simulation B was not sufficient to mitigate these negative impacts. If nuclear-based power generation in Japan reduced by 20% without any replacement, then the real GDP in Japan would decrease by approximately 40 billion US dollars, almost equivalent to 1% of GDP evaluated in 2004. Table 2 reports the impacts on real GDP in percent terms.

Figure 4. Impact on Real GDP in Japan (US$, billion)



Source: Author's simulation results.

Table 2. Impact on Real GDP in Japan (%)

	5% cut	10% cut	15% cut	20% cut
Simulation A	-0.04	-0.11	-0.28	-0.86
Simulation B	-0.02	-0.09	-0.25	-0.74

Source: Author's simulation results.

Recall from Figure 3 that the cost structure of nuclear-based power generation has relatively high share of rental cost. Once the use of nuclear is suppressed, then the primary factor demands for physical capital would be weakened, leading to lower rental price in Japan. The lowered rental price implies that the expected rate of return would diminish so that the resulting fall in investment reduces real GDP.

- **Policy Implications**

The shift in electric power sources will have economic impacts on production, consumption, and international trade. To capture the quantitative impacts through economic linkages, simulations with a global CGE model and database were analysed. As simulation results showed, reductions in the use of nuclear for electric power generation could have a large negative impact on the economy.

Given the variations in types of electric power generation across countries, it is desirable in policy formulation to design an appropriate mix of electric generation types based on existing facilities and feasibly planned future investments. Also, given the variations in cost structures of power generation, the economic consequences of shifting amongst different types would differ considerably.

Finally, a few cautionary notes should be made. This paper is not about the natural disaster and its economic consequences. Rather, we are focusing only on the smooth shift between electric power generations, assuming no damage to existing physical infrastructure. Related to this point, this paper is not about the economic costs of recovery arising from the losses caused by the natural disaster.

[1] In cutting the level of nuclear-based power generation, the model is configured to allow the sub-sectors to make losses / profits while their generation activities are controlled by the simulation settings. Consequently, as a caveat, this configuration would introduce a breach in equilibrium conditions. Therefore, the simulation results should not be taken as a full equilibrium response to the exogenous shocks but they are rather coarse estimates in the process recovering to the full equilibrium conditions.

About the authors

Ken itakura is Associate Professor, Faculty of Economics, Nagoya City University.

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