Chapter 6
Distributed Energy System in Thailand

Thailand's Electricity Supply Industry Structure

Thailand is one of the best known developing countries in ASEAN. With a population of about 70 million, its need for electricity is gradually increasing. The country's electricity market is the wholesale market, which is the same as that of many developing countries. However, the wholesale electricity market in Thailand is regulated by the government and related organisations such as the Department of Alternative Energy Development and Efficiency, Energy Policy and Planning Office (EPPO), and the Ministry of Energy, Energy Regulatory Commission. The Electricity Generating Authority of Thailand (EGAT) produces and transmits electricity and the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA) distribute it. Most of the distributed energy systems (DESs), known as small power producers (SPPs) and very small power producers (VSPPs), are connected to the distribution system of PEA and MEA. The transmission system in Thailand already covers 99% of residential areas (Figure 6.1).

Thailand's Electricity Situation

In 2016, per EGAT records, the net peak demand of Thailand of 30,973 MW occurred on Wednesday, 11 May 2016, at 14:00, higher than that in 2015 by 2,890 MW or 10.3%. Its 2016 total net energy demand was 196,868 GWh higher than that in 2015 by 7,347 GWh or 3.9%. The highest electricity consumption comes from the industrial sector (42%), followed by the residential sector (24%), the business sector (19%), and other sector (15%). The country's electricity consumption in 2016 grew as expected because of Thailand's economic growth of 3.2%.

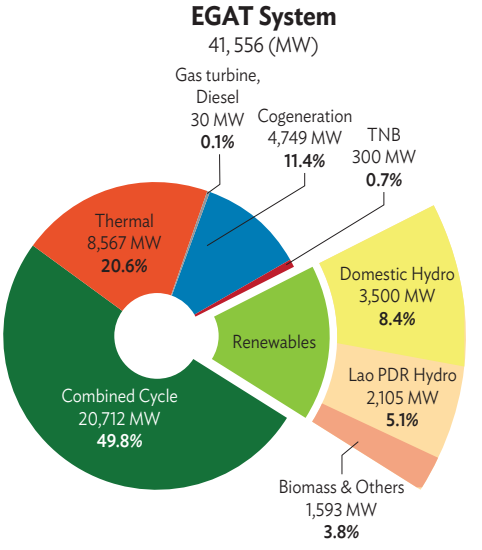
In 2016, its net power capacity amounted to 45,065 MW, comprising combined cycle power plant of 20,712 MW (49.8%), thermal power plant of 8,567 MW (20.6%), renewable energy of 7,196 MW (17.3%), cogeneration of 4,749 MW (11.4%), gas turbine and diesel power plants of 30 MW (0.1%), and power exchanges between

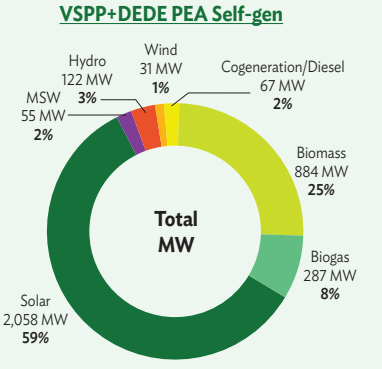
Thailand and Malaysia of 300 MW (0.7%). Figure 6.2 shows that Thailand's power system includes power generated by non-firm SPPs and VSPPs. It also shows the contract capacity on Thailand power system by power plant type in 2016.

Figure 6.1: Thailand National Power Grid

Source: GENI (2016).

