# A Study of Appropriate Model of Unit Cost for Electricity Generation in Thailand

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## Abstract

Today Thailand has been facing the energy problems due to the limited sources of natural energy. Meanwhile, the power consumption has been growing constantly and the tendency of consumption increases each year. Therefore, to solve these energy problems, especially in electricity-generating power which have been demanded throughout the country, the National Economic and Social Advisory Council had a resolution to submit the Cabinet the comments on nuclear-electricity generation, and proposed the government for approval on August 24, 2003. The government assigned the National Energy Commission's policy to set out the electricity production plan by nuclear power plant, requiring that the power house during 2020-2021 will be established. The Electricity Generation Authority of Thailand (EGAT) has executed "the Power Development Plan 2007", established the many sets of committees to accommodate the plan and carried out surveying for dominant information, for examples, parameters and variables, issues of resulting effect, and economic expansion so that these would be summarized and submitted to the government under the production plan procedure set out by EGAT.

According to the production plan for future energy reserves, the new power houses have been established. To accommodate the economic expansion, some potential factors needed to be taken into consideration included fuel supplied and low cost. Previous researches demonstrated that nuclear power plant was lowest on cost. In present study, the appropriate model of unit cost for electricity generation in Thailand was examined. The equation was described below;

$$\sum_{j=1}^{J}\sum_{t=t_1}^{t_2} a_{j(t-1)}x_{j(t_2-t_1+1)}u_j \leq S_n \qquad ;1 \leq t_1 \leq t_2 \leq T, n = 1,..,N$$

## 1. Introduction

Electric power is a fundamental factor important to economic and social development, and has played a role increasingly in everyday life and public as resulted from population growth, industrial community, investment, education, and even tourism.

Overall, the global power consumption during 1982-1990 increased by 24% and will grow up to 50-70% by 2020. Despite a enormous effort of cost-efficient and effective power consumption, the statistics over the past 50 year revealed that Thailand had power production capacity of 146,879.07 million Kw/hr. Of them, 66.2% derived from natural gas, 2.66% stove oil, 0.03% diesel, 12.60% lignite, 8.39% coal, 5.43% hydropower, and 3.06% imported from the People Republic of Lao and 1.64% other renewable energy.

According to the statistics, the demand of electric consumption has been soared every year. It's necessary for Thailand to make the power development plan for future reserves. To achieve this and to accommodate the economic expansion, it's required to construct new power houses, seek for new sources of supply with low cost. Previous researches concluded that nuclear power plant was lowest on electricity cost. In this study, it's purported to seek for new power reserves to replace the exhausted power. In doing so, it's necessary for researchers to determine the appropriate cost model for nuclear power plant in Thailand.

## 2. Theory and Related Research

The Power Development Plan (PDP 2007) during 2007-2021 was taken into account. Including the theory of nuclear power plant, Mathematical simulation theory, Genetic Algorithm-based problem-solving and related researches

### 2.1 Power Development Plan 2007-2021 (PDP 2007)

The Electricity Generating Authority of Thailand (EGAT) developed the "Power Development Plan 2007-2021: PDP 2007 under the policy frame set out by the Ministry of Energy on matters such as the trustworthiness on electric production, distribution of fuel sources, and importing electricity for neighboring countries, and forecasting the future demand of electricity power. The PDP2007 had been approved by the National Commission on Energy Policy and the Cabinet on June 2007. The syllabus involved reduction in nuclear electricity supply from 4,000 megawatts to 2,000 megawatts. The National

Commission on Energy Policy set up six sets of subcommittees to carry out the preparatory study in different areas such as safety, standard inspection, law and regulation, environmental control and public participation, and so on. The PDP 2007 objectives included energy security, global warming, and stabilization on power price.

**2.2 Nuclear Power Development in Countries (A case study: France)**

The current global energy and environment have urged many countries to develop the nuclear capacity and give more attention to apply the nuclear power to generate the electricity. For examples, the United States of America, a country which has ceased constructing the nuclear power plant for a decade, has currently applied for approval of nuclear power plant construction. One has been currently under construction and it's likely to increase constantly. In the mainland China, six nuclear power plants have been under construction. China is regarded a country with highest number of in-process nuclear power plants, totaled 11 units. Exhibit 2-1 showed detailed information about nuclear power plants in countries.

