Chapter 2
The Potential of Distributed Energy System from Renewable Energy in ASEAN

Introduction

The Distributed Energy System (DES) is a decentralised power system where electric power is produced and consumed locally at or near the point of use. DES involves the distributed power technologies, which can be stationary (typical of electrical applications) or mobile (as in marine and locomotive applications). There is no universal consensus on or standard definition of DES. DESs stand in contrast to central power stations that supply electricity from a centralised location, often far from users. Electricity from central power stations is transmitted via transmission and distribution lines to end users. Central power systems do not supply mechanical power and are always stationary and land based.

This is a study on the overall status and policies of DESs in selected ASEAN countries. It uses literature surveys and information exchange through meetings with relevant parties, such as the ASEAN Renewable Energy Sub-Sector Network, Energy Research Institute Network, Japan–ASEAN Capacity Building Programme, and other conferences. The study focuses on the following key questions:

- status of introduction of DESs, including what kind of DESs have been introduced, and
- how much energy they have supplied;

- Existing policies to promote introduction of the systems, such as
  - strategies, master plans, and roadmaps;
  - incentives/subsidies for renewable energy through the introduction of various policy instruments;
  - government-led model projects; and
  - small-power producers (SPPs) programmes;

- Analysis of the outcomes of the policies:
  - What kind of DESs the policies have promoted;
  - How much energy they have supplied; and
  - What kind of impacts the introduction has had on stable energy supply, electricity tariff, environment, etc. in the country communities.

The study team developed questionnaires to address the above hypotheses. This is critical in understanding the status, policies, and potentials of DES in the ASEAN region. Since DES information in each ASEAN country is difficult to obtain, this study also relies on various information from the power development plan or any energy master plan of countries. Using the current data from the Energy Outlook and Energy Saving Potential in the EAS region, the study estimated the generation output of DES-related energy sources in ASEAN, particularly the renewable sources such as solar, wind, biomass, hydropower, and geothermal.

Key Drivers of Distributed Energy System

Energy access

The ASEAN region has seen spectacular growth over the past 2 decades, and its growth has lifted hundreds of millions of people out of poverty. Energy demand has grown 2.5 times since 1990 and is expected to triple by 2035. Yet about 130 million people in ASEAN countries still lack access to electricity and therefore have yet to enjoy the health, social, and economic benefits (ACE, 2013). As the ASEAN Community declared in end 2015, the lack of power and energy access could threaten the region's economic growth and economic transition. Energy is largely linked with economic opportunities. The expansion of energy infrastructure projects is slow, and affects the potential of industrial development and growth. In ASEAN countries, small and very small power producers (SPPs and VSSPs) are playing a significant role in supply electricity gap and in meeting growing electricity demand. However, economic zones are also increasing to promote economic growth in ASEAN Member States. As often, the electricity supply in the economic zones are in the form of DES as auto-electricity producers. In some cases, the auto-producers also supply surplus electricity to the grid or nearby area. In rural areas of developing countries, schools and clinics operate with zero or little power. Therefore, DES has been recognised as a decentralised electricity system to meet end-use demand more effectively, and to serve areas where grid expansion is not economically viable. This situation is observed in Cambodia, Lao PDR, Myanmar, and some remote islands of Indonesia.

Table 2.1 shows electricity access in the ASEAN region. It also informs the progress of electricity access in urban and rural areas from 1990 to 2012, and only aggregate at the national level in 2016. While tremendous progress of 100% energy access has been observed in Australia, China, Japan, Republic of Korea, Malaysia, New Zealand, Singapore, Thailand, and Viet Nam, some countries in Southeast Asia have struggled to improve energy access of their population.

The rural areas of Cambodia and Myanmar still have very low access to electricity (Table 2.1). Only 31.1% of Cambodia's population and 32% of Myanmar's have access to electricity. While this rate is higher for major cities, large parts of rural Cambodia and Myanmar have very low or no electricity at all. India also harbours a large population without access to electricity.

Increasing energy access requires investment in infrastructure for grid expansion and off-grid electricity system. For both on-grid and off-grid systems, DES can be well used depending on the context and the development of the energy market in the country and the region.

Increasing energy demand

The key drivers of energy consumption in the EAS region are population, gross domestic product (GDP), growth of the transport sector as result of improved per capita GDP, and policies affecting the universal coverage of electricity access. The predicted primary energy supply and final energy demand almost doubled from 2013 to 2040 (Figures 2.1 and 2.2).

Increase of final energy consumption. Final energy consumption is projected to increase from 431 Mtoe in 2013 to 1,191 Mtoe in 2040. By sector, industry and transport energy demand is projected to grow most rapidly, increasing by 4.9% and 4.1% per year, respectively, because of industry expansion and motorisation driven by increasing disposable incomes in ASEAN Member States. The demand of commercial and residential ('Others') sector will grow 2.5% per year. Figure 2.1 shows final energy consumption by sector under the business-as-usual (BAU) scenario in ASEAN in 2013–2040.

Increase of primary energy supply. The above drivers have influenced the increase of estimated energy supply to meet final energy consumption by 2040. The ASEAN primary energy supply – the total primary energy supply of all energy sources – is projected to increase from 592 Mtoe in 2013 to 1,697 Mtoe in 2040 (Figure 2.2).