Figure 6. 2. Contact Capacity on Thailand Power System by Power Plant Type, 2016





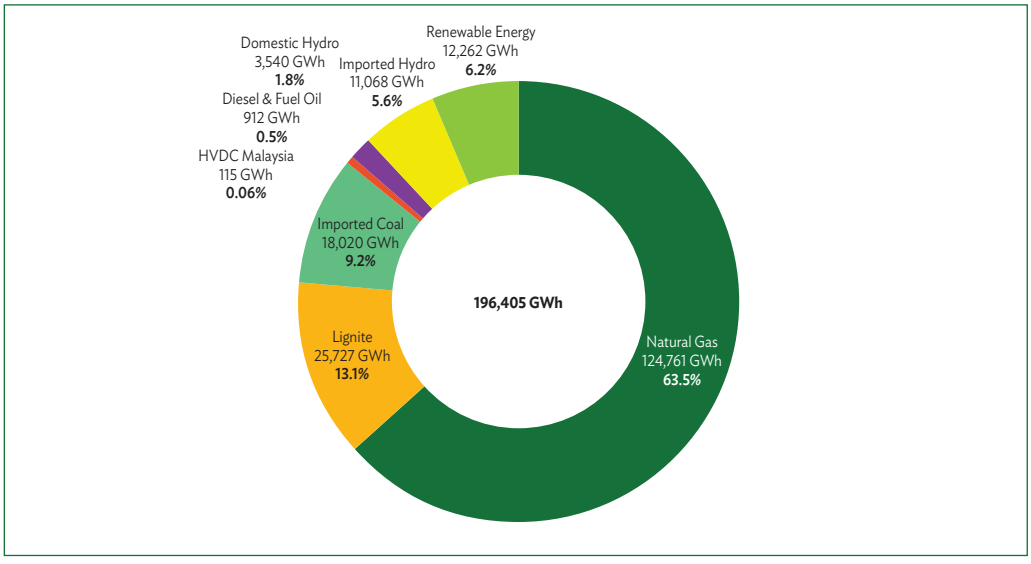
Thailand System	45,065 MW
- EGAT System	41,556 MW
- VSPP + DEDE PEA Self-gen	3,509 MW

DEDE = Department of Alternative Energy Development and Efficiency, EGAT = Electricity Generating Authority of Thailand, MW = megawatt, PEA = Provincial Electricity Authority, VSPP = very small power producer.

Source: MOE (2015).

In terms of fuel consumption for electricity generation in 2016, natural gas had the highest share in Thailand's generated power of about 63.5%, followed by lignite and import coal (22.3%), renewable energy comprising all types of renewable energy and hydropower from both neighbouring countries and domestic hydropower (13.7%), and others (0.5%). Figure 6.3 shows the energy generation by fuel type in 2016.

Figure 6.3. Energy Generation by Fuel Type, 2016



GWh = gigawatt-hour, HVDC = high voltage direct current.
Source: MOE (2015).

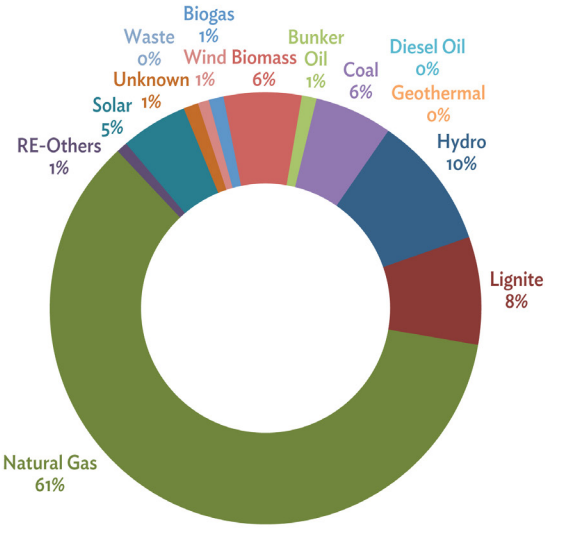
Current Situation of Thailand's Distributed Energy System

Thailand's total generation installed capacity, as of March 2017, was about 55,600 MW. (The total capacity reported is the total generation installed capacity including independent power systems. Thus, the number in this report is higher than other official national power development plans (PDPs) which excludes the independent power systems). The main fuel used for Thailand's electricity generation is natural gas. The installed capacity of natural gas–fired power plants is about 62%; of coal-fired power plants, 7.7%; bunker oil and diesel oil power plants, 1%; of hydro power plants, 8%; and of renewable energy, 13.1% (Figure 6.4). Main proportions in renewable energy capacity are biomass and solar photovoltaic (PV), which are estimated to be 5.7% and 4.9% of total capacity, respectively.

