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Nuclear power plant after Fukushima incident: Lessons from Japan to Thailand for choosing power plant options

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ABSTRACT

This study evaluates four power plant options in Thailand to suggest whether the country should adopt nuclear power plants. It includes a scenario that nuclear power plants are forced to be shut because of natural disaster like what happened at Fukushima Daiishi nuclear power plant in Japan. The results found that, in terms of net present value both in duration of 30 and 50 years, nuclear power plants is the best choice under certainty of no severe natural disaster that would interrupt the operation of the power plants. With a possible big natural disaster, it has proven that Thailand should not rely on only nuclear power plants; the country should balance the sources of electrical supplies to ensure that people will not suffer from severe electrical shortage.

Keywords: Nuclear power plant, Fukushima Daiishi, Power plant options, Electrical generation, Project Feasibility

JEL Classification: O13, Q42, Q43

1. Introduction

The shutdown of Fukushima Daiishi nuclear plant because of the severe damage after Japan was attacked by Tsunami on March 11th, 2011 led to the total shutdown of all nuclear plants in Japan for the maintenance. On May 5th, 2012, the last nuclear reactor at Tomari nuclear plant in Hokkaido was closed. It is the first time since 1970 that Japan has no nuclear derived electricity[1] (Batty, 2012).

Japan is facing the expected shortage of electricity around 20 percent in summer 2012 (Batty, 2012). Electricity is heavily generated by other sources such as coal and oil. However, the thermal power plants are old. Their capacity is much less than that of nuclear power plants. For the solution, Japanese government urges people to reduce the electrical consumption. Some companies switch to work at night to avoid the peak load of electrical consumption in daytime (Marcus, 2012).

The effect of the nuclear power plant shutdown on Japanese economy is tremendous. Japan faces the largest trade deficit, USD18.5 billion in 2011, because of huge imports of oil and coal to generate electricity using thermal power plants (Nakamishi, 2012).

Thailand will face the heavy shortage of electricity in next 18 years (Economics and Finance Academy, 2011). Demand for electricity in 2030 is projected to be 65,500 Mekawatts per day while the capacity of power plants will be reduced to 11,500 Mekawatts per day. Nuclear power plant is an option to fill this gap. However, it needs at least 4 years and up to 8 years to construct a nuclear power plant (Nuclear Power Program Development Office, 2009). Therefore, Thailand needs to rush for the decision making for whether the country should adopt nuclear power plant before it is too late.

This study investigates four scenarios of power generation in Thailand. The first scenario illustrates the decision to use thermal power plant for next 30 years. The second scenario shows the outcome of the decision to construct only one nuclear power reactor whose average cost of electricity is greater than the average cost from thermal power plant. The third scenario expands the numbers of nuclear power reactor to three to reduce the average cost to be lower than that of thermal power plant. The last scenario explores the situation that is like what happened in Japan. The fourth scenario will find the outcome when Thailand has three nuclear power reactors and they have to be shut due to natural disaster. The study will compare the outcomes from all scenarios and evaluate whether nuclear power plant is appropriate for Thailand.

2. Theory and literature review

As the nuclear power plant is a hot issue in Thailand nowadays, several studies were made upon the issue. Electricity Generating Authority of Thailand (EGAT) hired Burns and Roe Group Incorporated based in Oradell, New Jersey, to study the feasibility of the

[1] In 1970, the only two existing nuclear power plants were shut for the maintenance purpose leaving Japan stayed without electricity from nuclear power for 5 days (Batty, 2012).

operation of the first nuclear power plant in Thailand with the capacity of 1,000 Mekawatts (Nuclear Power Program Development Office, 2010). The result was positive. The report suggested that the first nuclear power plant should be located in the South of Thailand because of the need of sea water in the vapor condensing process. Moreover, Thailand should expand its nuclear derived electricity to 10 percent of overall electrical supply.

Even though the report from Burns and Roe Group Incorporated was sounded for the decision to use nuclear power in Thailand, the study was made before Tsunami hit Japan in March 2011. Thus, the study did not cover the risk of natural disaster in its model. At least, it did not expect that the natural disaster can cause the shutdown of all nuclear power plants in Japan.