Table 2.1. Access to Electricity, 1990–2016

	1990			2000			2012			2016
	Rural	Urban	National	Rural	Urban	National	Rural	Urban	National	National
Cambodia	5.0	36.6	19.2	9.0	49.9	16.6	18.8	91.3	31.1	49.8
Myanmar	.	.	.	.	.	.	.	.	32*	57
Lao PDR	39.7	100.0	51.5	40.0	68.7	46.3	54.8	97.9	70	87.1
Brunei Darussalam	56.4	70.5	65.7	61.2	72.7	69.4	67.1	79.0	76.2	100
India	38.7	86.5	50.9	48.4	98.6	62.3	69.7	98.2	78.7	84.5
Indonesia	.	.	66.9	.	.	.	.	.	74**	97.6
Viet Nam	84.5	100	87.9	86.6	96.9	89.1	97.7	100.0	99	100
Philippines	46.4	85.5	65.4	51.9	92.3	71.3	81.5	93.7	87.5	91
Malaysia	89.2	97.3	93.2	93.0	98.5	96.4	100	100	100	100
Singapore	99	100	100	99	100	100	99	100	100	100
Thailand	82	75.2	80	87.0	72.6	82.5	99.8	100	100	100

*The number was taken from the presentation of Khin Seint Wint (2014), Renewable Energy Association of Myanmar.

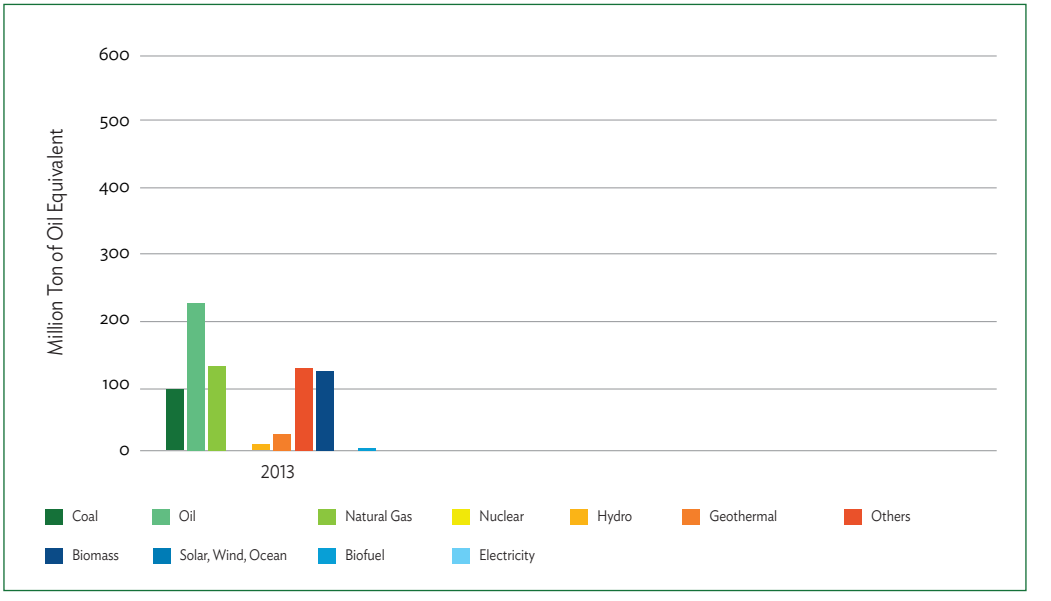
**The number was taken from ASEAN Guideline on Off-grid Rural Electrification Approaches (ACE, 2013).

Source: World Bank (2018).

Figure 2.1. ASEAN's Final Energy Demand by Sector (2013 to 2040), BAU

BAU = business as usual scenario.
Source: Author's calculation.

Figure 2.2. ASEAN's Primary Energy Suppl by Energy Sources (2013 to 2040), BAU



BAU = business as usual scenario.
Source: Author's calculation.

Oil continues to have the largest share of primary energy supply but its share is forecast to drop to 34.5% in 2040 from 36.6% in 2013. Coal is predicted to have the fastest growth rate at 5.7% per year in 2013–2040, and its share will increase from 16% to 25% during the same period. Coal will be the second-largest share after oil. Natural gas is predicted to grow at 4.4% per year in 2013–2040. Its share will increase from 21.5% to 23.8% during the same period. Hydropower, geothermal, wind, and solar energy will see some increase of their share as well, although small.

Amongst the fossil sources of energy, natural gas is projected to see the fastest growth in 2013–2040, increasing at an annual average rate of 3.7%. Its share in the total will consequently increase from 9.1% (equivalent to 499 Mtoe) in 2013 to 12.7% (equivalent to 1,339 Mtoe) in 2035. Nuclear energy is also projected to increase at a rapid rate of 6.4% per year on average and its share is forecast to increase from 1.5% in 2013 to 4.3% in 2040. This is due to the assumed resumption of nuclear power generation in Japan, the expansion of power generation capacity in China and India, and the introduction of this energy source in Viet Nam.

Estimates of Energy Supply, Needed Investment, and CO2 Emission Reduction from the Application of DES

Estimates of energy supply from DES Application. DES uses renewable energy sources such as biomass, wind power, small hydro, solar power, biogas, geothermal power, and other thermal plants with small capacity. However, DES estimates here are only for renewable energy sources. DES plays an important role in the electric power distribution system. The shift in preference towards green energy is one major factor that encourages the demand for DESs across the globe. Moreover, the opportunity in developing nations and development of eco-friendly DESs are the key opportunities for the growth of the market.