Existing Policies to Promote Distributed Energy Systems

The Royal Thai government, like many other countries, is concerned about promoting renewable energy. However, power generation costs from some renewable energy resources are still higher than those of conventional energy resources, such as coal, natural gas, and hydro, while renewable energy has been promoted to address global

Figure 6.4. Proportion of Installed Capacity by Fuel Type



Source: MOE (2015).

warming and climate change issues. Thus, the Thai government has been exerting efforts to reduce carbon dioxide (CO2) emission by gradually promoting renewable power into the power system. The government has been pushing forward the Alternative Energy Development Plan (AEDP), Figure 6.5, for Thailand to become a low-carbon society.

In the past, to attract investors, the Adder System[1] was applied to encourage renewable power generation. Nowadays, the Feed-in Tariff (FiT) mechanism is being implemented to reflect the real cost of generating renewable power and to specify the time frame of purchasing. The plan intended to encourage waste (garbage), biomass, and biogas power generation as the priority. According to the plan, the potential of generating power from waste is 500 MW. However, the potential power generation from biomass would be 2,500 MW. The policies of the Ministry of Agriculture and Cooperatives (Thailand) to increase the plantation area of sugar cane and palm, as well as to raise productivity of cassava from 3.5 to 7 tons per Rai (or 0.4 Acre) per year, could provide feedstock for biomass power generation up to the capacity of 1,500 MW. In addition, area by area zoning and limited power generation capacity measures were adopted to prevent challenges from the previous plan. Technology improvement is expected to build the competitiveness of renewable energy over that of conventional energy,

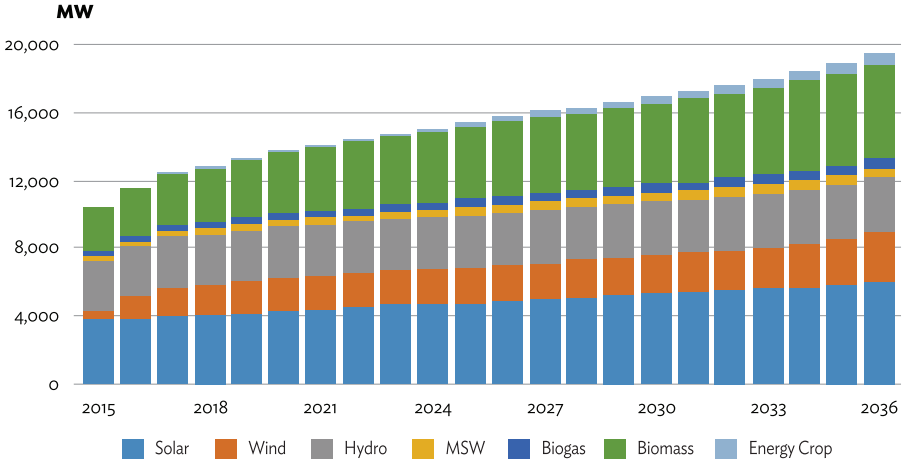
[1] The Thai government has applied the premium model of feed-in tariff (FIT), or generally called 'Adder' since 2007. The premium rates and support duration will be differentiated by renewable energy type. Power utilities will buy electricity from producers at a rate equal to the base tariff, plus the wholesale fixed tariff and Adder. The Adder will be passed on to consumers in the form of the retail fixed tariff. Therefore, in no case will the electricity tariff burden on the people will increase due to the duplication of revenue of producers, except the base tariff is reviewed by including the retail fixed tariff.

especially liquefied natural gas. The main target of the AEDP is to increase the portion of renewable energy generation from 8% to 20% of the total power requirement in 2036, which accounts for a total of 19,684.4 MW.

According to the plan, SPPs and VSPPs, which can be accounted as DES, will be included in the plan. The estimated capacity of the future DES will later be discussed.

Figure 6.5. Alternative Energy Development Plan

Type	Solar	Wind	Hydro	MSW	Biogas	Biomass	Energy Crop	Total
End of 2014	1,298.5	224.5	3,048.4	65.7	311.5	2,541.8	-	7,490.4
End of 2036	6,000	3,002	3,282.4	500	600	5,570	680	19,634.4



MSW = Municipal Solid Waste, MW = megawatt

Source: EGAT (2017).