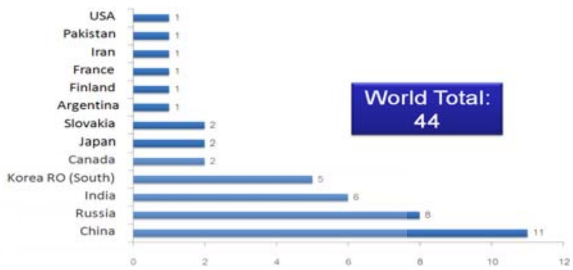


**Exhibit 1-1 Number of In-Process Nuclear power plants Worldwide**

**2.3 An Initial Consideration of Nuclear power plant Management**

The initial consideration of nuclear power plant management was analysis of key components to acquire a nuclear power plant, which included parameters, primary and secondary variables and system involvement which composed of nine following areas;

1. National and international legal framework
2. Nuclear safety
3. Nuclear power supply market
4. Financial market
5. Economics of nuclear power
6. Safeguards nuclear
7. Security of nuclear materials and other radioactive materials
8. Management system
9. Regional and interregional cooperation

**2.4 Nuclear Power Plant Planning**

To make plan and executed systematically, the concept and preparation of construction is necessary in respect of decision-making, design, construction, testing, accepted performance, safety, demolishment, and reliability, the planning process for nuclear power plant included three major steps;

1) Drafting the project step included pre-project, project decision-making, plant construction, plant operation, and decommissioning.

2) Framing work included 5 steps; project decision-making, plant construction, plant operation, and decommissioning.

3) Inspecting the process until completion

**3. Methodology**

The methodology can be applied to determine the volume of cost-efficient purchase for various products with randomized discrete variable demand by using the Genetic Algorithm (GA). This section described the methodology as follow;

**Steps**

1) Examine the demand of power consumption and production capacity in Thailand

2) Investigate issues and find out solutions

3) Explore theory and related researches

- Examine the Power Development Plan 2007-2021 (PDP 2007)

- Investigate theories relevant to the different kinds of electric generating plant

- Examine the Mathematical simulation to determine the appropriate ratio of fuel sources for electric generation and to determine the reasonable price for nuclear power plant.

- Examine theory relevant to Genetic Algorithms

- Investigate related researches

- Model the Mathematical simulation to determine the appropriate number of overall lowest cost power plants

4) Collect parameter data used in the simulation case in Thailand

5) Apply the genetic algorithm for problem-solving

6) Analyze the results

## 4. Framing general model and problems

Following the production plan for future power reserves to meet the population growth and increased demand of power consumption, it's necessary to increase the production capacity. With the reasons of technical and economic differences in energy, it has influenced the expansion plan of power plants. One of policies on electric generation was to construct the nuclear power plant to see which type of energy mostly suits to leverage the production capacity of electricity in Thailand and to be guidelines for decision-making in selecting the future power for electric generation. The detailed model of problems was described below.

### 4.1 Framing general model

In Thailand, the electric power comes from various sources; for examples, the Electricity Generation Authority of Thailand (EGAT) which provide various types of fuel, buying from private organizations and neighboring countries. This leads to a decision on which type of fuel is mostly suit to leverage the production capacity of electricity in Thailand. Exhibit 3-1 showed nature of problems.

Exhibit 1 Model of General Problems by Electric Generation Type (j) year (t)

| Unit type | Years (2007-2021) | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | ... | T |
| 1 | $X_{11}$ | $X_{12}$ | $X_{13}$ | ... | $X_{1T}$ |
| 2 | $X_{21}$ | $X_{22}$ | $X_{23}$ | ... | $X_{2T}$ |
| 3 | $X_{31}$ | $X_{32}$ | $X_{33}$ | ... | $X_{3T}$ |
| ... | ... | ... | ... | ... | ... |
| J | $X_{J1}$ | $X_{J2}$ | $X_{J3}$ | ... | $X_{JT}$ |

NOTE: j means type of fuel used in power production, where j = 1,2,…,J

t means year considered for power plant construction, where t = 1,2,…,T

$X_{JT}$ means number of power plants used fuel type j at year

### 4.2 Framing problems

1) Each production session, overall mass of all kinds of fuels shall meet the demand of power consumption ($P_t$) at each period

2) Overall production for all kinds of fuels shall meet the demand of power consumption ($E_t$) at each period

3) Increased production capacity at each session shall not exceed the maximum production capacity for each kind of fuels at each period.

4) Policy requirement on PDP 2007 in Thailand

**Objectives**

To determine the appropriate number of overall lowest cost power plants which consisted of constructing cost and operating cost (maintenance and fuel cost)

**Mathematical Model**

Fabricating the Mathematical model was intended to determine the appropriate number of lowest cost power plants under the policy and requirements that was written in the following equation.

