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Practical Experience and Prospects for Electricity Accessibility in ASEAN

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Preface

Energy is the basis of human production and life, and an important guarantee for improved social public service and better living standards. However, regional and local energy shortages remain around the world. At the same time, in 2015, the United Nations (UN) Conference on Sustainable Development sets the goal of "Ensuring access to affordable, reliable, sustainable and modern energy services for all" as one of the Sustainable Development Goals (SDGs) by 2030. Therefore, acceleration of energy access and realisation of the UN 2030 SDGs as early as possible are important measures for building a community with a shared future for mankind. Energy accessibility is also one of the goals under the ASEAN Plan for Energy Cooperation (APAEC) 2016–2025, along with energy security, energy affordability and energy sustainability.

Over the years, the ASEAN Member States (AMS) have made certain achievements in promoting energy access. By the end of 2019, the electrification rates of these countries (except Myanmar and Cambodia) were all above 95%. On the one hand, given ASEAN's large population, there are still around 50 million people without access to electricity; but on the other hand, the conditions in the AMS vary across many dimensions including geography, population, economic development level, and energy resources, which lead to very different levels of energy access. Based on the status quo, a few of the AMS probably still lag far behind the UN 2030 SDGs regarding energy access, and are facing challenges in providing universal energy access.

The following research analyses the status quo of energy access of key countries, probes into the factors hindering energy access, and puts forward proposals for solving the energy access problems in line with local conditions, and thus achieving the UN 2030 SDGs and APAEC 2016–2025 as early as possible and enabling all households to benefit from energy. The main goals of this research are:

1. To present the status quo of energy access conditions in ASEAN, classify the electricity access, analyse the relative targets and policies of the AMS, and identify the present problems and challenges.
2. In line with the geographical conditions and electricity access classifications of the AMS, to propose energy access solutions for isolated islands, rural, and remote areas.
3. To present the successes and general experience relating to the provision of energy access in the AMS, China, and Africa.
4. To analyse the status quo and existing problems relating to energy access in Indonesia, Vietnam, Lao PDR, and Myanmar, and propose ways to solve the energy access problems in accordance with local conditions.

1 Status Quo of Electrification

1.1 Status Quo of Electrification Rates

Over the years, the AMS have been actively working towards energy and electricity access and have made remarkable achievements. As of 2019, all the AMS had electrification rates above 95%, except Cambodia and Myanmar. However, given the large population in ASEAN, there are still 50 million people without electricity. This fact greatly hinders economic progress in ASEAN.

