

# Potential of Decentralized Generation in Thailand and Its Contribution

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**Abstract:** 91% of electricity generated in Thailand is mainly by Centralized Generation (CG) [1]. Moreover the recent power development plan [2] relies mostly on Centralized Generation (CG) including centralized fossil fuel plants, large hydropower and nuclear power plants. While the existing potential of Decentralized Generation (CG) such as on site generation CHP plants and renewable energy resources, until now have not been fully utilized. In order to present the significant benefits that DG can contribute, if they are fully utilized, this paper determines primary energy saving, economical and environmental values that can be benefited from DG with the most appropriate generation shares based on its potential. In this study, WADE economic model has been applied for the analysis to calculate the generation share in the next 20 years based on 4.95% of electricity demand growth. With the penetration of DG in the system regarding its potential and existing power development plan of Thailand, DG share will increase from 2% (1,759 MW) to 17% (12,282 MW) by the year 2026. This decentralized system results in significant savings on primary energy 84.3 TWh/year (11%), emissions reduction (NO<sub>x</sub>, SO<sub>2</sub>, PM10, CO<sub>2</sub>) 40 Mton (17%), capital cost savings US\$ 1.42 billion (3%), and mostly in a reduction of required additional capacity of around 4,955 MW (6%).

**Keyword:** Decentralized Generation, Potential, Primary Energy Saving, Emissions Reduction, Thailand.

## 1. Introduction

In the next 20 years in Thailand, Decentralized Generation (DG) is expected to play a major role in energy generation. The Thai Government now has a provision on DG development in the country and provides a favourable investment for investor. Regulatory frameworks for Small Power Producer (SPP) and Very Small Power Producer (VSPP) have been set up to promote power generation from renewable fuels or cogeneration facilities in the private sector. Centralized Generation (CG) generally happens not at the place where the load is and therefore requires long transmission lines to the users. With existing high CG share, the losses on transmission are higher than for a Decentralized Generation (DG). In order to utilize energy resources in more efficiently and sustainably way and to alleviate climate change the potential of Decentralized Generation (DG) is estimated in this study for its contribution to the country in the next 20 years.

## 2. Electricity Generation in Thailand

### 2.1 Capacity and Generation

At present, electricity generation in Thailand is mainly based on Centralized Generation (CG) (91%) produced by the Electricity Generating Authority of Thailand (EGAT) 50% and by Independent Power Producers (IPP) 41%. The rest are 7% from Small Power Producers (SPP) and 2% imported from neighboring countries, mainly Laos and Malaysia. Based on the electricity generation database of Thailand in the year 2006, electricity generation was mainly produced from natural gas (69%) and coal and lignite (18%). The total capacity and generation in Thailand are 28,173 MW and 142,892 GWh respectively, with annual electricity demand growth 5.57% and peak demand growth 5.78%. [2]

EGAT's plants are predominantly thermal and combined cycle gas turbine power plants (CCGT). Major CG shares are CCGT power plants 67,310 GWh (51.89%), gas steam turbine plants 25,269 GWh (19.48%) and coal steam turbine plant 22,068 GWh (17.01%).

Decentralized Generation (DG) is the generation of electricity at or near consumer sites and integrated with the distribution systems including SPPs and VSPPs. These power

plants are Gas CHP 8,425 GWh, Biomass 2,281 GWh, Coal CHP 2,058 GWh, Small hydropower 189 GWh, Biogas 120 GWh, Oil CHP 48 GWh, and others (wind, solar, waste to energy) 55 GWh.

### 2.2 Transmission and Distribution

EGAT sells and transmits bulk electricity, both generated by its own power plants and purchased from private power sources, via its transmission network at different voltages, ranging from 500 kV, 300 kV, 230 kV, 132 kV, 115 kV to 69 kV to two distributing authorities, which are the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA), who then deliver electricity to customers countrywide [1]. The overall transmission loss is 8.1% [2]. The investment cost of a transmission line for new generation is 240 USD/kW [3] and the distribution cost is approximately 1.5 times of transmission cost [4] or 360 USD/kW.

### 2.3 Emission Factors

According to the emissions inventory of power generation in Thailand [5], emission factors are derived from the emission data sources used by EGAT to monitor the emissions of power plants. Emission factors of selected types of power plants type are presented in Table 1. The four major pollutants are carbon dioxide (CO<sub>2</sub>), nitrogen oxide (NO<sub>x</sub>), sulfur dioxide (SO<sub>x</sub>), and particulate matter (PM10).