The global DES market is categorised into off-grid and on-grid segments. The DES market is estimated to increase because of the adoption of financial incentive schemes worldwide to promote clean energy as emphasised in COP21 (Conference of the Parties) and Nationally Determined Contributions (NDC) commitments. DES is also predicted to significantly increase in the ASEAN region to meet energy demand (Table 2.2). All ASEAN countries are expected to have increased solar, wind, and biomass from 26,927 GWh (BAU case) to 44,731 GWh (APS case) by 2040. Hydropower and geothermal outputs are also expected to increase in countries with resource potential.

Table 2.2. Estimates of Off-grid DES Generation Output (MWh) in ASEAN (solar, wind, biomass, hydro and geothermal)

EAS Region	BAU vs APS	Generation output (GWh) 2013			Generation output (GWh) 2040		
		Solar, wind, biomass	Hydropower	Geothermal	Solar, wind, biomass	Hydropower	Geothermal
Cambodia	BAU	1.4	50	0	11.6	1,650	0
	APS				25.6	1,197	0
Myanmar	BAU	0	443	0	918	2,137	350
	APS				2,363	1,497	350
Lao PDR	BAU	0	775	0	0	2,528	0
	APS				0	2,397	0
Brunei Darussalam	BAU	0.34	0	0	9	0	0
	APS				175	1.45	0
Indonesia	BAU	54	846	1,882	12,890	4,380	15,295
	APS				13,905	5,475	18,921
Viet Nam	BAU	26.4	2,847	0	160.8	6,231	0
	APS				12,353	6,550	0
Philippines	BAU	59.8	500	1921	1033	738	3,028
	APS				1952	1,575	6,668
Malaysia	BAU	150	529	0	839	1,600	0
	APS				2,967	1,695	0
Singapore	BAU	274	0	0	1,292	0	0
	APS				1,710	0	0
Thailand	BAU	1,671	287	0	9,773	740	0
	APS				9,277	792	0
Total	**BAU**	**2,240**	**6,281**	**3,804**	**26,927**	**20,008**	**18,673**
	APS				**44,731**	**21,182**	**25,941**

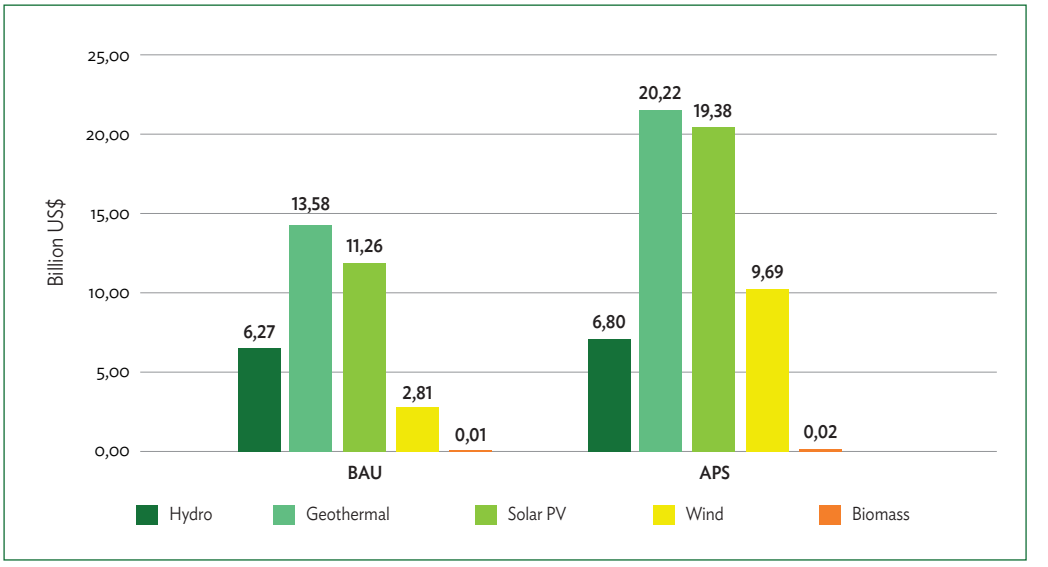
DES = Distributed Energy System; ASEAN = Association of Southeast Asian Nations; MWh = megawatt-hour, APS = alternative policy scenario, BAU = business-as-usual scenario, GWh = gigawatt-hour.

Note: Various assumptions were made to calculate the future potential off-grid for solar, wind, biomass, hydro, and geothermal energy.

Source: Authors' calculation.

Estimates of needed investment from application of DES. The increase in DES energy supply in the ASEAN region also implies the opportunities for DES-related renewable investment (Figure 2.3). The figure shows that investment opportunities by 2040 in BAU for combined solar, wind, biomass, hydropower, and geothermal are about US$34 billion, and in the APS, about US$56 billion. Investments for solar and geothermal power are expected to double from BAU to APS. For wind power, investments will increase more than threefold to meet the expected generation output by 2040.

Figure 2.3. Estimates of Off-grid DES-Related Renewable Investment Opportunities by 2040



APS = alternative policy scenario, BAU = business-as-usual scenario.

Note: Various assumptions were made to calculate the estimated DES-related renewable investment opportunity.

Source: Authors' calculation.

Table 2.3. Estimates of CO_2 Emission Reduction from Off-grid Application of DES (MWh) in ASEAN (solar, wind, biomass, hydro, and geothermal)

	Generation Output (GWh) 2040				CO_2 Emission Reduction *(Million Metric Ton)
	Solar, wind, biomass	Hydropower	Geothermal	Total	
BAU	26,927	20,008	18,673	65,608	46.1
APS	44,731	21,182	25,941	91,854	64.6

DES = Distributed Energy System; MWh = megawatt-hour, APS = alternative policy scenario, BAU = business-as-usual scenario. GWh = gigawatt-hour.

