Feasibility study of a nuclear power plant in Thailand

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Abstract

This research aims to study appropriate alternative nuclear technologies, costs of their power compared with other types of power plant, approaches in convincing public to accept nuclear power plant and guidelines in selecting appropriate construction location by learning from the experiences found in 4 other countries namely: Japan, China, South Korea, and Vietnam to be proposed as effective solutions to be implemented in Thailand. Findings in this study conclude that the optimal technology suitable for Thailand is the 1,170MW AP-1000 high-pressure nuclear power plant (PWR) technology. This is due to its advantages in cost effectiveness, shortest payback period, shortest construction time, most modernity, simple maintenance and spares parts availability, less radioactive waste, highest safety and efficiency. Besides, investment cost of this technology is 40,000-80,000 Baht / kW, which is more expensive than coal plant, but when comparing to those of solar and wind power plants, it is much cheaper. Furthermore, nuclear power plants have the advantage in terms of long-term energy security and lower operating costs than other types of power plants. Two major approaches in convincing public to accept nuclear power plant solutions include; Building confidence toward perspectives of public regarding nuclear technology and its operation personnel, and ensuring public about advantages of this technology. These approaches can be implemented in the following 3 stages; 1) Pre-construction phase, where feasibility study is required, safety must be first considered in technology design. Public involvement and public relations of the project must be implemented 2) During construction period, project public relations must be continuously promoted 3) Operation running period, or post construction period ; public relations about radioactivity , greenhouse gas emission and nuclear waste management must be continuously implemented. Offering study visiting for people and official agencies and responding to public demand in creating confidence regarding to nuclear officers sine Thailand has less personnel, therefore, improving personal skills for people in this field is a must. In term of safety, this study reveals that Nuclear Power Plant is a clean technology that is environmentally friendly and does not emit greenhouse gases. For radiations effecting people living in the nearby areas, they basically encounter natural radiation for 67.7%, medical radiation for 30.7% and radiation from nuclear power for only 0.15%

Keywords : nuclear power, alternative energy, electricity power

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INTRODUCTION

Electricity is an important factor in the development of Thailand. The demand for electricity is growing every year. In 2007 the electricity demand was 133,178 million units, 135,449 million units in 2008 , 135,209 million units in 2009, 149,320 million units in 2010, 148,700 million units in 2011.(Department of Alternative Energy Development and Efficiency, Ministry of Energy, 2011). Therefore the demand averagely increases by 5.4% a year. Normally, sources of electricity generation come from natural gas for 70%, coal for 21% , hydro power for 7% and 2% of other sources. According to PTT information, natural gas is expected to remain available for power production by the year 2032. Therefore, it's necessary to find other sources to obtain power security, and this Thailand is required to obtain new large-scale, low-cost, environmentally-friendly electricity power plant in which nuclear power plant will meet these requirements. However, nuclear power plant construction cannot be practically implemented due to its negative images that affect public emotions. And this is the reason why this study is proposed to provide reasonable solutions in implementing nuclear plant construction in Thailand.

Dulyawong Wongsang and colleagues (2008: Abstract) found that Thailand has the potential to run nuclear power plants in various aspects including location, technology, infrastructures, facilities, investment, management of used fuels and readiness in building nuclear power plants. Chawalit Pichalai (2009: Abstracts) found that Thailand is needed to have nuclear power plant as a major source of new alternative energy due to the next 10 years fuel for electricity production will become scarce and inadequate. Thus, it is required finding other sources of energy to help reducing global warming as well as providing a stable electricity power. With inexpensive cost of electricity, it totally helps to improve competitiveness to the economy of the country. Yuthapong Kaewsawang (1998: ABSTRACT) found that the cost of production for BWR and PWR plants are very similar. The BWR cost is about 48.85 mills / kWh while the cost of PWR power plant is 49.25 mills / kWh. As we can see, nuclear power plants are clearly advantageous when environmental costs are included.

However, the main problem for nuclear power plant in Thailand are public acceptance and the manipulation of used fuels. Sawapob Trakapong (2010: Abstract) found that financial and economic return rates are reasonable if Thailand will invest in nuclear power plant. Rungaroon Yartbunthung (1996: abstract) found that population sample of the study in Sriracha, Chonburi relatively have less knowledge involving nuclear power plant projects, especially in regards to the potential impact of the applications. Sithichai Thaisaen (2008: abstract) found that staffs working in the factories in Industrial Estate Authority of Thailand in Eastern region have a moderate level of awareness regarding nuclear power plants. However, they have a high level of awareness in terms of safety of nuclear power plants, environmental and location impacts and the construction location of nuclear power plants. A.C.Kadak et al. (1998: abstracts) carried out the study in selecting appropriate 3 models of nuclear power plant: ALWR, HTGR, and AP 600 models based on 29 indicators, and the found that ALWR model is the most appropriate.