Of the conventional power plant types, coal-fired power plants have the highest emission factor of CO<sub>2</sub> at 1,086 kg/MWh (101.3 kg/GJ), NO<sub>x</sub> at 2.83 kg/MWh (0.26 kg/GJ), and SO<sub>x</sub> at 2.83 kg/MWh (0.12 kg/GJ), while PM10 is presented at 0.09 kg/MWh (0.01 kg/GJ). The CO<sub>2</sub> emission factor is in the range of 451.6 – 1,086 kg/MWh, while nitrogen oxide is in the range of 0.62 – 2.83 kg/MWh. Sulfur dioxide is only present in coal fired and thermal power plants at 2.83 kg/MWh (after passing flue gas desulfurization) and 0.95 kg/MWh, respectively. Particulate Matter (PM10) is in the range of 0.03 – 0.14 kg/MWh as detailed in Table 1.

There is only one municipal waste incinerator power plant which is the Phuket incinerator plant. It can be seen that the CO<sub>2</sub> emission factor for this plant is high at 14,085 kg/MWh because of the high amount of plastic burnt at relatively low efficiency. [6]

**Table 1.** Emission Factors of Power Plants in Thailand during years 2001-2004 [5, 6, 7].

| Power Plant Type                                       | Carbon Dioxide (CO <sub>2</sub> ) |                    | Nitrogen Oxide (NO <sub>x</sub> ) |                    | Sulfur Dioxide (SO <sub>x</sub> ) |                    | Particular Matter (PM10) |                    |
|--|-----------------------------------|--------------------|-----------------------------------|--------------------|-----------------------------------|--------------------|--------------------------|--------------------|
|  | kg/MWh <sup>1</sup>               | kg/GJ <sup>2</sup> | kg/MWh <sup>1</sup>               | kg/GJ <sup>2</sup> | kg/MWh <sup>1</sup>               | kg/GJ <sup>2</sup> | kg/MWh <sup>1</sup>      | kg/GJ <sup>2</sup> |
| Coal Fired   | 1,086                             | 101.3              | 2.83                              | 0.26               | 42.41*                            | 3.98*              | 0.09                     | 0.010              |
|  |                                   |                    |                                   |                    | 2.83**                            | 0.12**             |                          |                    |
| Thermal-Steam Turbine (Natural Gas Fueled)             | 638                               | 64                 | 0.62                              | 0.06               | 0.95                              | 0.095              | 0.14                     | 0.014              |
| Gas Turbine (Natural Gas Fueled)                       | 822.2                             | 50.19              | 2.03                              | 0.13               | -                                 | -                  | 0.074                    | 0.004              |
| Combined Cycle Gas Turbine (CCGT) (Natural Gas Fueled) | 451.6                             | 54.79              | 1.07                              | 0.13               | -                                 | -                  | 0.03                     | 137.9              |
| Biomass  | -                                 | -                  | 0.19                              | 0.04               | 0.12                              | 0.025              | 0.12                     | 0.025              |
| Biogas   | -                                 | -                  | 2.5                               | 0.54               | 0.0003                            | 0.0003             | -                        | -                  |
| Municipal Waste Incinerator ***                        | 14,085                            | -                  | 46.7                              | -                  | 8.74                              | -                  | n.a.                     | -                  |

**Remark:**<sup>1</sup> per unit electricity, <sup>2</sup> per unit fuel

\* before / \*\* after passing Flue Gas Desulfurization (FGD)

\*\*\*Phuket incineration plant [6]

**2.4 Natural Gas Resources**

The natural gas industry in Thailand is dominated by Petroleum Authority of Thailand (PTT) which covers the full range of natural gas business i.e. exploration, production from domestic and import sources, transportation, gas separation and marketing. PTT has a transmission pipeline with a current natural gas supply of 4,380 MSCF/day (million standard cubic foot per day). The existing total pipeline length is 3,372 km with 1,397 km located onshore and 1,975 km offshore. In year 2012, the extension of the transmission pipeline will increase the gas supply to 6,980 MSCF/day [8].