Table 6.1. The Current Renewable Energy Tariff

Technology	Feed-in-Tariff (FiT) ($ cent/kWh)
Solar PV	11.44
Wind Power	16.83
Biomass	11.77
Biogas	10.44
Micro hydro	13.6
Geothermal	N/A

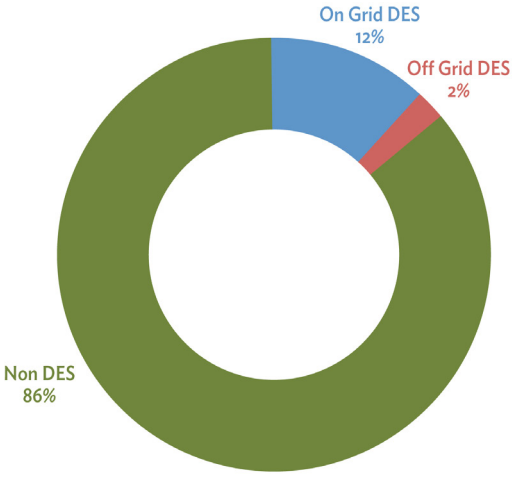
kWh = kilowatt-hour, PV = photovoltaic.

Source: EGAT, 2017.

Estimation of Current DES Status both On Grid and Off Grid

According to the assumptions of studies by the Economic Research Institute for ASEAN and East Asia (ERIA), the solar farm, solar PV, and small hydro under 50 MW are accounted for as DES. Coal, gas, geothermal, solar thermal, waste incineration plants, and biomass thermal plants under 100 MW are likewise accounted for as DES. The current installed capacity status estimates the total DES capacity (both on grid and off grid) calculated based on the above DES definition to be 7,500 MW. Therefore, DES makes up about 14% of total capacity (Figure 6.6).

Figure 6.6. Current Proportion of DES Capacity to Total Thailand Capacity



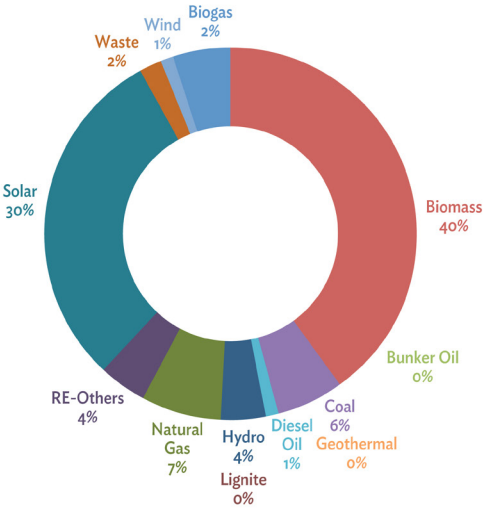
DES = Distributed Energy System.

Source: Authors' estimation.

ERIA's definition of off-grid is slightly different from the one this study. In this study, off-grid power plants are those that are not connected as a supply to the main national grid (EGAT grid) but those connected to the national grid to use the national grid as back-up. In this case, we define it as independent power system and it is accounted as off-grid. Also, the off-grid power plants in this study are those connected to the independent distribution grid (PEA and MEA that are not connected to the main national grid). The independent distribution grids are used on islands and in some rural areas. Hence, based on the definition of off-grid in this report, off-grid DES installed capacity is about 940 MW, which is about 2% of the total installed capacity of Thailand. Obviously, from the total of 14% DES, the on-grid DES is estimated to be 6,570 MW, which is 12% of the total capacity of Thailand. From 7,500 MW of DES-installed capacity, the renewable DES–installed capacity is about 6,500 MW or 86% of installed DES capacity. The

renewable- installed capacity is 12% of Thailand's total capacity. The major fuel types contributing to DES capacity are biomass (40%) and solar (30%) (Figure 6.7). Biomass and solar currently play a major role in DES since the government has promoted biomass and solar in the 2010 AEDP.

Figure 6.7. Current Proportion of DES Capacity by Fuel Type



Source: Authors' estimation.

Areas that use on-grid and off-grid DES

Most of Thailand's DESs are connected on grid. The off-grid capacity of DES is only about 13% of total DES capacity in Thailand. Most of the 940 MW of the off-grid DES capacity (about 870 MW) is being used in industrial areas. Only 55 MW is used in remote residential areas, which include deep forest and remote mountainous villages.