Thatchai Sumitra, the former president of Nuclear Society of Thailand presented his analysis on the feasibility of nuclear power plant in Thailand in 2009. His study (Sumitra, 2009) supported the usage of nuclear power plant in Thailand and believed that Thailand can cope with the nuclear technology, environmental conservation, human resource development and nuclear waste management. However, he mentioned that the only obstacle of the nuclear adoption is the public acceptance. He raised the case of the blast of Chernobyl nuclear power plant in Ukraine to be the warning of nuclear disaster that may be in concern of people. To respond to these reports of Sumitra (2009) and Burns and Roe Group Incorporated, Peimani (2011) said that, even though the country has conducted the feasibility studies of the nuclear power plant, Thailand has no significant step toward the construction of the first nuclear power plant.

There are several literatures after the shutdown of Fukushima power plant concerning the perspectives on nuclear power in Asia. Peimani (2011) showed the immediately after the Fukushima incident, China suspended the approval of new nuclear projects to investigate the safety standard. Months after the incident, China declares that the nuclear safety is guaranteed in the country and decided to move forward the plan to operate 66 nuclear power plants by 2020 which account for 6 percent of total electrical consumption demand in China.

Peimani (2011) also mentioned that Chinese Taipei (Taiwan) decided to continue her three nuclear power plants after Fukushima incident. South Korea did the same with her 21 nuclear power plants and 6 more under construction. The government of South Korea admitted that there is no alternative energy source to substitute nuclear power at that time that can meet public demand for electricity. For countries that have not started nuclear power plants yet which are Thailand, Vietnam, Malaysia, the Philippines and Indonesia, they have revised their plans for the construction of nuclear power plants especially on the safety consideration.

3. Methodology and data

This study applies the method of Net Present Value (NPV) to compare scenarios of power plant options. It collects data on costs and revenue of the operation of nuclear power plant and thermal power plant. It sets four scenarios as follows:

Scenario 1: Thailand continues to use only thermal power plants

In this scenario, Thailand projects her electrical consumption demand for next 30 years and 50 years (2 sub-scenarios). Then she constructs thermal power plants using coal to cover the demand, i.e. the capacity equals the demand in next 30 years or 50 years. After the 10^{th} year, the unit cost increases to 2.28 times of the initial cost due to the shortage of domestic coal supply. All coals are needed to import with higher costs.

Scenario 2: Thailand constructs only one nuclear reactor

In this scenario, Thailand constructs her first nuclear power plant with only one nuclear reactor inside. The capacity is according to the study of Burns and Roe Group Incorporated which is 1,000 MW per hour. The nuclear power plants supply at its full capacity which is 8,760 million Units. The residual demand will be taken care by thermal power plants.

Scenario 3: Thailand constructs three nuclear reactors.

In this scenario, Thailand constructs her first nuclear power plant with three nuclear reactors inside. The capacity is 3,000 MW per hour per reactor. The nuclear power plants supply at its full capacity which is 26,280 million Units. The residual demand will be taken care by thermal power plants.

The construction cost of the second reactor is half of the first reactor. Moreover, the cost of the third reactor is also half of the second reactor.

Scenario 4: Thailand constructs three nuclear reactors but there is a natural disaster that forces all nuclear reactors to be shut.

This scenario is almost similar to the third scenario. The difference is at a natural disaster in the 15^{th} year that forces all nuclear reactors to be shut. Thailand needs to construct thermal power plants immediately to compensate the reduced electrical supply from the nuclear power plant.

Costs of a nuclear power plant are as follows:

1) Construction: THB115 million per Megawatts
2) Unit cost: THB2.79 per Unit (Kilowatts-hours)

Costs of a thermal power plant using coal are as follows:

1) Construction: THB115 million per Megawatts
2) Unit cost in first 10 years: THB2.94 per Unit (Kilowatts-hours)
3) Unit cost after 10 years: THB6.70 per Unit (Kilowatts-hours)

The projection of electrical consumption in Thailand follows these assumptions:

1) Base consumption in 2013: 164,320 million Unit (Kilowatts-hours)
2) Consumption growth: 5,000 million Unit (Kilowatts-hours) per year

Assumptions for the calculation of Net Present Value (NPV) are as follows:

1) Discount rate: 3 percent
2) Length of the project: 30 years in the first sub-scenario
   50 years in the second sub-scenario
3) Natural disaster that causes the shutdown of all nuclear power plants takes place in the 15th year after the construction of the first nuclear power plant.
4) Electrical price: THB6.00 per Unit (Kilowatts-hours)

4. Results and discussions

The net present values of all scenarios are shown in Table 1 (sub-scenario of 30 years) and Table 2 (sub-scenario of 50 years).