The existing distribution pipeline length is 920 km running through 10 provinces. The distribution lines branch out from the transmission lines to industrial plants located mostly in Bangkok and nearby provinces, such as Pathumthani, Chonburi, Chachoengsao, Samutprakarn, Ayutthaya and Ratchaburi. Some provinces in the south also have access to PTT natural gas supplies. By the year 2012, the distribution pipeline will be extended to 1,650 km covering 23 provinces. PTT is also building a liquefied natural gas (LNG) storage terminal to be ready by 2011 with a capacity of 5 million metric ton per year located at Map Ta Phut Industrial Estate located in Rayong Province and will be ready by 2011 [9-10].

**2.5 Energy Prices**

Table 2 shows the average energy costs in 2008 which are used for the calculation in this paper. In order to promote CHP, the natural gas price for CHP is set lower than natural gas for other conventional power generation e.g. IPP and EGAT plants.

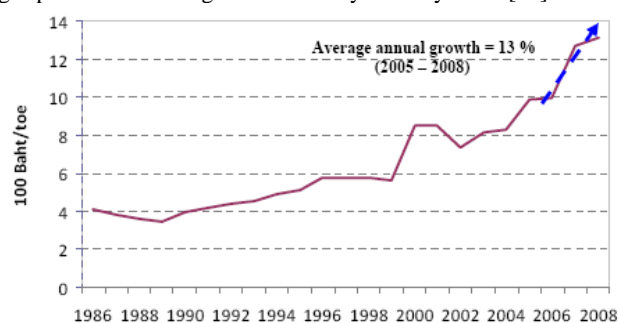
**Table 2.** Energy Prices in Thailand (2008) [11-13].

|                               |                 |              |
|-------------------------------|-----------------|--------------|
| Electricity                   | 3.10 Baht/kWh   | 24.56 USD/GJ |
| Natural Gas for CHP           | 0.88 Baht/kWh   | 6.95 USD/GJ  |
| Natural Gas for Industry      | 1.13 Baht/kWh   | 8.99 USD/GJ  |
| Heavy Fuel Oil (HFO)          | 1.34 Baht/kWh   | 10.61 USD/GJ |
| Liquefied Petroleum Gas (LPG) | 1.84 Baht/kWh   | 14.60 USD/GJ |
| Average Coal Price            | 1703.4 Baht/ton | 1.83 USD/GJ  |

**Remark:** 1USD = 35 Baht

The natural gas and electricity prices are key factors affecting on economics of CHP projects. The change of natural gas prices during the past 10 years (1998–2008) is shown in

Figure 1. The average annual growth rate over the past 10 years is around 8.9%. However, in the last five years, the growth rate increased dramatically to 13%. Nevertheless, the electricity price is dependent on natural gas price. A 10% change in the natural gas price would change the electricity tariff by 3.5% [14].

**Figure 1.** Trend of average natural gas price in Thailand during 1986 – 2008 [15].**3. Methodology****3.1 Modeling Approach**

The World Alliance for Decentralized Energy (WADE) model is an economic model designed in 2002 for energy supply planning where the demand is projected using a constant value. The model is a tool to assess the cost and environmental benefit by achieving high penetration of the DG system and encompasses detailed information to describe electricity generation from each power plant. This model has been used widely in some countries, such as in Canada, China, EU-15, G8+5, Iran, Sri Lanka, Scotland, the United Kingdom, and the United States of America [16-18]. Before the WADE model, there was no model available that directly compared a centralized generation system with decentralized one [19-20]. Therefore, it was selected for this study because the WADE model is the only model that presents a clear picture on contribution of the DG system compared with the CG. The results are clearly presented in a comparison between percentages of DG and CG shares.

The WADE economic model is applied to determine the economic and environmental value of DG as a part of the future energy supply mix. Its emphasis is on transmission and distribution (T&D) network capital and energy requirements differentiate the WADE Model's approach from other energy economic analyses. New T&D systems are critically important because they represent a

key difference between DG and CG. DG is located close to the load and there is no need for new transmission lines and less need for distribution infrastructure. Since electricity is lost during transmission and distribution, DG improves energy efficiency by reducing these losses and contributing to reductions in greenhouse gas emissions. The model builds yearly capacity and a generation forecast of electricity to meet expected load growth and to substitute retiring capacity up to 20 years. The model requires inputs on existing capacity and generation by technology types, emissions, and investment cost, projections for future technology standards, such as pollution emissions, and economic developments, such as fuel prices and overall and peak demand growth. The model determines the amount of new generation required to replace retiring plants and meet demand growth [20].