The rest, approximately 15 MW, is used on islands. Therefore, about 93% of off-grid DES capacity is used in industrial areas, about 6% is used in remote residential areas, and about 1% is used on islands (Figure 6.8).

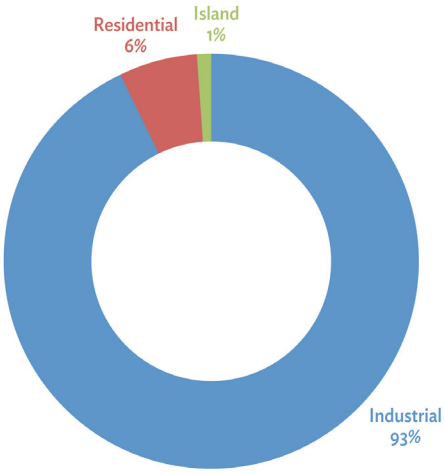
Diversity, security, and CO2 reduction

Currently, DES in Thailand, which consists of many types of fuel in the generation mix, is one factor that increases the diversity of the total fuel mix in the country's generation capacity. Since most of the fuel used is natural gas, which is more than 60% of the total, the increase of biomass and solar in DES helps reduce the use of natural gas and results in the diversity of fuel mix. However, DESs in Thailand are not only for diversity

and security but also for reducing electricity cost in industrial areas, for the return on investment of the government's promotion of FiT, and for the electricity need in some remote areas and islands.

The energy generated by solar, wind, and hydro from DES in Thailand is about 5.34 million MWh. Thus, CO_2 reduction using the factor of 7.30x10-4 metric tons CO_2/kWh is about 3,760 million metric tons CO_2 per year.

Figure 6.8. Off-grid Electricity Area



Source: Authors' estimation.

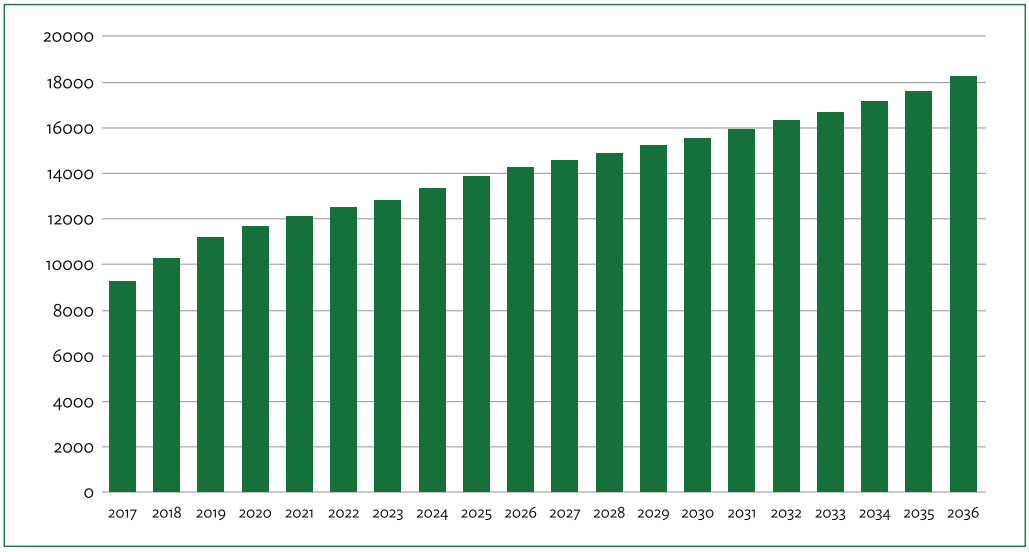
Estimation of Future DES in Thailand and Its Growth Opportunity

The government had already promoted renewables in its past PDPs. It continues to promote renewables into the system. Therefore, DES in Thailand tends to grow every year. The proportion of DES is expected to increase from 14% at 2017 to 23% at 2036. Figure 6.9 shows the estimated DES capacity according to the PDP.