*The Greenhouse Gas Equivalencies Calculator uses the Emissions & Generation Resource Integrated Database (eGRID) US annual non-baseload CO_2 output emission rate to convert reductions of kilowatt-hours into avoided units of CO_2 emissions.

Source: Authors' calculation.

Estimates of CO2 emission reduction from the application of DES. The increase in DES-related renewable energy supply in the ASEAN region will strongly reduce CO2 emission in the region. Estimates show reduced CO2 emission – of about 46.1 million metric tons in BAU, and 64.6 million metric tons in the APS – from the application of solar, wind, biomass, geothermal, and hydropower (Table 2.3). The method of calculating CO2 emission reduction is referred to as the Greenhouse Gas Equivalencies; it uses the emission factor of 7.03 × 10-4 metric tons CO2/kWh (EPA, 2016).

Potential System Cost of Generating Electricity and the Need for an Enabling Policy Framework to Promote DES in ASEAN

Potential system cost of generating electricity. The potential reduction of total system levelised cost of electricity (LCOE) for various generation plant technologies provides hope for the uptake of DES-related renewable technology. The study by the US Energy Information Administration (2016) on the 'Levelized Cost and Levelized Avoided Cost of New Generation Resources' in the Annual Energy Outlook 2016 showed that the LCOE from all renewable resources have high potential of lowering total system LCOE. The potential LCOE ranged from 4.1 cents/kWh to 5.1 cents/kWh for geothermal, 8.1–11.5 cents/kWh for biomass, 4.3–7.8 cents/kWh for wind, and 6.5–12.6 cents/kWh for solar PV. The LCOE of these renewable resources look competitive to their fossil fuel-generating plants (Table 2.4). However, these estimates of technology development are for technology entering the US market in 2022 (EIA, 2016).

Table 2.4. Estimates of System Levelized Cost of Electricity (LCOE) for Various Generation Plants Entering the Market in 2022

Plant Type	Range for Total System Levelized Costs (2015 $/MWh)	
	Minimum	Maximum
Advanced Coal with CCS	129.9	162.3
Conventional Combined Cycle	53.4	67.4
Advanced Combined Cycle	52.4	65.5
Advanced CC with CCS	78.0	93.9
Conventional Combustion Turbine	103.5	122.8
Advanced Combustion Turbine	87.7	105.8
Advanced Nuclear	99.5	108.3

Geothermal	41.1	51.8
Biomass	81.5	115.6
Wind	43.0	78.5
Wind – Offshore	137.1	213.9
Solar PV	65.6	126.2
Solar Thermal	172.3	363.4
Hydroelectric	59.6	78.1

CC = , CCS = , PV = photovoltaic.

Source: EIA (2016).

The need for enabling policy framework to promote DES. Although DES is mainly a decentralised energy resources system, the policy framework promoting it is related to renewable energy policies, and it has always been the most important driver of DES deployment. An enabling policy framework provides a long-term government commitment and credible targets. The framework involves policy, fiscal, and financial attractiveness for investment in DES and renewable energy. The enabling policy frameworks used so far are the following:

- **National policy design** aims to provide a trajectory for future energy mix. This includes renewable energy target; renewable energy law or strategy; biomass and biofuels law or programme; solar heating, solar power, wind, and geothermal law or programme.

- **Fiscal incentives** aim to reduce upfront costs by introducing fiscal policy instruments such as tax exemptions (value added, fuel, income, import and export, and local taxes); introduction of carbon tax; and accelerated depreciation.

- **Grid access** aims to give project developers confidence through grid access priority and transmission discount policy if the production of electricity is from renewables.

- **Regulatory instruments** provide incentives for investing in renewables through the implementation of energy policies such as feed-in tariff (FiT), feed-in premium, auction, net metering, and quota.

- **Finance** reduces risk for investors through the implementation of currency hedging, dedicated fund, eligible fund, or guarantees.

- Other policies aim to help and target energy access in remote areas through the promotion of renewable energy in social housing, rural access programmes, cookstove programmes, and other energy access activities by non-governmental organisations, and communities.

The above policy frameworks need to be reinforced and applied to suit the context in each country if DES and renewable energy are to be promoted as the future energy mix. Various policy instruments are being promoted in ASEAN. At the regional level, ASEAN has targeted 23% share of the renewable energy in the primary energy supply by year 2025. ASEAN Member States also set up the renewable targets in each country and developed various instruments to promote renewable energy (Table 2.5).

Table 2.5. Renewable Target in ASEAN Member States

Country	Renewable Target	Policy Instruments
Brunei Darussalam	10% RE share in power generation by 2035*	Need to be developed
Cambodia	More than 2 GW of hydropower by 2020	Permits and tax incentives are in place
Indonesia	23% NRE share in energy mix in 2025	Feed-in-tariff
Lao PDR	30% RE share of total energy consumptions by 2025*	Permits and tax incentives are in place
Malaysia	4 GW RE installed capacity by 2030*	Feed-in-tariff and capital subsidies
Myanmar	15%–20% RE share in installed capacity by 2030*	Need to be developed
Philippines	15 GW installed capacity in 2030	Feed-in-tariff, capital subsidies, tax incentives, and RPS
Singapore	350 MW installed capacity of solar by 2020	Feed-in-tariff, permits, and tax incentives
Thailand	30% AE share in total energy consumption by 2036*	Feed-in-tariff, permits, and tax incentives
Viet Nam	27 GW RE installation in 2030*	Feed-in-tariff, permits, and tax incentives

* large hydropower is excluded.