**Table 3.** Technology Classification in the WADE model for Thailand’s Power Generation.

| Centralized Generation (CG)       | Decentralized Energy (DG) |
|-----------------------------------|---------------------------|
| Coal Steam Turbine                | Coal CHP                  |
| Lignite Steam Turbine             | Oil CHP                   |
| Oil Steam Turbine                 | Gas CHP                   |
| Gas Steam Turbine                 | Biomass                   |
| Combined Cycle Gas Turbine (CCGT) | Biogas                    |
| Diesel Gas Turbine                | Solar PV                  |
| Diesel Engine                     | Wind                      |
| Large Hydropower                  | Hydro – small             |
| Interconnector                    | Waste to Energy           |

The main purpose of this study is to investigate the application of high penetration of DG in Thailand’s future electricity mix over the next 20 years. WADE allows users to choose the technologies to be included in the power generation scheme. Power plants in Thailand can be classified into the technologies listed in Table 3.

**Model Inputs**

Figure 2 shows the data input and output of the WADE model, and specifies the required inputs and outputs. The data input requirements are detailed and extensive, requiring comprehensive information about various aspects of existing electricity generation.

The model also requires inputs on projections for future technology standards, such as pollution emissions, economic developments, such as fuel prices and overall and peak demand growth. The user can specify the yearly retirement for each

technology, and determine which technologies are built to replace retired capacity and to meet future demand.

Based on the inputs, the model determines the amount of new generation required to replace retiring plants and to meet demand growth. First the generation required to meet total demand is calculated by equations (1) and (2) from which the shortfall is determined. The model first builds capacity to satisfy normal demand, including backup margins, and then sees if the peak demand can be met. If more capacity is needed, it will be built in the same way as for meeting normal demand.

$$\text{additional CG required} = [(\text{CG sales}) / (1 - \text{peak T\&D losses})] - \text{remaining CG capacity after retirement} \quad (1)$$

$$\text{additional DG required} = \text{DG sales} - \text{remaining DG capacity after retirement} \quad (2)$$

**Model Outputs**

Five basic official outputs provided by the model include total additional capacity and generation to meet future demand, total capital cost, retail cost, fossil fuel consumption and pollutant emission.

**3.2 Scenarios Development**

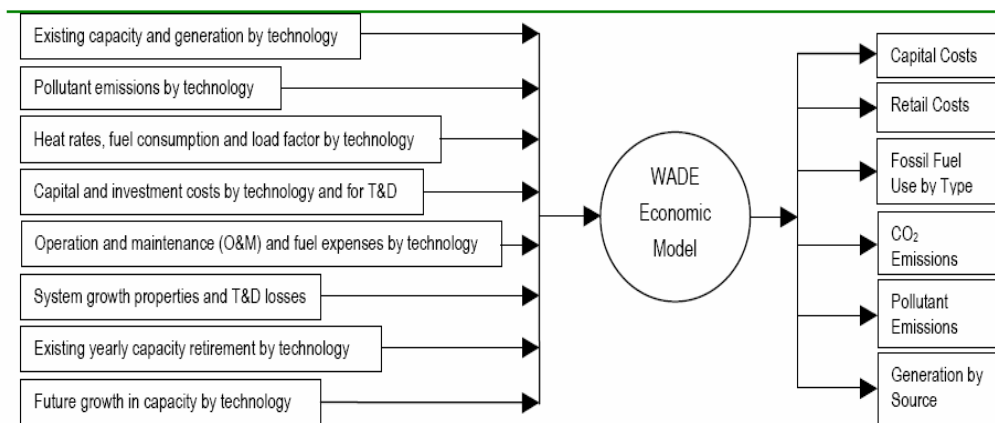
There are two set groups of scenarios: (1) Reference Scenarios and (2) Sensitivity Analysis Scenarios. Reference scenarios are principally used to compare the development of Centralized Generation (CG) with the case of high penetration of Decentralized Generation (DG) in the country. A Business as Usual (BAU) scenario focuses on the development of CG only, while the High DG scenario focuses on the development of DG based on its potential.

There are three Sensitivity Analysis scenarios: (1) Low Electricity Demand Growth, (2) High Natural Gas Prices, and (3) High T&D Capital Cost. These scenarios are set up to observe generation capacity, cost, and emission reduction under the various circumstances suggested by their titles.

