*2012 International Conference on Future Environment and Energy*
*IPCBEE vol.28(2012) © (2012)IACSIT Press, Singapoore*

# Scenarios on Power Generation in Thailand

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**Abstract.** The objective of this study is to explore the possible scenarios under the constraint of nuclear and coal-fired power development. In addition, the consequence on the overall cost, greenhouse gas and diversification index of Thailand power generation system is also investigated. The reference scenario has been created on the basis of the recent power development plan (PDP2010). Three alternative scenarios with the repeal of NPP, coal-fired power and their combination have been comparatively simulated. The results indicate the incremental cost up to 1.7 times, compared to the REF scenario. Diversification index could be rising to double level in 2030 for the scenario without nuclear and coal, while the greenhouse gas will rise by 30 percent for the case of coal utilization replacing nuclear.

**Keywords:** Energy scenario, Power generation, Public acceptance, Generation cost

## 1. Introduction

Fuel mixes of power generation in Thailand depends mainly on natural gas, accounted for 70 percent of total feedstock requirement. The rest are consisting of coal-fired power, hydro power and other renewable energy. Large portion of natural gas can be explained by the availability of domestic natural gas reserve in the Thai gulf as well as its competitive generation cost. The official Power Development Plan (PDP) has been announced to prepare and secure the capacity of power supply in the future. Majority of this plan is to diversify the large portion of natural gas by using more alternative fuels e.g. renewable energy (RE), coal-fire power and the first commissioning of nuclear power plant (NPP).

The incident of NPP accident at Fukushima has a great impact on the perception of nuclear power in the region, particularly the issue of nuclear safety. Potential of economic growth and public acceptance would be the key driving force to drive the decision of the policy maker for nuclear policy. China and Vietnam will still kept their nuclear power projects on tracking, while some counties including Thailand are still in the decision phase and has possibility to postpone the project for a while. In the mean time, public acceptance becomes the critical barrier for the development of power plant capacity in Thailand from time to time. The direct survey of key stakeholders shows that NPP and coal-fired power are the most unfavorable options, while energy efficiency and renewable energy are the promising solution [1]. According to the recent official plan [2], ambitious target of RE has been set to achieve the installed capacity of 6066 MW within 2030, compared to the capacity of 754 MW in 2009. Furthermore, the RE for power generation can be treated as an intermittent resource and expects to serve the partial load for local distribution. Thus, uncertainty of NPP and coal would definitely shape the future fuel mix of power generation in the long-run.

The previous results indicated that nuclear and coal options are able to reduce significantly the overall generation cost of the system. Benefit of cost reduction for coal-fired power would be diminished at carbon price above 40 USD/ton [3]. Penetration of renewable would affect to the grid reliability under the current power system, and should not be considered as a single dependable option for the GHG mitigation target in

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power sector [4], [5]. Most of results are relied on the economic perspective before global financial crisis in 2009, and the recent Japanese NPP accident in 2011. The objective of this study is to explore the possible scenarios under the constraint of public acceptance after the major change of economic condition in 2009 and NPP accident in 2011. In addition, the consequence on the overall cost, greenhouse gas emission (GHG) and diversification index of Thailand power generation system is also investigated.

## 2. Methodology

The energy-accounting model, i.e. LEAP (Long-Range Energy Alternative Planning system) [6] is utilized in this study. It is generally designed for balancing the energy system with an integrated environmental database. For the application of power generation, peak load requirement can be evaluated directly by the product of electricity demand and the assigned load duration curve. Additional capacity of power generation technology can be calculated based on the merit order with the constraint of planning reserve margin. Primary resource is withdrawal by the required feedstock during the transformation process. Moreover, targets of electricity import and export are also allowed for the target planning of power purchasing in the future. As the results total generation cost and environmental impact can be calculated from the electricity generation process by individual technology. The simulation structure has been summarized in Fig. 1.