GW = gigawatt, NRE = non-renewable energy, RE = renewable energy.

Source: ACE (2016).

Some ASEAN countries have developed detailed policy instruments to ensure the targets are achieved through the implementation of various projects and programmes. Nonetheless, some countries are also far behind in terms of policy design and implementation.

The case study of Thailand on the review of policies to promote DES provides a snapshot and stock-taking in terms of policy design in promoting DES and renewable energy. Other ASEAN countries may learn from this case study and develop their own policy to fit the political and social contexts.

Case study on enabling policy framework: Thailand's DES-related energy development planning

Thailand is the only country in Southeast Asia with a comprehensive long-term energy development plan. Key energy policy documents are laid out in the new Power Development Plan known as (PDP 2015–2036), the Alternative Energy Development Plan (AEDP, 2012–2021), and the Energy Efficiency Development Plan (EEDP, 2011–2030). The new PDP 2015–2036 highlights energy security of power supply and transmission and distribution systems in response to the demand for electricity. It also seeks the best energy mix, avoiding too much reliance on gas as a source of power generation. The new PDP also aims to reduce CO2 emissions by promoting electricity production from renewable energy sources and to promote energy efficiency.

The Government of Thailand has continuously promoted private sector investment in the generation business through bid solicitations to buy power from large-scale independent power producers (IPPs) and small power producers (SPPs), with the Electricity Generating Authority of Thailand (EGAT) being the single buyer of bulk electricity. This is done under the terms and regulations set by the Energy Regulatory Commission to ensure the best interests of public consumers, optimisation of energy resources, and fairness to all. For DES-related renewable energy, Thailand has set a 30% share of renewables in total final energy consumption by 2036 (AEDP 2015–2036). In absolute terms, renewable consumption is targeted at 39,388 Ktoe out of total final consumption of 131,000 Ktoe by 2036. Thailand has been introducing FiT to promote renewable energy by type of energy source (Table 2.6).

The Department of Alternative Energy Development and Efficiency (DEDE) of Thailand also developed the Energy Saving Company (ESCO) fund to cope with risk and to encourage investment in renewable-focused ventures. In addition, the fund pools capital was set up with contribution from Thailand's Energy Conservation and Promotion Fund and private investors. The ESCO fund aims to support access to low-cost equipment leasing. As of the time of writing, the ESCO fund has invested 6.1 billion baht (B) – B510 million from the government and the rest from private sources) – in 54 separate projects accounting for total energy savings of B1.1 billion (DEDE, 2016).

Table 2.6. Feed-in-Tariff Rate by Type of Renewable Energy Source in Thailand

Capacity (MW)	FiT (THB/kWh)			Period of Subsidy (Year)	FiT Premium (THB/kWh)	
	FiT(f)	FiT(v),2017	FiT(1)		Biofuel Project (8 years)	Project in Southern Territory Area (throughout Project Period)
1) MSW (Hybrid Management)						
Existing Capacity ≤ 1 MW	3.13	3.21	6.34	20	0.70	0.50
Existing Capacity > 1–3 MW	2.61	3.21	5.82	20	0.70	0.50
Existing Capacity > 3 MW	2.39	2.69	5.08	20	0.70	0.50
2) MSW (Sanitary Landfill)	5.60	-	5.60	10	-	0.50
3) Biomass						
Existing Capacity ≤ 1 MW	3.13	2.21	5.34	20	0.50	0.50
Existing Capacity > 1–3 MW	2.61	2.21	4.82	20	0.40	0.50
Existing Capacity > 3 MW	2.39	1.85	4.24	20	0.30	0.50
4) Biogas (Waste Water/Sewage)	3.76	-	3.76	20	0.50	0.50
5) Biogas (Energy Crop)	2.79	2.55	5.34	20	0.50	0.50
6) Hydropower						
Existing Capacity ≤ 200 kW	4.90	-	4.90	20	-	0.50
7) Wind	6.06	-	6.06	20	-	0.50