**3.2.1 Reference Scenario**

**(1) Business as Usual (BAU)**

This scenario assumes that there is *no new DG* power generation added during simulation period (2007-2026). The incremental demand over 20 years would be fulfilled by CG. The retired plants would all be replaced by centralized power generation with electricity demand growth rate 5.57% and peak demand growth 5.78% as proposed in Power Development Plan (PDP 2007, Revision 1) [2]; however, any new nuclear power plants are not taken into account.



**Figure 2.** Overview of WADE Economic Model Inputs and Outputs [20].

**(2) High Decentralized Generation (DG)**

The High DG scenario focuses on a high penetration of the decentralized system into the electricity market. The retired plants are replaced by DG mainly with natural gas CHP and the rest is replaced by some CG systems that have already been planned and upcoming as proposed in PDP 2007 (Revision 1). DG growth is expected to come mainly from:

- 300–1,000 kW natural gas-based CHP in buildings (such as hospitals and large commercials buildings providing electrical, cooling, and thermal energy) by applying gas engines as prime movers with electrical efficiency at 39% and total efficiency 82%.
- VSPP>10 MW natural gas-based CHP in local manufacturing plants and industrial locations providing electrical and thermal energy, by applying gas turbines as prime movers with electrical efficiency at 31.5% and total efficiency 82%.
- SPP>10–120 MW natural gas-based CHP in industrial estates, small factories and building complexes, by applying gas turbines as prime movers with electrical efficiency at 41.7% and total efficiency 82%.
- Potential renewable technologies that are planned in the RE Development Plan [21], such as small biomass CHP, biogas CHP, wind power, small hydropower, and solar power.

New DGs are replaced annually based on yearly power demand as forecasted in PDP Revision 1 until the year 2021, by assuming that there no new CGs added and the retired plants are replaced by DG. From 2021 onwards, the growth rates of DG are limited by the potential of each DG technology.

**Reference Scenarios Validation**

To validate the reference scenarios, the total generation capacities of CG are compared to the capacities planned for the next 15 years by PDP 2007 (Revision 1). In order to avoid overestimation of resources, the total capacity of the DG in the High DG scenario is validated with the technical potential from studies of natural gas-based CHP [22] together with the Renewable Energy Development Plan in next 15 years [21]. The total generation capacity of the reference scenarios are compared with government plans, as shown in Table 4. The results of capacity generation in selected years have small deviations at ± 2% which means that the reference scenarios are acceptable and

represent the power generation in the next 20 years.

**3.2.2 Sensitivity Analysis**

**(1) Low Electricity Demand Growth**

Regarding the economic situation, lower electricity demand growth is expected. PDP 2007 Revision 2 [23] has proposed a new electricity demand forecast based on GDP growth which is lower than of previous years. A new annual demand growth rate is proposed at 4.95% while the annual peak demand growth is 4.93%.

**(2) High Natural Gas Price**

This scenario is set to observe the future generation with high natural gas price circumstance. According to the trend of natural gas price growth, as in Figure 1, in the last ten years (1998–2008) the annual growth rate of natural gas price was approximately 8.9%. However, during the last four years (2005–2008), the natural gas price had increased dramatically by 13% per year. Therefore, it is assumed that the future growth of natural gas price will increase similarly.

**(3) High T&D Cost**

High T&D costs scenario attempts to capture the benefit of DG applying to reduce the costs of transmission. Reference scenarios are examined by doubling the transmission and distribution costs to find out the impact of these changes on the cost analysis.