Research Objectives

1. To study suitable nuclear technology for Thailand.
2. To study the cost of nuclear power generation as compared to other power plants.
3. To find ways to get public acceptance of nuclear power plants.
4. To find a suitable location for nuclear power plants construction in Thailand.

Research Methodology

This research was conducted by collecting information from relevant documents and research, as well as electronics medias derived from International Atomic Energy Agency (IAEA), Electricity Generating Authority of Thailand (EGAT), World Association and other relevant agencies to be analyzed for applying in the following.

1. Collect necessary data and study relevant factors in connection to nuclear power plant projects in Thailand, Japan, China, South Korea and Vietnam.
2. Analyze all gathered data to be a summary, and distinguish and summarize key points.
3. Analyze and compare to find out suitable nuclear power plant technologies, and approaches that will enable the public to accept and as well as providing proper guidelines in selecting suitable location.
4. Compare the costs of nuclear power generation with other types of power plant.
5. Summarize appropriate solutions for the construction of nuclear power plant in Thailand.

Results

This study of appropriate nuclear technology study was conducted by selecting the 3rd and 3+ generation power plants, which is the most secure generation in according to the resolution of the National Energy Policy Council (NEPC) made on June 8, 2012, which required the plan in reducing power generation to remain only 2 plants (1,000 MW) by transforming into nuclear power plant according to PDP 2010 Rev.3 plan. The power plants to be considered in this study include 3 models with generation capacity close to 1,000 MW; which are ABWR, EPR and AP 1000 models. Indicators are based on the study of Nuclear Power Plant Design Project by A.C. Kadak et al., 1998. And the results are shown in Table 1.

Attribute	Importance	ABWR (BWR) 1350MW		EPR (PWR 1600 MW		AP 1000 (PWR) 1170 MW	
		คะแนน	ผลคูณ	คะแนน	ผลคูณ	คะแนน	ผลคูณ
Safety	10	3	30	1	10	2	20
Economics	10	3	30	2	20	1	10
Payback	10	2	20	3	30	1	10
Government Support	9	1	9	1	9	1	9
Construction Time	9	3	27	2	18	1	9
Modular	8	3	24	2	16	1	8
Local Support	8	1	8	1	8	1	8
High Efficiency	8	1	8	2	16	2	16
Regulatory Transparency	8	2	16	3	24	1	8
Fuel Integrity	7	3	21	2	14	1	7
Small Staff	7	2	14	3	21	1	7
Low Level Waste	7	2	14	1	7	1	7
Short Refuel Time	7	2	14	2	14	1	7
Online Maintenance	7	1	7	1	7	1	7

Table 1 Reactor Design Decision Matrix for Thailand

Attribute	Importance	ABWR (BWR) 1350MW		EPR (PWR) 1600 MW		AP 1000 (PWR) 1170 MW	
		คะแนน	ผลลัพธ์	คะแนน	ผลลัพธ์	คะแนน	ผลลัพธ์
Safety	10	3	30	1	10	2	20
Economics	10	3	30	2	20	1	10
Payback	10	2	20	3	30	1	10
Government Support	9	1	9	1	9	1	9
Construction Time	9	3	27	2	18	1	9
Modular	8	3	24	2	16	1	8
Local Support	8	1	8	1	8	1	8
High Efficiency	8	1	8	2	16	2	16
Regulatory Transparency	8	2	16	3	24	1	8
Fuel Integrity	7	3	21	2	14	1	7
Small Staff	7	2	14	3	21	1	7
Low Level Waste	7	2	14	1	7	1	7
Short Refuel Time	7	2	14	2	14	1	7
Online Maintenance	7	1	7	1	7	1	7

Table 1 Reactor Design Decision Matrix for Thailand (continued)

Remarks: Scoring 1: Most appropriate 2: Medium appropriate 3: Minimal appropriate

Findings shown in the table 1 reveal that:

- Total score of ABWR type are 407 points: highest
- Total score of EPR type are 363 points: Moderate
- Total score of AP1000 type are 235 points: Lowest

Conclusion - AP1000 (PWR) nuclear power plant type is the most suitable, with advantages in highest safety and economic value, shortest construction and payback periods, most modern type with simple maintenance and spare parts availability, less radioactive waste, having high efficiency.