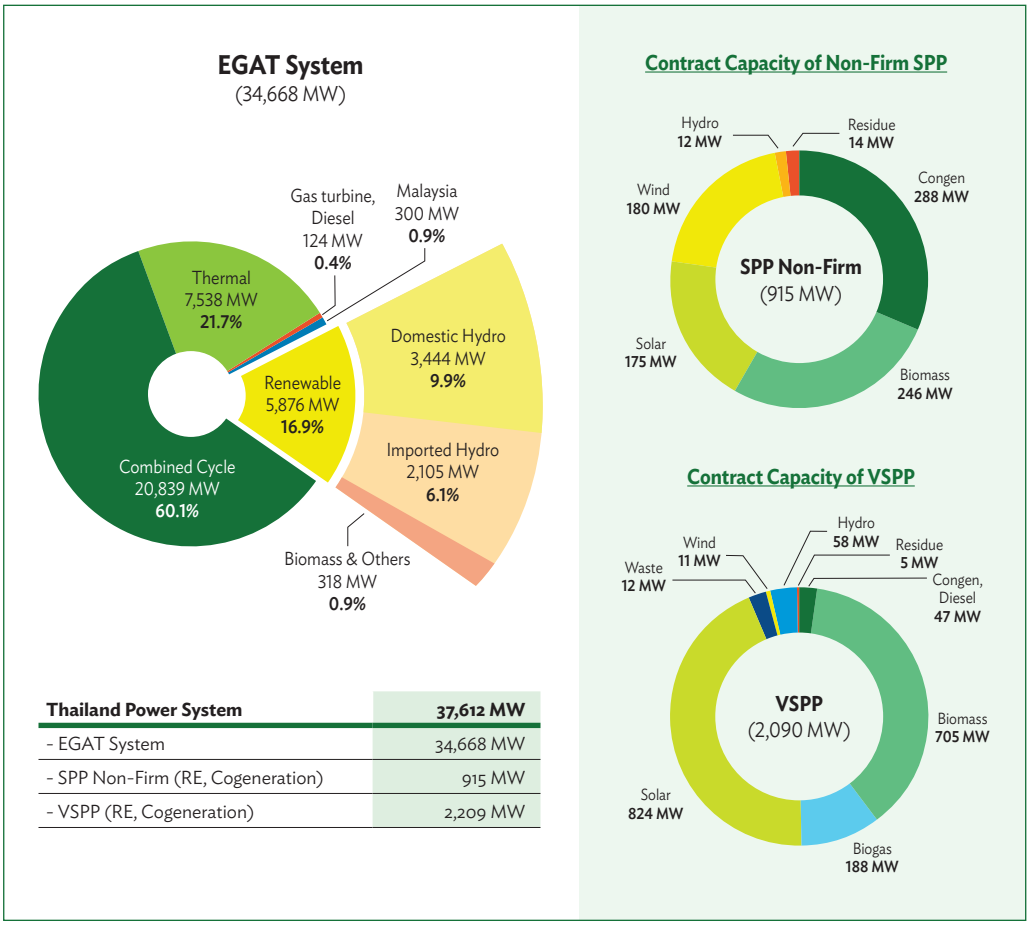
kW = kilowatt, kWh = kilowatt-hour, MSW = , MW = megawatt, THB = Thai Baht.

Note: FiT(f) is FiT fix rate throughout the project; FiT(v) is FiT variable rate adjusted by inflation standard; FiT(i)=FiT(f)+FiT(v, i-1) * (1+Core Inflation(i-1))+FiT Premium.

Source: Ministry of Energy (2016).

Most DES-related schemes in Thailand are in VSPPs. Thailand's VSPP regulations were approved by its government in 2002. These regulations allow small community-owned or small entrepreneur-owned renewable energy generation to connect to the grid and sell excess electricity to utilities. In December 2006, the government announced important changes in VSPP regulations that allow each generator to export up to 10 MW to the grid and offer FiT subsidies for renewable electricity production. The VSPP programme is now also open to efficient fossil-fuel combined heat and power (CHP). Currently, the share of DES or the combined VSPP and SPP to the generation mix is only about 5.4% (Figure 2.4 and Table 2.7).

Figure 2.4. Status of Installed Capacity by Energy Type (as of 2014)



Thailand Power System	37,612 MW
- EGAT System	34,668 MW
- SPP Non-Firm (RE, Cogeneration)	915 MW
- VSPP (RE, Cogeneration)	2,209 MW

EGAT = Electricity Generating Authority of Thailand, MW = megawatt, RE = renewable energy, SPP = small power producer, VSPP = very small power producer.

Source: Ministry of Energy (2015).

Table 2.7. Installed Capacity by Type of Power Producer (as of 2014)

Types of Owner	Capacity (MW)	Share (%)
Electricity Generating Authority of Thailand (EGAT)	15,482	41.2
Independent power producers (IPPs)	13,167	35.0
Small power producers (SPPs)	4,530	12.0
Very small power producers (VSPPs)	2,029	5.4
Power imports	2,404	6.4
Total	**37,612**	**100.0**

MW = megawatt.
Source: Ministry of Energy, The Power Development Plan (PDP), 2015.

The future total capacity of VSPP power purchase to be online in 2015–2036 according to the AEDP would be 9,735.6 MW, increasing from 2,029 MW in 2014, with renewable power plants having a capacity of 9,701 MW, and cogeneration power plants, with a capacity of 34.6 MW. So, the increase of VSPPs in 2014–2036 was almost fourfold during this period.

The future installed capacity of 97 SPPs, which already have power purchasing agreements with EGAT to be online in 2015–2025, is 5,922 MW. So, the increase of SPPs from 2014 to 2025 is 30.7%. The details are as follows: (i) 41 projects of cogeneration power plants with a total capacity of 3,660 MW; (ii) 25 extension projects of cogeneration power plants with a total capacity of 424 MW; and (iii) 31 projects of renewable energy generation with a total capacity of 1,838 MW.

If Thailand's case could be replicated in other ASEAN countries, or at least in Cambodia, Lao PDR, Myanmar, and Viet Nam (the CLMV countries), the electricity coverage to be supplied by DES will be significantly important as it represents 17.4% (both SPPs and VSPPs) of the generation mix. The prospects of Thailand's DES will increase almost fourfold in terms of installed capacity in 2015–2036. Thus, DES will play an important role in providing electricity access to CLMV and other ASEAN countries for now and in the future.