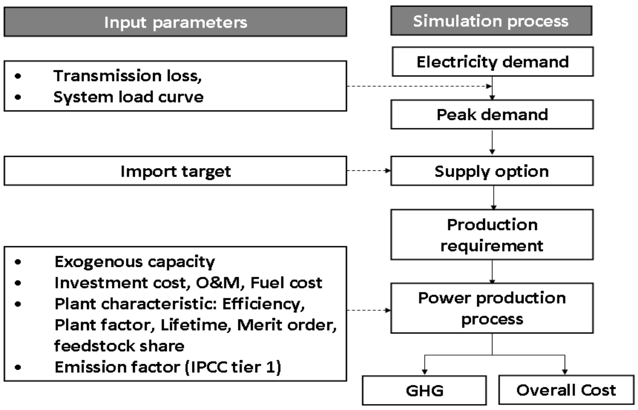



Fig. 1: Calculation scheme for power production process

In this study, the characteristics of the existing power plant technology in Thailand are illustrated in table 1. The annual cost of power production can be calculated by the summation of annualized capital cost, O&M and fuel cost as described above with 5% interest rate. Global warming potential (GWP) is calculated directly from the integrated environmental database, which relies on emission factor recommended by the IPCC [9].

Table. 1: Characteristics of power plant classified by fuel type

| Technology | Technical Assumption[a] | | | | Cost Assumption[b] | | | |
|---|---|---|---|---|---|---|---|---|
| | Size | Life time | Efficiency | Capacity Factor | Capital | Fixed O&M | Varied O&M | Fuel Cost[c] |
| | MW | yr | % | % | M.THB/MW | | THB/kwh | THB/MBTU |
| Hydro power[2] | 1000 | 50 | 38 | 45 | 87.5 | 0.04 | 0.13 | 0 |
| Thermal: Oil-fired[1] | 700 | 30 | 35 | 80 | 38.5 | 0.17 | 0.14 | 335 |
| Thermal: Coal-fired with FGD[1] | 700 | 30 | 35 | 90 | 42.0 | 0.29 | 0.17 | 92 |
| Combined cycle[1] | 700 | 20 | 45 | 90 | 17.5 | 0.11 | 0.09 | 250 |
| Gas turbine[1] | 230 | 20 | 35 | 90 | 9.1 | 0.01 | 0.04 | 250 |
| Nuclear[1] | 1000 | 30 | 35 | 90 | 56.0 | 0.39 | 0.28 | 28 |
| Biomass[2] | 80 | 30 | 35 | 50 | 49.0 | 1.47 | 0.25 | 107 |
| Biogas[3] | 10 | 30 | 30 | 50 | 80.8 | 1.47 | 1.20 | 0 |
| Waste[3] | 10 | 30 | 30 | 50 | 49.0 | 1.47 | 0.25 | 107 |
| Wind[2] | 10 | 20 | 15 | 20 | 56.6 | 0.82 | 0.65 | 0 |
| PV[2] | 5 | 20 | 15 | 15 | 175.0 | 0.42 | 0.03 | 0 |

Remark: (a) Author's estimation for technical data.

(b) Cost data referred to [7] for superscript 1, and referred to [8] for superscript 2, author's estimation for superscript 3.

# 3. Scenario

## 3.1. Reference scenario (REF)

The reference scenario represents the future prospect with the achievement of the plan. Demand forecast and supply options are based on the latest official load forecast and power development plan (PDP2010). It is assumed that the growth rate of gross domestic production is approximately 4.2 percent annually. Capacity expansion and supply option are referred to the recent power development plan (PDP2010), of which the increase of base-load capacity is mainly from natural gas combined cycle, coal-fired, and nuclear power plant, expected to commissioning in 2020. The target of 6000 MW of renewable energy capacity in 2030 has been set to build up the market with their full potential under the current prospective. Biomass will take the majority among renewable energy due to their competitive cost. However, the limited potential of agricultural residual will be the major constraint. Solar and wind energy are treated as intermittent resources and aim to reduce partial load of local distribution.

## 3.2. No nuclear scenario with minimized cost (NN-LC)

This scenario represents negative perspective of public acceptance on NPP. Barriers of the NPP commissioning are built up from time to time, such as difficulty of commissioning site development, delay of nuclear development program and etc. In order to slow down the electricity tariff due to the repeal of NPP, coal-fired power will be selected replacing the missing 5,000 MW of NPP installed capacities. Renewable energy deployment can be implemented on target similar to the REF scenario.