2. Results in the study on economic value to compare electricity production costs are shown in Table 2.2

Cost (Baht/kW)		
Investing Cost	Production Cost	External Cost
17,500 –32,500	1.75 – 3.00	0.35 – 1.55
40,000 – 60,000	1.50 – 1.75	0.95 – 4.95
40,000 – 80,000	1.25 – 1.50	0.12 – 0.94
67,500 –110,000	2.00 – 5.50	0.10 – 2.50
100,000	1.50 – 3.25	0.00 – 0.30
200,000 – 450,000	12.50 – 32.50	0.07 – 0.17
200,000 – 450,000	2.50 – 6.00	0.03 – 0.13

Table 2: All cost comparisons for various types of power generation

Source: European Commission ExternE 1999, IEA

Findings shown in the table 2 reveal that:

- Investment cost of nuclear power are between 40,000-80,000 Baht / kW, cheaper than biomass, hydro, solar, and wind powers but more expensive than natural gas and coal.
- Production cost of nuclear power lied between 1.25 -1.50 Baht / kW.
- External costs of nuclear power production lie between 1.25 and 1.50 Baht / kW, cheaper than natural gas and coal, but more expensive than biomass, solar and wind powers.

Conclusion – Investment cost of nuclear power plants is more expensive than those of natural gas and coal but cheaper than other types of energy while its cost of production is lowest. And it external cost is cheaper than natural gas and coal, but more expensive than other types of energy.

3. In the study of the approaches in convincing public to accept nuclear power plants, the results of the study and the analysis based on approaches found in Japan, China, South Korea and Vietnam are summarized as in the following .-

3.1 Building confidence in nuclear power technology can be implemented as in the following

steps: 1) Start a feasibility study, allow people to participate in the decision of construction. 2) Design and Technology must give first priority to safety while allowing the public to participate in the operation to reduce the suspicion towards the dangers that used to occur. 3) Safety regulations must be strictly carried out in accordance with IAEA standards. 4) Publicize authentic knowledge about nuclear power plants. 5) Offer study visiting to people and official agencies. 6) Fully respond to community demands.

3.2 Building acceptance of nuclear personnel which can be implemented by developing nuclear personnel together with transferring technology particularly for those in the country where the project is started. Education and training offered by domestic experts must be provided as much as possible, while sending personnel to study abroad is very much essential.

4. The study of appropriate location for nuclear power plant construction and the results of the study and the analysis of approaches as found in Japan, China, South Korea and Vietnam will be summarized as follows. -

4.1 The construction location must have engineering suitability as follows 1) No vibration caused by earthquake exists. 2) No fault line or active fault line of earthquake exists. 3) Sufficient water supply for cooling must be available. 4) No risk to occurrence of tsunami. 5) No frequent flood exists as it will be difficult to recover, or leads to contamination. 6) Convenient transportation must be available.

4.2 The construction location must have environmental suitability as follows 1) No very dense population exists 2) No sensitive area exists, such as tourist attraction, historical area which will result in a severe effects.

4.3 In consideration of suitable construction area by bringing above factors into consideration based on guidelines provided by the Electricity Generating Authority of Thailand (EGAT), such consideration used to be carried out with only engineering factors using 2 consideration methods ; 1) Consideration of the calculation results as shown in Table 3.

Table 3 : Suitable areas for construction.

ลำดับที่	พื้นที่จังหวัด	Engineer (%)						Enviriment(%)		
		25	15	12	12	6	5	15	10	total
		earthquake	Fault energy	Reserve	Tsunami	Flood	Trans mission	Pop Density	Tourist	
1	ตราด	5	5	5	5	3	5	4	5	4.73
2	จันทบุรี	5	4	5	5	3	5	4	5	4.58
3	ปราจีนบุรี	5	5	3	5	3	5	4	5	4.49
4	สระแก้ว	5	5	2	5	3	4	4	5	4.32
5	บุรีรัมย์	5	5	2	5	2	2	4	5	4.16
6	ฉะเชิงเทรา	5	4	5	5	1	5	2	5	4.16
7	ชลบุรี	5	4	5	5	2	5	2	4	4.12
8	ระยอง	5	4	5	5	4	5	2	2	4.04
9	ชัยภูมิ	4	5	2	5	3	3	4	5	4.02
10	มหาสารคาม	4	5	2	5	2	3	4	5	3.96

Remarks

1. Consideration priority ; Earthquake 25%, Fault energy 15%, Water reserve 12%, Tsunami 12%, Flood 6%,Transmission 5%, Population Density 15%, Tourism 10%

2. Scoring; 1: Not appropriate 2: Less appropriate 3: Moderate appropriate 4: More appropriate 5: Most appropriate

2) Consideration using overlay maps that contain conditional data arranged in the order of conditional priority to find out suitable area. And its results are shown in Figure 1.