Case study on enabling policy framework: Myanmar's DES-related energy development planning

Myanmar is endowed with rich natural resources. Its renewable energy resources are sufficient to meet most daily energy needs if developed. However, about 70% of the

population and 84% of rural households lacked grid electricity access in 2014 (World Bank, 2015). Off-grid schemes are rare and typically provide high-cost, low-reliability power service for a few hours per day. Myanmar is the largest country in mainland Southeast Asia but has one of the lowest population densities of the region. This imposes a diseconomy of scale for conventional centralised electricity grid development and expansion. Electrification varies widely between urban and rural areas. Although about 27% of the 64,346 villages are electrified, the national power grid covers only 7% of the total villages (Tin Ngwe, 2014). Considering the broad distribution of abundant renewable energy resources such as biomass, hydropower, solar, and wind, Myanmar can potentially accelerate on- and off-grid electrification with renewable energy, delivering universal electricity access much quicker than conventional centralised generation and grid expansion.

The Government's National Electrification Plan (NEP) 2015, developed with World Bank technical assistance, aims to electrify 7.2 million households and to achieve universal access to electricity by 2030. The plan calls for investments of US$5.8 billion over the next 15 years to extend the distribution grid and electrify off-grid areas. The government has also developed a complementary Energy Master Plan with the assistance of the Asian Development Bank and a Power Sector Master Plan (for generation and transmission sub-sectors) with the assistance of the Japan International Cooperation Agency.

Given decades of closed economy, the energy sector's institutional and regulatory frameworks have been fragmented, particularly in rural electrification. The Ministry of Energy is responsible for overall energy policy, while the Ministry of Electric Power leads power sector development. The rural off-grid electrification falls under the Department of Rural Development in the Ministry of Livestock, Fisheries and Rural Development. Myanmar has undertaken reform in all sectors, including the energy sector, after the 2015 national election. Major energy-related master plans in Myanmar include the following:

- NEP 2015 highlighted universal electricity access by 2030, or 7.2 million new connections. The plan uses a two-pronged approach: rapid extension of the national grid, coupled with off-grid electricity, including modern solar home systems and mini-grids. The first phase of the plan calls for 1.7 million households to be connected to electricity by 2020 and an investment of about US$700 million. The plan started off with $400 million in funds from the World Bank's International Development Association, out of which US$80 million would be used for off-grid electrification. Total grid investment is estimated at as much as US$ 6 billion.

- The Power Sector Master Plan 2013–2030 highlighted the strategies to ensure a sustainable, affordable, and secure supply of energy for Myanmar over the longer term. The plan also aims to develop a mix of energy sources to provide a stable and reliable energy supply through to 2030, in which coal-fired power generation would see its share increase from 2% in 2015 to 20% in 2030. By 2030, it targets the following primary energy mix: 33% biomass, 22% oil, 20% coal, 13% gas, 11% hydro, and 1% renewable energy. The plan estimates Myanmar's total energy sector needs to amount to US$30 billion–US$40 billion over the next 15 to 20 years,

Myanmar's electrification, following NEP (Tables 2.8 and 2.9), would cover almost 100% by 2030. This also implies that there would be huge installed generation capacity from different fuel-based generators not limited to coal, gas, and hydropower but small DESs such that renewable energy would play a significant role in covering electricity access. The off-grid renewable energy and DES generators are expected to have a share of 7%–10% in the generation mix.

Table 2.8. Power Generation Mix

Applications	Existing installed capacity (2013)	Future installed capacity (2030)
	MW	MW
Coal-fired Plant	120	5,030
Gas-fired Plant	115	2,484
Hydro Plant	2,780	19,037
Renewables	5	2,000-4,200*

Note: *Japan International Cooperation Agency predicts the increase of renewable energy installed capacity up to 2,000 MW by 2030. And ERIA's Energy Outlook and Saving Potential Study (2015) predicted the ambitious renewable energy installed capacity of up to 4,000 MW of wind power plant, and 200 MW installed capacity of solar power plant by 2035.
Source: JICA Electric Power Master Plan Study and EOSP (ERIA, 2015).

Table 2.9. National Electrification Rate and its future electrification plan in NEP 2015

	Reference: 2015	Plan: 2020	Plan: 2025	Plan: 2030	Comment
Households (HH) electricity rate	33%	47%	76%	100%	If 99% are electrified (source: WB, 2015)
Household (HH) connection to grid (cumulative)	3,630,000 (HH)	567,4939 (HH)	8,260,788 (HH)	11,000,000 (HH)	It needs at least a 500,000 HH connection every year
New HH connection required	N/A	2,044,939 (HH)	4,640,000 (HH)	7,220,000 (HH)	And doubling the connection rate is required

Source: NEP (2015) targets and Author's calculation based on NEP 2015.

Currently, about 7.2 million households have yet to connect to modern electricity sources. NEP 2015 mainly addresses this issue to cover the 100% electrification in Myanmar. NEP also recognises the need of DES for off-grid electricity. About half a million new connections will be needed every year to meet the full coverage of electricity. This is an enormous task and will require huge investment and coordination. Perhaps, it would be realistic if the plan mentions DES for not only the off-grid but its role in providing an effective energy system in Myanmar.

Myanmar's enabling policy framework

Direction of Energy Policy Development in Myanmar. Myanmar´s Energy Master Plan prepared by the National Energy Management Committee, assisted by the Asian Development Bank, considers renewable energy (solar, hydro, wind, and biomass electricity generation) for both grid connection and off-grid applications (Table 2.10). In the draft document of the Myanmar Renewable Energy Policy (EMP, 2014), an indicative assessment of the anticipated share and volume of the various renewable energy technologies to electricity generation leads to the following distribution towards the year 2030. The overall renewable energy contribution to the newly installed generation capacity (without large hydro) will then be 26.8% or 3,995 MW compared to a total capacity of 14.9 GW.