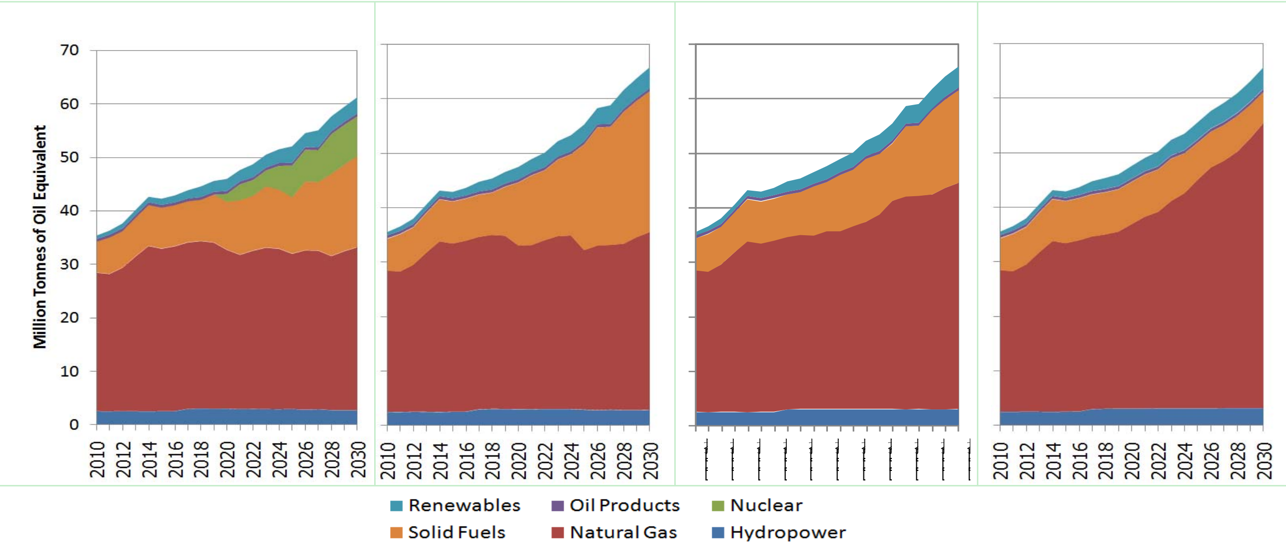
## 3.3. No nuclear scenario with low environmental impact (NN-L)

This scenario also represents negative perspective of public acceptance on NPP. In contrast to the NN-LC scenario, climate change and environmental impact becomes the major concern instead. In this case, renewable energy deployment can be implemented on target with their full potential similar to the REF scenario. Thus, the multiple units of 230 MW natural gas combine cycle are selected to replace the missing NPP capacity in order to minimize the emitted greenhouse gases level.

## 3.4. No nuclear and No coal scenario (NN-NC)

This scenario represents the negative perception on both NPP and coal-fired power generation. Beside the difficulty of NPP development, coal-fire power also becomes unacceptable option due to its environment impact. Clean coal technology cannot be competitive with the current conventional technology. Therefore, natural gas combined cycle is the only option allowed to serve the rising of electricity demand, and recover the missing capacity of NPP and coal-fired power plant.

Assumption of fuel mix for each scenario is illustrated in Fig. 2.