Until 2036, the government's policy is to increase DES, including SPPs and VSPPs and renewables more than 10,000 MW, especially focusing on solar and biomass due to their potential. The government also has a policy to subsidise the cost of renewables using FiT. Thus, there are still a lot of opportunities to invest in DES in Thailand according to the policies. Yet, there is almost no room to increase electricity coverage in Thailand since it is already 99%. Therefore, on-grid DES is expected to grow much more than off-

grid DES in the near future, according to the PDP. However, if the levelised off-grid DES electricity cost is lower than the retail electricity price provided by MEA and PEA, the off-grid capacity might skyrocket in the future.

Figure 6.9. Estimated DES Capacity in Thailand, 2017–2036



DES = Distributed Energy System.

Source: Authors' estimation.

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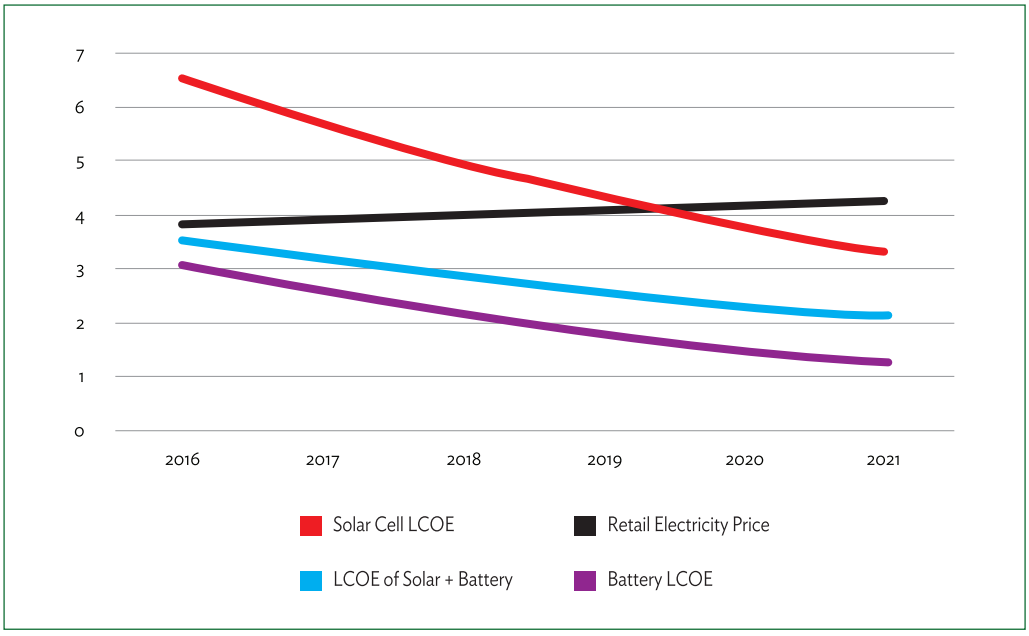
Current cost of on-grid and off-grid, estimation of future cost of wind and solar compared with the retail electricity price in Thailand

Today, the cost of large-scale electricity production in Thailand is still lower than the levelised DES electricity cost. Large-scale utility power plants provided by EGAT offer reasonably low prices for consumers; thus, DES cost in Thailand is still not competitive. In the case of unsubsidised DES cost through FiT, the national grid cost plus the provided electricity cost in most remote areas is still lower than the DES off-grid cost.

The levelised cost of electricity (LCOE) of wind and solar is dropping sharply, and battery cost is decreasing annually. Hence, if future DES cost is anticipated to be lower than the retail electricity price, then DES will rapidly grow. The LCOE of solar and wind is expected to go below 1.5 baht (B)/kWh in 2036 (Source: Bloomberg new energy finance); battery capital expenditure cost is also expected to fall below 10 million B/MWh before 2022 (Seba, 2014). According to these assumptions, the residential self-generation electricity cost will be lower than the retail electricity price in 2022. Figure 6.10 compares the price of solar cell combined with that of battery electricity and the retail electricity price in Thailand when using 10 kWh/day.

Figure 6.10. Comparison of Estimated Price of Electricity in Thailand



LCOE = levelised cost of electricity.
Source: Authors' estimation.