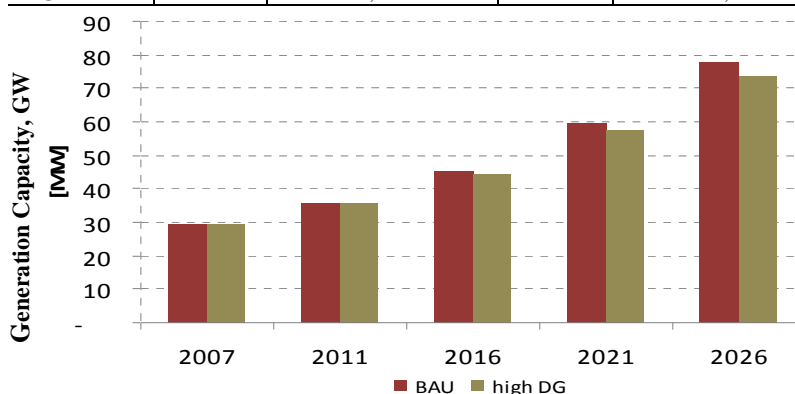
**4. Results and Findings**

The model calculates the proper shares between CG and DG in the next 20 years. Figure 3 presents the total generation capacity of the BAU and the High DG scenarios. It shows that the total generation capacity needed in the High DG scenario is lower than the BAU scenario, because the DG systems can avoid energy loss in transmission network. Therefore, to satisfy the same amount of electricity demand, the High DG scenario requires a lower generation capacity than the BAU scenario. With the penetration of DG regarding its potential and existing power development plan of Thailand, DG share will increase from 2% (1,759 MW) to 17% (12,282 MW) by the year 2026.

**Table 4.** Validation of Reference Scenario.

| Power Generation    | Year 2011          |                                 | Year 2016          |                                 | Year 2021          |                                 |
|---------------------|--------------------|---------------------------------|--------------------|---------------------------------|--------------------|---------------------------------|
|                     | Reference Scenario | Government Plan + CHP potential | Reference Scenario | Government Plan + CHP potential | Reference Scenario | Government Plan + CHP potential |
| Total capacity [MW] | 36,858             | 37,467                          | 47,928             | 48,754                          | 65,036             | 63,808                          |
| % difference        |                    | -2%                             |                    | -2%                             |                    | +2%                             |

| Year 2026 | BAU Scenario |                     | High DG Scenario |                     |
|-----------|--------------|---------------------|------------------|---------------------|
|           | % Share      | Total capacity (MW) | % Share          | Total capacity (MW) |
| CG        | 98%          | 76,031              | 83%              | 61,293              |
| DG        | 2%           | 1,759               | 17%              | 12,282              |



**Figure 3.** Generation capacity of BAU and High DG scenario by year 2026.

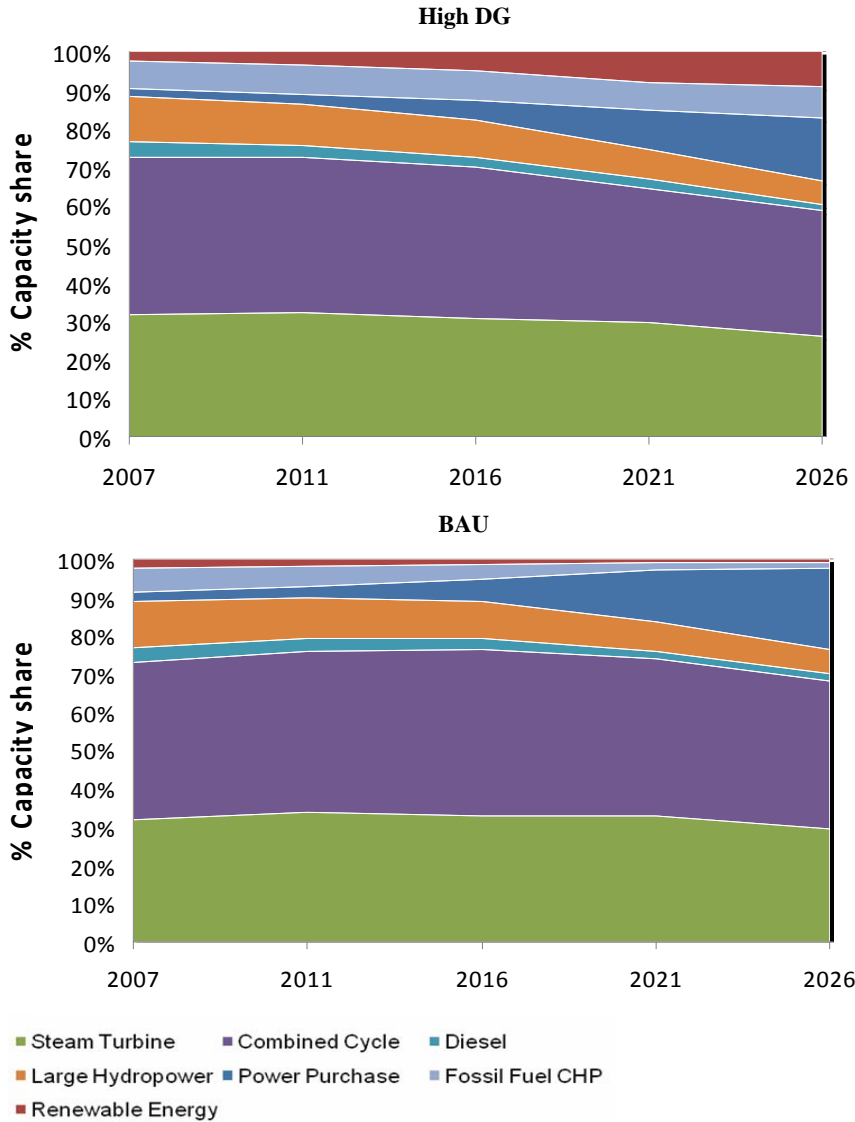
High DG scenario results in decreasing of CG shares by substitution of DG as in Figure 4. Natural gas CHP and renewable energy, such as small hydropower, wind power, and biomass/biogas power are increased to substitute for CCGT, large hydropower and imported electricity.