TABLE 1. Net present value of all scenarios for the duration of 30 years

Scenario	NPV of the revenue (THB million)	NPV of the cost (THB million)	Net present value (THB million)
1) Thermal power plants	26,248,208	24,409,540	1,838,668
2) One nuclear power plant	26,248,208	24,089,450	2,158,758
3) Three nuclear power plants without incidents	26,248,208	23,309,708	**2,938,500**
4) Three nuclear power plants with incidents	26,248,208	24,886,569	1,361,639

Source: Calculation

TABLE 2. Net present value of all scenarios for the duration of 50 years

Scenario	NPV of the revenue (THB million)	NPV of the cost (THB million)	Net present value (THB million)
1) Thermal power plants	39,114,999	39,445,389	-330,390
2) One nuclear power plant	39,114,999	38,921,308	193,691
3) Three nuclear power plants without incidents	39,114,999	37,733,583	**1,381,416**
4) Three nuclear power plants with incidents	39,114,999	39,922,418	-807,419

Source: Calculation

A reason why the third scenario is the best choice both in the duration of 30 and 50 years is that the unit cost of electricity generated by nuclear power plant is the cheapest (Table 3). However, it should be noted that the cheapest unit cost is because of the highest capacity utilization. Nuclear power plant is the most stable kind of power plants that can generate electricity to the system. Solar power is the least stable one because of the uncertainty of daylight. Wind power plant is also good for environment but the unsteady wind blow causes the cost to be high. It is interesting that the capacity utilization and unit costs from coal and nuclear power plants are almost the same.

In the long-terms (50 years), the results show that coal power plants are not a good option due to the lost in operation. Moreover, Thailand will face a heavy lost when it operates nuclear power plants but has to shutdown them due to natural disaster.

TABLE 3. Unit cost of electricity generated by different kinds of power plants in Japan

Power plants	Capacity utilization (%)	Unit cost (Yen/Kwh)
Solar	12.0	46.00
Wind	20.0	12.00
Water power	45.0	10.75
Petroleum	55.0	13.65
LNG (Liquid Natural Gas)	70.0	6.45
Coal	75.0	5.75
Nuclear	77.5	5.50

Note: Kwh = Kilowatts-hour or Unit, measured by kilowatts multiply numbers of hours

To eliminate the effect of capacity utilization, the study calculates the unit costs under assumption of full capacity utilization. The result shows that wind power is the cheapest one. Nuclear comes second. It is still interesting that the unit cost of electricity generated by coal power plant is quite similar to that of nuclear power plant.

TABLE 4: Unit cost of electricity generated by different kinds of power plants in case of full capacity utilization in Japan

Power plants	Capacity utilization (%)	Unit cost (Yen/Kwh)
Wind	100.0	2.40
Nuclear	100.0	4.26
Coal	100.0	4.31
LNG (Liquid Natural Gas)	100.0	4.52
Water power	100.0	4.84
Solar	100.0	5.52
Petroleum	100.0	7.51

Note: Kwh = Kilowatts-hour or Unit, measured by kilowatts multiply numbers of hours

5. Conclusions

The results show that, under the certainty of no natural disaster that may force power plants to be shut, three nuclear power plants are appropriate for Thailand. The capacity utilization of nuclear power plant is superior to thermal, wind and solar power plants. This makes the unit cost of electricity generated by nuclear power plant the cheapest.

When natural disaster is still a big threat for the energy sector, nuclear power plant should not be constructed in Thailand. The project will face a big lost when the plants need to be shut. It is like what Sumitra (2009) have said that when nuclear power plants are forced to shut down, it is totally wasteful for the construction. Embrecths (2012) also warned that normal situation will not harm anyone, but the extreme cases such as what happened to Fukushima Daiichi nuclear plant will do.

Therefore, the decision whether nuclear power plants should be adopted in Thailand depends on the perspective upon the probability of natural disaster incidents. Before the construction, it is naturally that the Thai government may be too optimistic toward the occurrence of natural disasters. However, the big flood in 2011 has proven that an unexpected natural disaster can take place in the country. Moreover, the history has also proven that when it did take place, the situation was hard for the government to control.

If nuclear power plant is the only one choice to meet the increasing electrical consumption, Thailand should balance the portion of electrical generation among nuclear, thermal, wind and solar power plants to ensure that the country can switch the

electrical supply from nuclear power to other sources without suffering from the tremendous shortage of electrical supply. Electrical Generating Authority of Thailand (EGAT) should maintain thermal power plants in good condition to be ready for the emergency incident. Moreover, an increase in wind and solar energy is also a must for the energy security reason.

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