In conclusion, current DESs in Thailand are mainly used in the private industrial section and investment in accordance with Thai government policy. The main types of DES being promoted in the country are solar and biomass. The on-grid DES in Thailand is expected to grow in the near future. DES is estimated to grow at 10,000 MW. However, the off-grid DES demand can skyrocket when the price of self-generation electricity falls below that of the electricity retail price.

Thailand's DES Policy

The new Cabinet formed in 2014 initiated the direction of Thailand's Energy 4.0. The Ministry of Energy of Thailand focused Energy 4.0 on the Thailand Integrated Energy Blueprint to drive the country's energy innovation and continue the desire of King Rama IX to strengthen families and communities.

The Energy Policy on the Electricity Sector (Energy 4.0) is shown in Figure 6.11. To enhance the power sector, the Ministry of Energy has set policies related to DES in two areas:

1. unbalanced fuel diversification and unstable renewable generation, and
2. centralisation of generation and distribution systems with high investment in transmission system.

Case Study on Thailand's Smart Grid Projects

The pilot programme included in the expedition plan of the Ministry of Energy, administration by the Energy Planning and Policy Office comprises three pilot projects:

1. Mae Hong Son smart grid, Muang district, Mae Hong Son province, operated by EGAT,
2. Micro Grid project in Mae Sariang district, Mae Hong Son province, operated by PEA.
3. Smart Grid project in Pattaya area Chonburi province, operated by PEA.

The Pilot Project of Mae Hong Son Smart Grid, Muang District, Mae Hong Son Province

The province of Mae Hong Son is preserved forest. It is the only province in Thailand where the electricity transmission system of EGAT is not accessible. Currently, electricity in the Mae Hong Son area is generated from various energy sources. Some of the electricity has to be distributed from the PEA′s power distribution system through densely forested areas; Mae Hong Son province then has frequent power failures due to falling trees. Reliability and quality of electricity are important issues to be addressed in this area.

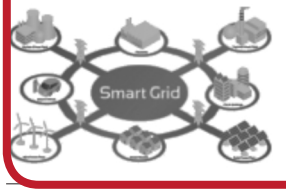
As a result, EGAT developed a smart grid as a pilot project in the Muang District of Mae Hong Son Province to make the power system in the district more stable. Mae Hong Son

is considered appropriate for the implementation of the pilot programme. Because of the location of the project, it is possible to control and operate the system together with the PEA Micro Grid System at Mae Sariang.

EGAT has an approved budget of B720 million for the project. To accelerate the smart grid operation, immediate action modifications have been made to the project, which covers smart grid technology and extends to a broader scope. An additional budget of B361 million has been proposed, leading to a total budget of B1.081 billion for this project.

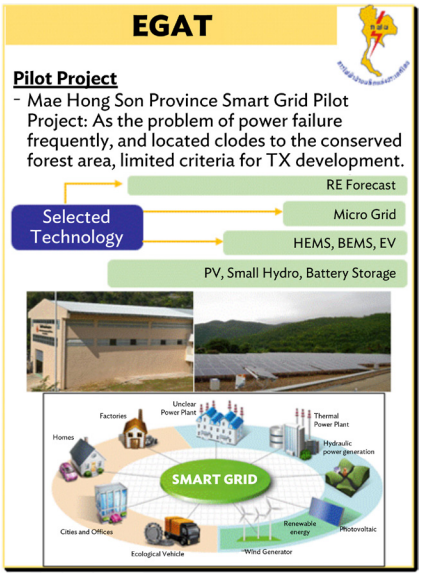
Figure 6.11. Energy Policy on the Electricity Sector (Energy 4.0)