Fossil fuel saving regarding lower generation capacity is also a consequential benefit. In high DG scenario, fossil fuels such as coal, oil, and natural gas that are mostly supplied to CG plants are decreased while bio-fuels such as biomass, biogas and other renewable energy are introduced into DG plants with 32 TWh/year. The High penetration of DG resulted in fossil

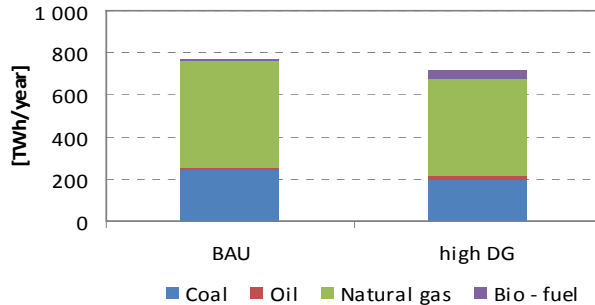
fuel savings of 85 TWh/year or 11% and total fuel saving of 52 TWh/year or 7% as shown in Table 5 and Figure 5.

**Table 5.** Comparison of fuel consumptions in BAU and High DG scenarios by type.

| Unit : TWh/year | BAU | High DG |
|-----------------|-----|---------|
| Coal            | 244 | 202     |
| Oil             | 11  | 11      |
| Natural Gas     | 511 | 468     |
| Fossil Fuel     | 766 | 681     |
| Bio-Fuel        | 3   | 35      |
| Total Fuel      | 769 | 717     |



**Figure 4.** Capacity shares by plant type in BAU and High DG scenarios.



**Figure 5.** Total fuel consumptions in BAU and High DG scenarios.

As a result of fossil fuels savings, emissions are also reduced by the penetration of high DG. There are significant reductions of 21 million ton CO<sub>2</sub> (16%) with total emissions reduction (NO<sub>x</sub>, SO<sub>2</sub>, PM10, CO<sub>2</sub>) of 40 million ton (17%), as shown in Table 6.

**Table 6.** Emission of BAU and High DG Scenarios.

| Emissions (Million ton) | NO <sub>x</sub> | SO <sub>2</sub> | PM10 | CO <sub>2</sub> | Total |
|-------------------------|-----------------|-----------------|------|-----------------|-------|
| BAU                     | 58              | 37              | 7    | 128             | 230   |
| high DG                 | 50              | 28              | 5    | 107             | 190   |
| % DG saving             | 14%             | 25%             | 24%  | 16%             | 17%   |

Building a large power plant and transmission network for CG plants is obviously a higher investment than building small power plants nearby consumers with a shorter distribution network. Moreover, it is known that a major cost of electricity generation comes from fuel costs, when fuel consumption is reduced, it is expected that capital and retail costs of electricity generation are also reduced consequently.

By the year 2026, under lower peak demand growth rate (4.93%), electricity retail cost of high DG scenario will be around 13% lower than BAU scenario for all cases as presented in Figure 6. This is evidence that the cost of electricity is saved by producing it with DG from its energy and fuel saving.

The reference case presents a slightly higher price than the low peak demand case, because in the reference case, there is an extra capacity required to serve during peak demand and the electricity costs need to cover this extra capacity. In the case of double transmission and distribution costs, the electricity retail price has a slight impact on the total price (8% increased) as compared to the high gas price scenario which the electricity price increased by 43% from current gas prices as the fuel price shares a major part of electricity generation. However, in High DG scenario, it has less impact on the electricity price than the BAU scenario does.

