Chapter 1
Introduction and Methodology of Distributed Energy System

Background and Objective

The recent economic growth in East Asia Summit (EAS) participating countries, especially emerging ones, has driven energy demand to rapidly rise. Although these countries have been introducing energy supply infrastructures such as power plants, some of them are still faced with instability, high cost of energy supply, and high emissions of greenhouse gases (GHGs). For example, islands, mountainous, and other remote off-grid areas mainly rely on diesel power and other energy sources, where high energy costs and reduced GHGs emissions are the big challenge. In the emerging countries of ASEAN, industrial and commercial zones, which contribute to economic growth, are sometimes faced with unstable energy supply; this will likely prevent companies from investing and providing goods and services. Distributed energy systems (DESs) can solve these challenges due to the increasing availability of small power generation and intelligent grid technologies. It is necessary to find what role DESs can play so that ASEAN participating countries could utilise these systems. The energy ministers, during the 9th EAS Energy Ministers Meeting, welcomed the DES study as they realised the role of DES in enhancing electricity access and providing solutions to energy problems for the well-being of both investors and consumers.

The DES concept is not new, and it has been applied since the start of power generation in the late 18th century when Thomas Edison built the first power plant to provide electrical and mechanical power at or near the point of use (Brandon, 2014). Now the DES concept and application have been widely used to respond to increasing energy demand. The flexibility of DES at multiple locations makes it economically and technically viable, attracting many industrial, commercial, and residential units. Most widely installed DESs can be found in mountainous, island, and remote areas and economic zones with microgrids because of their scale and flexibility.

Globally DES has gained popularity to provide secure, reliable, and affordable energy to customers. The wave of decentralised energy systems through DES applications is

gaining market share because of their lower capital cost, thus making energy affordable in many parts of the world. The technological development of small and distributed generators from all types of energy sources (diesel, gas, coal slurry, wind, solar, geothermal, and mini-hydropower) has become more effective and less costly today than they were a decade ago. DES creates a decentralised power system through which distributed generators meet local power demand. Because they are small and have lower capital requirements, they can be built and made operational faster with less risk than large power plants.

The ASEAN primary energy supply is projected to increase by almost threefold from 592 Mtoe in 2013 to 1,697 Mtoe in 2040 (Kimura and Han, 2016). This pattern of increasing energy demand threatens energy security, especially the provision of energy access, affordable price, and stable energy supply sources. The idea of transboundary grids is being promoted in the ASEAN Power Grid (APG). The APG is expected to significantly maximise ASEAN's benefit from avoiding power generation costs; however, they are expensive and it may take years to realise the connectivity. DESs, however, can overcome cost constraints that typically inhibit the development of large capital projects and transmission and distribution lines.

Thus, this study will map out the current situation of DES in selected ASEAN member states and discuss the opportunities for DES in the ASEAN region to support and foster the convergence of the ASEAN Economic Community and sustainable economic growth by providing affordable, reliable, and better energy sources with less GHG emissions.

Hypotheses of the Study

This study tries to understand the overall status and policies of DESs in selected ASEAN countries through a literature survey and information exchange with relevant parties, such as meetings of 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 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 (SPP) programmes.

- Analysis of the outcomes of the policies:
  - what kinds of DESs the policies have promoted;
  - how much energy they have supplied; and
  - what kind of impacts the introduction has had on stable supply of energy, electricity tariff, environment, and others on the communities and on the country.

The study developed questionnaires to address the above hypotheses that are critical in understanding the status, policies, and potentials of DESs in the ASEAN region. Since information on DES in each ASEAN country is difficult to capture, this study relies on various information from the power development plan, or any energy master plan of country studies.

Methodology of the Study

This study considered DES as a flexible energy system. It is small yet effective in responding to the growing energy demand. DES could offer an off-grid energy system for economic zones and isolated and remote areas. For urban areas, it could offer a smart energy system that could be integrated into the national grid system.

Generally, DES refers to two classes of technologies. First are the renewable energy sources, which include biomass, solar, and hydro, with generating capacities scaled from a few kilowatts to as much as 10 megawatts (MW). Renewable energy technologies can either be integrated into local distribution grids or as 'stand-alone' systems in areas where extension of transmission lines is not economically viable. Second, DES is an on-site generation system and usually refers to industrial cogeneration or combined heat and power (CHP) systems that are fired by gas or coal slurry. Cogeneration allows consumers to save much of the fuel and cost of generating electricity and heat by using one facility, instead of a power plant to make electricity and boilers to make heat.

To define DES, the working group of the DES study set up by ERIA considers the scope of the installed capacity of distributed generations by type of fuel as follows:

- Solar farm, solar PV, small hydro is the development of solar and hydroelectric power on a scale serving a small community or industrial plant. The definition of solar farm and a small hydro project varies but a generating capacity of 1–10 MW is generally acceptable, which aligns to the concept of distributed generation.
- However, small and mini thermal power plants are generally in the form of small and very small power producers (SPPs and VSPPs) in ASEAN countries. Generally, coal, gas, nuclear, geothermal, solar thermal electric, waste incineration plants, and biomass-fuelled thermal power plants are DESs if they have capacities of less than 100 MW.

Given the limited availability of data on DES in ASEAN member states, it is very crucial to roll out questionnaires (see Annex 1) designed to capture information gaps on DES. The Ministry of Economy, Trade and Industry of Japan commissioned the Economic Research Institute of ASEAN and East Asia (ERIA) to carry out this important study.