To Enhance Power Sector

Presently	Key Measures 2017-2018	Target 2036
Unbalanced fuel diversification and unstable RE generation	• RE Generation Plan by Region • Firm RE & Energy Storage System • More Transmission System for RE	• Less Natural Gas in Gen. Mix (from 64% to 37%) • More RE (from 8% to 20%) • More Coal (from 18% to 23%) • More Power Import (from 10% to 20%)
Not Full Capacity of Generation & Transmission System Utilization	• Power Pool Market for old and high potential power plants • Merit Order (with less constraints) • Power Purchase from Neighboring Countries	• ASAN Hub on Electricity • Competitive electricity tariff to ASEAN Countries
Inefficient Use of Electricity	• Change/Use High Efficient Equipment • Block Grant/Matching Fund (Gov't Hospitals) • HEPs / MEPs • Building Code • ESCO	• Energy Saving by 89,000 GWh • Not to Construct New Power Plants 10,000 MW (equivalently)
Centralised of Generation & Distribution System with High Investment of TX System	• Decentralised Generation System (Distributed Generation: DG) • Micro Gris Pilot Projects	• Decentralised Power System • Less Investment in Tx System • Smart Power System • Smart Grid
INNOVATION 	• **Micro Grid** • **SMART Energy Management** • **SMART Grid**	• **Energy Storage System** • **SPP Hybrid Firm/VSPP Firm** • **Next Generation of Renewable**

Source: Authors' estimation.

Figure 6.12. The Pilot Project of Mae Hong Son Smart Grid of EGAT



BEMS = Building Energy Management System, EGAT = Electricity Generating Authority of Thailand, EV = electric vehicles, HEMS = Household Energy Management System, PV = Photovoltaic, TX = transmission system.
Source: EGAT (2017).

The Pilot Project of Micro Grid, Mae Sariang District, Mae Hong Son Province

The power system in Mae Sariang district, Mae Hong Son province, is supplied from Hod substation, which is about 110 kilometres away, and through the forest (Figure 6.13). These areas are those where electricity is generated from several sources, such as the PEA's diesel power plant, the small hydropower plant of the Department of Alternative Energy Development and Efficiency (DEDE), the solar power plant of VSPPs, diesel emergency generators of large consumers, etc. However, these power sources have unstable and inadequate generation capacity, resulting in poor power quality and causing frequent power failure

PEA has conducted a pilot project in this area to study and develop the micro-grid controller for planning and operating power systems with various types and sizes of power generation. With highly unstable generation of renewable energy, to maximise the potential of the power system to increase its security, and to ensure reliability and overall power quality as a whole.

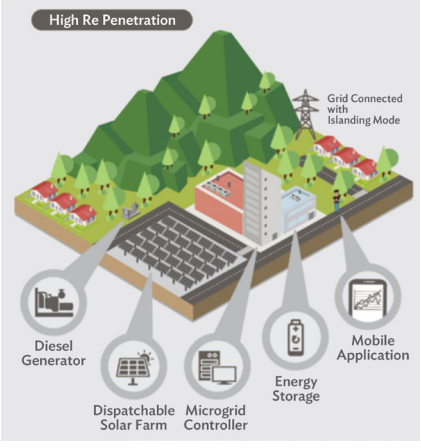
At present, PEA has an approved budget of B265 million. To accelerate the concrete smart grid operation, as part of the short-term expediting programme, the details of the project including smart grid technology and the broader scope of operations have been expanded. An additional budget of B582 million has been proposed, leading to a total budget of B847 million for this PEA project.

The Pilot Project of Smart Grid in Pattaya City Area, Chonburi Province

The smart grid project in Pattaya City Area, Chonburi Province, is the first smart grid project of PEA. The Pattaya area was selected because it was considered appropriate and 'ready' in many aspects. It has major cities with high electricity demand, wide distribution of power consumers (residential, office buildings, hotels, businesses, and industrial sectors), and integrated communication and technologies. Pattaya City also has a policy to develop into a smart city, so it is appropriate to demonstrate new technologies; the infrastructure of the communication system is quite ready in that area.

Presently, PEA has an approved budget of B1,069 million. To accelerate the concrete operation of the smart grid, as part of the short-term expediting programme, the details of the project including smart grid technology and additional operations have been expanded. An additional budget of B439 million has been proposed, leading to a total budget of B1.508 billion for this PEA project.

Figure 6.13. The Pilot Project of Micro Grid, Mae Sariang District, Mae Hong Son Province, PEA



Source: Energy Policy and Planning Office (2017).

Figure 6.14. The Pilot Project of Smart Grid in Pattaya City Area, Chonburi Province, PEA

Source: Energy Policy and Planning Office (2017).