## 5. Conclusions

Decentralized Generation (DG) can contribute significant benefits of primary energy savings, reduction of energy losses during transmission, lower installed capacity of power generation

and T&D cost, emissions reduction, and a secure power generation system. As demonstrated in this study, the penetration of DG will increase the generation share from 2% (1,759 MW) to 17% (12,282 MW) by the year 2026 and contribute a significant savings on primary energy 85 TWh/year (11%), emissions (NO<sub>x</sub>, SO<sub>2</sub>, PM10, CO<sub>2</sub>) reduction 40 Mton (17%), capital cost savings US\$1.42 billion (3%), and a reduction of a required additional installed capacity of around 4,955 MW (6%). The result of this study proves that a high DG share in Thailand's future electricity mix could partly replace of centralized power generation and meet the incremental growth demand by the year 2026. In addition, this study also proves that DG provides more benefits in the economic and environmental sectors, in a condition that DG has to be able to compete with CG.

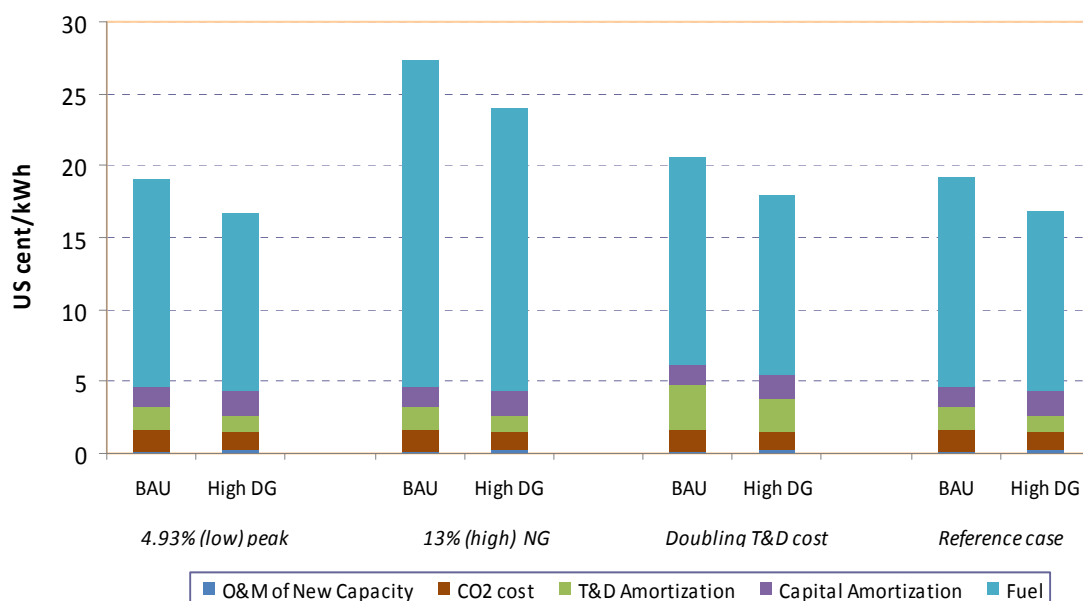
The WADE economic model has some limitations on the calculations, as it focuses only on the utilization of electricity without heat utilization concerns, while CHP technology produces both electricity and heat. Regarding the basic principle of CHP application, the contribution of waste heat recovery from electricity generation is the main objective of CHP utilization. In order to reflect the full efficiency of CHP, both electricity and heat utilization and distribution must be taken into account in the model (e.g. heat distribution cost, installation costs).

The WADE economic model forecasts the future generation by referring to the past. By using the past generation and consumption and historical statistics, uncertainty can be experienced, as there is always an unpredictable market situation, such as demand growth, energy prices, investment costs, and energy policy. Therefore, the effect of uncertainty factors on the model is unavoidable.

The WADE economic model is a useful model to support Decentralized Generation (DG), as it presents a clear picture on the contribution of the DG system compared with the Centralized Generation (CG). The model also assists policy planners to have an overview of future generation for future policy planning.

## Acknowledgement

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**Figure 6.** Retail cost of electricity generated by scenarios.

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