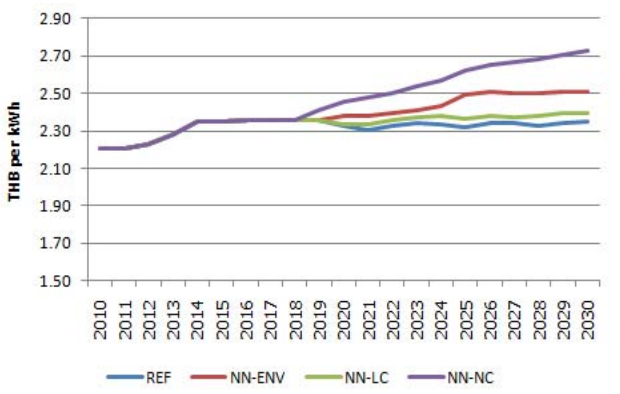



(a) REF | (b) NN-LC | (c) NN-ENV | (d) NN-NC

Fig. 2: Scenario of fuel mix for power generation

# 4. Results and Discussion

Comparison of overall cost for each scenario is illustrated in Fig. 3. The result indicated that the constraint of public acceptance affects to the increasing of overall cost. The maximum level of incremental cost is approximately 17 percent in 2030 by comparing the NN-NC with the REF case. It also affects to the diversification index as illustrated in Fig. 4. The result shows that Thailand will be able to maintain the dependency of natural gas in power sector, and kept it at lower level compared to the current status except for the case of no nuclear and no coal at the same time (NN-NC). An impact of LNG import on the overall cost is also investigated. Based on the current gas price structure, the incoming LNG import will be added into the component of the pool price. Requirement of LNG for each scenario is relied on the incremental demand of natural gas compared to the REF case. Under the LNG price forecast [10], the result of incremental cost due to LNG import is illustrated in Fig. 5. It is clearly seen that an ultimate impact will be occurred in the NN-NC case. The overall cost could be rising to the level of 1.7 times in 20 year ahead at constant price. In contrast to the cost aspect, an ultimate case for GHG emission is the NN-LC scenario. As illustrated in Fig. 6, the GHG level will be increased up to 1.3 times in the worst case, compared to the REF scenario. This would definitely affect to the target of national GHG mitigation.




Remark: Exchange rate for constant price 30 THB/USD

Fig. 3 Overall cost for power generation[1]

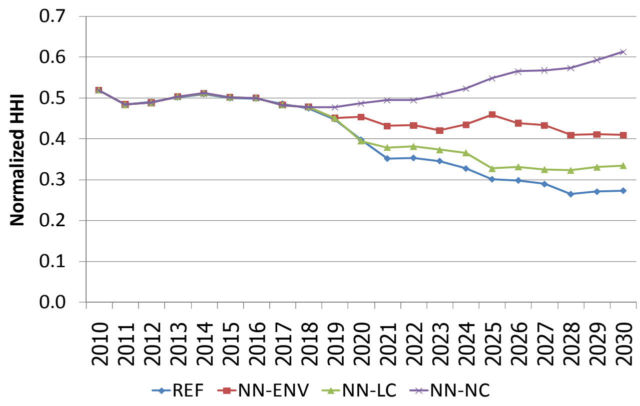



Fig. 4 Diversification index (HHI)[2]

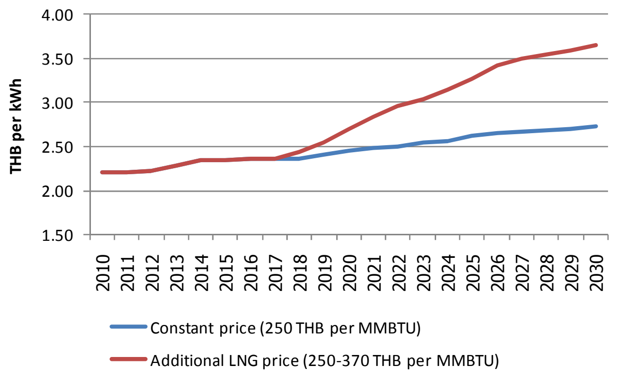



Fig. 5 Impact of LNG import on the overall cost

(Exchange rate for constant price 30 THB/USD)

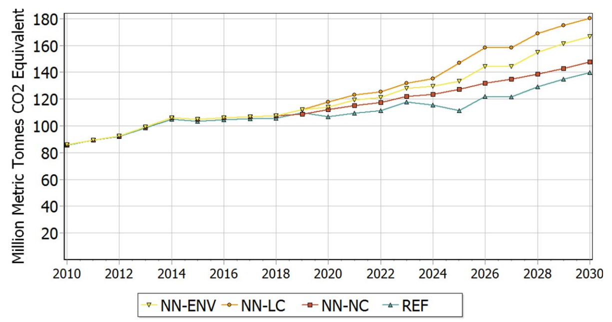



Fig. 6 Energy-related GHG for power generation

# 5. Conclusion

Scenario of fuel mix for power generation has been explored. Uncertainty of NPP and coal-fired power plant development has been focused. Repeal of NPP and coal-fired power plant will increase significantly

[1] Overall cost is consisting of annualized capital cost, O&M and fuel cost, calculated by 5 percent discounted rate.
[2] HHI = Herfindah Hirshman Index (HHI)

the overall cost up to 1.7 times in 2030 compared to the REF scenario. It is caused by the replacement with higher price technology of natural gas combine cycle together with the higher fuel price due to the LNG import. In addition, diversification index will be double for the scenario without NPP and coal-fired power at the same time. In term of the environmental concern, the GHG will rise up to 1.3 times for the worst case of NN-LC scenario. It must be noted that this calculation is relied on the expected electricity demand forecast and target renewable energy deployment.

## 6. Acknowledgements

The content presented in this paper is part of the National Research University Project of CHE and Ratchadaphiseksomphot Endowment Fund (EN1182A).

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