Table 2.10. Myanmar's Renewable Energy Policy and Targets

Renewable Sources	Installed Capacity by 2035
Hydro Power off-grid	198 MW
Wind Power grid connected	446 MW
Solar Power grid connected	2,658 MW
Solar Power off-grid	544 MW
Biomass grid connected	147 MW
Biogas gasification off-grid	3 MW
Total	**3,995 MW**

Source: National Energy Management Committee (NEMC), 2014.

The draft Myanmar renewable energy policy and the proposed policy directions to support DES:

- Very small power producer (VSPP): For installations up to 50 kW erected by owners on their legal premises. All electricity produced and not used for own

consumption or that of neighbours can be freely fed to the grid. The responsible grid operator should issue a permit within 2 months from application, if applicable standard generation equipment is demonstrated. Connection by the grid operator should be completed within 1 month from the 'ready for commissioning' notice by the owner. Investment for the generator shall be tax deductible.

- Small power producer (SPP): For installations from 50 kW up to 1,000 kW erected by owners on their legal premises. All electricity produced and not used for own consumption or that of neighbours shall be metered and purchased by the responsible grid operator, who should issue a permit within 3 months from application, if applicable standard of the generation equipment is demonstrated. Connection by the grid operator will be completed within 1 month from the owner's notice that it is ready for commissioning. Generators of this size could affect grid performance. The Government of Myanmar would take a liberal view on these installations as long as these are below 10% of the national generation. However, it may impose regulations for power management and power purchase. Applicable standards of the generation equipment, therefore, include an adjustable power factor and a facility for remote power management (gradual shutdown) by the grid operator. The power purchase agreement will compensate for losses caused by such shutdown. Renewable energy–based generation shall be preferred to conventional generation.

- Independent power producer (IPP): For installations from 1 MW up erected by owners on their legal premises, the electricity produced and not used for own consumption or that of neighbours shall be metered and purchased by the responsible grid operator, who should issue a permit within 3 months from application, if applicable standards of the generation equipment are demonstrated. The generation equipment needs to have adjustable power factor and power management facility. The power purchase agreement will be negotiated by the Government of Myanmar based on tendering a concession, where the bidder with lowest FiT shall be preferred. The government will tender for concessions of 200 MW annually to be installed in different parts of the country to benefit from the favourable effects of distributed generation.

- Power purchase by application of a FiT shall be valid for 20 years from the date of first connection. With due notice, the government reserves the right to adjust the tariff for additional generators to account for lower costs and efficiency gains. Likewise, tariff bonus can be granted for feed-in at peak hours. Tariff shall never be reduced retroactively. FiT shall be determined in consideration of the real

generation cost and in recognition of the macro-economic effect on electricity prices. Tariff shall encourage self-consumption. For the benefit of planning, a uniform tariff of 150K/kWh shall be proposed. Variations may be established for generators of different size and technology. The government published FiT for the next period in due time, beginning in 2014. The RET owner shall bear the cost of connection and lines to the next suitable connection point if so required.

- To facilitate long-term financing for renewable energy investments, a financing window at development banks shall be made available. Generation equipment may be considered as collateral with its marketable value. The Government of Myanmar shall provide a financing volume at interest reflecting government rates. Taxing of income from private renewable energy generation shall be equal to the taxing of public generation.

- Off-grid renewable energy applications find their dominant use in rural electrification. While the government considers countrywide grid electrification the goal, it will strongly encourage renewable energy solutions to achieve rural electrification targets as swiftly and efficiently as possible. These solutions shall include local power generation from hydro energy, solar radiation, and biomass, depending on the economic and operational preferences. Both the public and the private sectors shall be entrusted with the implementation in the form of energy service providers and they will cooperate in planning and operation. The cost shall be borne jointly by the Government of Myanmar and the users. Knowing the important role of Myanmar communities in rural electrification, the government will enable villages to sustainably operate and maintain energy systems. To lessen the burden for rural citizens, the government shall apply the tool of a connection premium to public and private developers.

- The government shall publish an off-grid electrification support regulation, describing duties and eligibilities of energy service providers and consumers, procedures, and standards applicable as well as funding and time frame available.

- New electricity connections in clusters of at least 20 households shall be built, operated, and maintained for the long term by operators, who may be village committees or private entrepreneurs. Operators will seek to connect a maximum number of households for best efficiency but are free to determine connection priority. Renewable energy installations providing at least 200 Wh daily all

year round shall be eligible for a connection premium of K150,000 per newly connected household. For the remaining cost, each newly connected household shall contribute in lump or loan. Operation and maintenance (O&M) shall be organised at the village level and a sufficient O&M fee shall be collected from users.

- The government is aware that currently numerous rural generation systems exist for which the upgrading, repair, or conversion into hybrid generation using renewable energy technology will be the least cost alternative. For these the same connection premium of K150,000 per newly connected household providing at least 200 Wh/d from renewable energy all days all year shall apply.

- In case the national grid will eventually be connected, the continued operation of the renewable energy supply system as a valuable and reliable resource shall be assured. The system operator shall ensure that the existing system will not interfere with grid standards like voltage and frequency, shall act as retailer of the grid electricity, and shall retain the operation and maintenance fees applied before connection.