**Target Equation**

$$\text{Min}\sum_{j=1}^{J}\sum_{t=1}^{T}(C_{jt}x_{jt}+f_{jt}y_{jt})\,;\,x_{jt}\in I \quad (3\text{-}1)$$

Because of low constructing cost, the payback factors will be as follow;

$$r_{jt} = \frac{\sum_{k=0}^{t-1} L_j - k}{L_j(L_j+1)/2} \quad (3\text{-}2)$$
$$;\,j=1,..,J,\,t=1,...,T$$

Thus, the constructing cost for power plant j at time t is as follows;

$$C_{jt} = C_{j0}[(1-e_j)(1+i)]^{-t}r_{jt} \quad (3\text{-}3)$$
$$;\,j=1,..,J,\,t=1,...,T$$

The operating cost depending on the production volume is below;

$$f_{jt} = f_{j0}[(1-e_j)(1+i)]^{-t} \quad (3\text{-}4)$$
$$;\,j=1,..,J,\,t=1,...,T$$

**Limitation Restriction**

Limitation Restriction#1 represented an adequacy between the produced electric volume and annual consumption

$$\sum_{j=1}^{J}\sum_{t=1}^{\tau}a_{j(t-1)}x_{j(\tau-t+1)}u_j \geq P_\tau(1+m_\tau) \quad (3\text{-}5)$$
$$;1\leq\tau\leq T$$

The feasibility was also taken into consideration. The power production capacity for each type of fuel decreased with the operating time as follows;

$$a_{jt} = a_{j0}(1-0.007)^t \quad (3\text{-}6)$$
$$;\,j=1,..,J,\,t=1,...,T$$

Limitation Restriction#2 epresented an adequacy of electric generation and annual consumption demand

$$\sum_{j=1}^{J}y_{jt} \geq E_t \;;\,t=1,2,...,T \quad (3\text{-}7)$$

Limitation Restriction#3 epresented an increase in production at each period which is not exceeding the maximum capacity of production for each type of fuel for each session

$$y_{jt} \leq y_{j\max} \;;\,j=1,...,J,\,t=1,...,T \quad (3\text{-}8)$$

Limitation Restriction#4 epresented the Production Development Plan 2007 (PDP 2007) indicating the electric production volume at each period for individual policy, which is not exceeding the planned production capacity.

$$\sum_{j=1}^{J}\sum_{t=t_1}^{t_2} a_{j(t-1)} x_{j(t_2-t_1+1)} u_j \le S_n \qquad (3\text{-}9)$$
$$;1 \le t_1 \le t_2 \le T, n = 1,..,N$$

Where production capacity under individual policy ($S_n$) composed of purchasing from major sources of electric generation like the EGAT, purchasing from small power plants (SPP) and neighboring countries $t_1$ is a beginning year of the policy , and เป็น $t_2$ is the final year of the policy, and n is the PDP 2007 policy

**Decision Variable**

$x_{jt}$ = number of power plant type j, at constructing time t

**Parameters**

$y_{jt}$ = Accumulated power of the power plant j, at time t

$C_{j0}$ = Initial constructing cost of power plant j

$C_{jt}$ = Constructing cost of power plant type j, at constructing time t

$f_{j0}$ = Initial constructing cost of power plant type j

$f_{jt}$ = Operating cost of power plant type j, at constructing time t

$a_{j0}$ = Feasibility factor for power plant type j

$a_{jt}$ = Feasibility factor for power plant type j, at time t

$L_j$ = Lifespan of power plant type j

$e_j$ = Escalation rate of power plant type j

i = Interest rat

$u_j$ = Unit Size of power plant type j

$S_n$ = Power production capacity under the policy n

$P_t$ = Demand of electric consumption (MW)

$E_t$ = Demand of electric power

$m_t$ = Minim power reserves (%)

$y_{j\,max}$ = Maximum fuel storage of power plant type j

**5. Conclusion**

Constructing the power plant is primarily based on decision-making in respect of long-term plan and minimum cost. The study of power development plan for future power reserves was conducted through investment on new power plant construction. However, it's quite necessary to consider the low-cost fuel sources to accommodate the economic growth. Several researches concluded that nuclear power plant has been a lowest cost power house. For these reasons, this paper examined the model deterring the appropriate unit cost of electric generation in Thailand; below was the equation.

$$\sum_{j=1}^{J}\sum_{t=t_1}^{t_2} a_{j(t-1)} x_{j(t_2-t_1+1)} u_j \leq S_n$$

$$;1 \leq t_1 \leq t_2 \leq T, n = 1,..,N$$

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