Thus, ERIA formed a working group to collect data and information through questionnaires distributed to selected ASEAN member states. The working group consisted of representatives from Cambodia, Indonesia, Malaysia, Philippines, and Thailand.

ERIA also designed the reporting template for each selected researcher to write for respective DES's situation and analysis of their countries (See Designed Questionnaire for Distributed Energy System, p. 5).

Scope of the Study

The regional and country reports

- highlight the merits of DES of each country studied;
- classify several patterns in the country case study (site survey) such as industry zone and off grid (islands) and study the economy of DES, energy security brought by DES, reduction of carbon dioxide (CO2) by DES, and cost–benefit analysis of grid and off-grid systems; and
- elucidate the feasibility of installing DES in ASEAN.

Designed Questionnaire for Distributed Energy System

Definition of DES: this study also considers the installed capacity of distributed generations by type of fuels as follows:

- *Solar farm, solar PV, small hydro refer to the development of solar and hydroelectric power on a scale serving a small community or industrial plant. The definition of a solar farm and a small hydro project varies, but a generating capacity of 1 to 10 megawatts (MW) is generally acceptable, which aligns to the concept of distributed generation.*

- *However, the small and mini thermal power plants are generally in the form of small and very small power producers (SPPs and VSPPs) in ASEAN countries. Generally, coal, gas, nuclear, geothermal, solar thermal electric, waste incineration plants, and biomass-fuelled thermal power plants, are DESs if they have capacities of less than 100 MW.*

1. Country Name:
2. Energy access/Electrification rate: % (percent) Year: (year of the data)
3. Current average off-grid/mini-grid electricity tariff: cent/kWh
4. What kind of distributed energy system (off-grid energy system)?

Applications	Current/existing capacity		Required capacity to meet off-grid/mini grid future demand (2025, 2040)		Comments
	MW	MWh	MW	MWh	
Solar PV					
Wind					
Biomass/biogas					
Micro hydro					
Geothermal					
Diesel generator					
Thermal power (coal, slurry, fuel oil, others)					
CHP incl. heat recovery facility					
Other generators					

5. Model case(s) of introduction of distributed energy system (off-grid/mini grid energy system)

(1) Site Name:

Applications	Current/existing capacity		Required capacity to meet off-grid/mini grid future demand (2025, 2040)		Comments
	MW	MWh	MW	MWh	
Solar PV					
Wind					
Biomass/biogas					
Micro hydro					
Geothermal					
Diesel generator					
Thermal power (coal, slurry, fuel oil, others)					
CHP incl. heat recovery facility					
Other generators					

(2) Site Name:

Applications	Current/existing capacity		Required capacity to meet off-grid/mini grid future demand (2025, 2040)		Comments
	MW	MWh	MW	MWh	
Solar PV					
Wind					
Biomass/biogas					
Micro hydro					
Geothermal					
Diesel generator					
Thermal power (coal, slurry, fuel oil, others)					
CHP incl. heat recovery facility					
Other generators					

6. What kind of distributed energy system (Industrial Zone)?

Applications	Current/existing capacity		Required capacity to meet off-grid/mini grid future demand (2025, 2040)		Comments
	MW	MWh	MW	MWh	
Solar PV					
Wind					
Biomass/biogas					
Micro hydro					
Geothermal					
Diesel generator					
Thermal power (coal, slurry, fuel oil, others)					
CHP incl. heat recovery facility					
Other generators					

7. Model case(s) of introduction of distributed energy system (Industrial Zone)
(1) Site Name:

Applications	Current/existing capacity		Required capacity to meet off-grid/mini grid future demand (2025, 2040)		Comments
	MW	MWh	MW	MWh	
Solar PV					
Wind					
Biomass/biogas					
Micro hydro					
Geothermal					
Diesel generator					
Thermal power (coal, slurry, fuel oil, others)					
CHP incl. heat recovery facility					
Other generators					

(2) Site Name:

Applications	Current/existing capacity		Required capacity to meet off-grid/mini grid future demand (2025, 2040)		Comments
	MW	MWh	MW	MWh	
Solar PV					
Wind					
Biomass/biogas					
Micro hydro					
Geothermal					
Diesel generator					
Thermal power (coal, slurry, fuel oil, others)					
CHP incl. heat recovery facility					
Other generators					

8. Current policy to promote distributed energy system (i.e. renewable and Very Small Power Producers Programme)

(1) Financial support

Policies	Feed-in-Tariff	Government Rebate System/ capital cost subsidy (*)	Other subsidy, if any	Comments
	US$ cent/kWh	US$/kW	US$/ kW	
Solar PV				
Wind				
Biomass/biogas				
Micro hydro				
Geothermal				
Diesel generator				
Thermal power (coal, slurry, fuel oil, others)				
CHP incl. heat recovery facility				
Other generators				

- Government rebate system (for solar and other renewable energy sources) through credit rebate, meaning 'upfront discount', could potentially reduce the upfront-system cost.

(2) Government-led project (i.e. demonstration project)
Project Name:
Outline of project:

9. Technology applications by location and purpose (just tick/check)

Policies	Locations of Application					Purposes of use			
	Isolated village	Island	Mountain	Industrial zone	Unban/ city	Residential use	Commercial use	Industrial use	Others
Solar PV									
Wind									
Biomass/ biogas									
Micro hydro									
Geothermal									
Diesel generator									
Thermal power (coal, slurry, fuel oil, others)									
CHP incl. heat recov-ery facility									
Other generators									