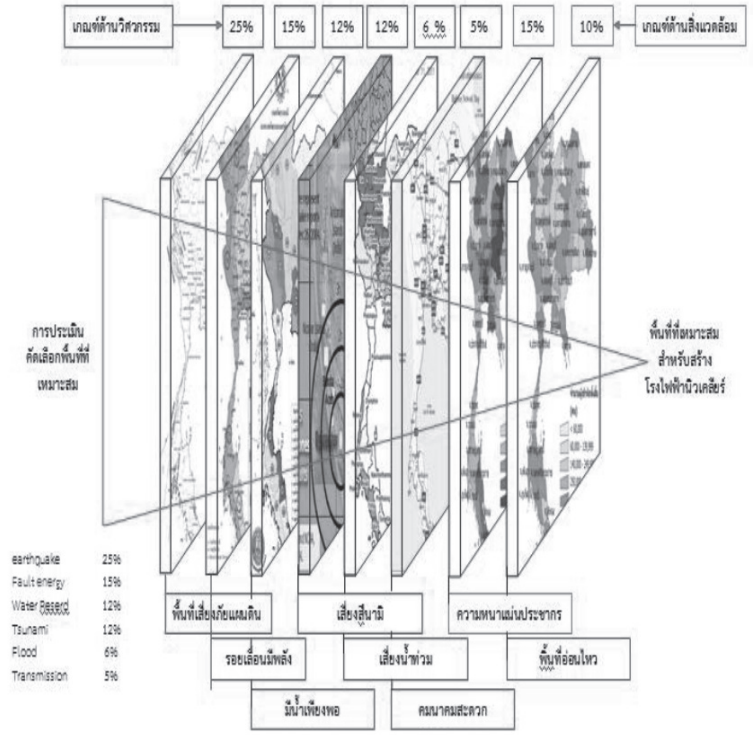

Figure 1: Overlay mapping to find out suitable area.

Results of consideration using 2 methods suggest that the most 5 appropriate locations for nuclear power plants construction locate in Trat, Chanthaburi, Prachin Buri, Sa Kaeo and Buriram provinces respectively.

Conclusions and Recommendations

1. Conclusions of the feasibility study on the construction of nuclear power plants in Thailand are as follows:

1.1 The most suitable nuclear power plant for Thailand is the 1170 MW AP 1000 (PWR) nuclear power plant, which has outstanding features in terms of safety and most cost-effectiveness, less construction period and shortest payback period, most modern technology, less maintenance requirements and various available parts, low radioactive waste and high efficiency operation.

1.2 When comparing the cost of nuclear power generation with other types of power plants, this study concludes that investment costs of nuclear power plants are more expensive than of natural gas and coal power plants, but cheaper than other power plants. Whereas it has the advantages of long-term energy security and lower operational costs than any other power plants.

1.3 Approaches in convincing people to accept nuclear power plant in Thailand will be in relation to 2 major issues ; building confidence towards nuclear technology and nuclear personnel which can be implemented in the following 3 stages; 1) Pre-construction phase, where feasibility study is required, safety must be first considered in technology design. Public involvement and public relations of the project must be implemented. 2) During construction period where

project public relations must be continuously promoted. 3) Operation running period, or post construction period; where public relations about radioactivity , greenhouse gas emission and nuclear waste management must be continuously implemented as well as offering study visiting for people and official agencies and responding to public demands.

1.4 Guidelines in selecting appropriate construction location for Thailand involve 2 issues; 1) The location must have engineering suitability as follows; no vibration caused by earthquake exists, no fault line or active fault line of earthquake exists, sufficient water supply for cooling must be available, no risk to the occurrence of tsunami, no frequent flood exists, convenient transportation must be available. 2) The location must have environmental suitability that there is no very dense population exists and there is no sensitive area, such as tourist attraction.

2. Recommendations in considering for the selection of nuclear power plants should be supported with providing relevant knowledge by the government. Although nuclear power is clean energy, many nuclear incidents experienced in the past suggest that there are several possibilities that the radiation might occur and this should be brought into consideration. One of other factors to consider is that storage location of radioactivity wastes, including the training of nuclear personnel to control power plant to meet the required standards.

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