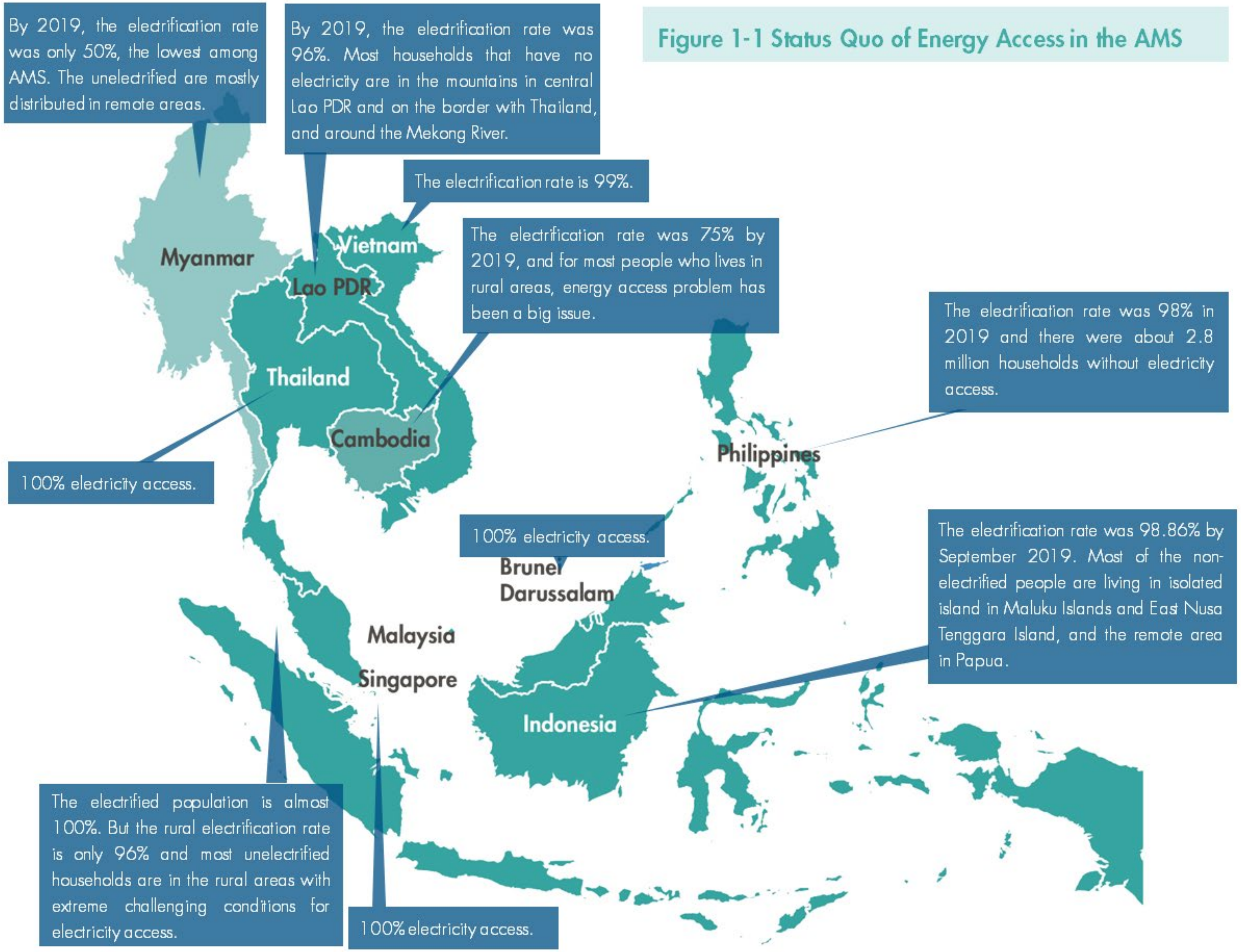
Table 1-1 Electrification Rates of the AMS (Unit: %)

	2015	2016	2017	2018	2019
Brunei Darussalam	100*	100*	100*	100*	100*
Cambodia	53	65	69	72	75
Indonesia	88	91	95	98	99
Lao PDR	91	92	94	94	96
Malaysia	100*	100*	100*	100*	100*
Myanmar	32	32	33	44	50
Philippines	89	91	93	95	98
Singapore	100*	100*	100*	100*	100*
Thailand	100*	100*	100*	100*	100*
Vietnam	99	99	99	100*	100*

Source: WEO2019 Electricity Database, ASEAN Energy Database System (AEDS)

Note: *not exactly 100% as several very remote and isolated areas may never be connected/electrified.

Figure 1-1 Status Quo of Energy Access in the AMS



Source: WEO2019 Electricity Database, ASEAN Energy Database System (AEDS)

1.2 Classification of Electrification Rates

The definition of energy access varies among the AMS. However, in general, in addition to the electrification rate estimated in terms of the electrified population, the electricity quality (adequacy, equality, reliability, stability, security, and electricity supply) should also be considered.

Table 1-2 Electrification Rates and Annual Electricity Consumption per capita in AMS

ASEAN Member States	Electrification rate in 2019 (Unit: %)	Electricity consumption in 2017
Brunei Darussalam	100*	8,256 kWh/person
Cambodia	75	437 kWh/person
Indonesia	99	822 kWh/person
Lao PDR	96	724 kWh/person
Malaysia	100*	4,636 kWh/person
Myanmar	50*	319 kWh/person
Philippines	98*	741 kWh/person
Singapore	100*	8,664 kWh/person
Thailand	100*	2,782 kWh/person
Vietnam	100*	1,809 kWh/person

Source: ASEAN Energy Database System (AEDS)

Based on the indicators of electrification rate and annual electricity consumption per capita, the energy access levels of the AMS in 2019 can be classified into the following categories:

(1) Reliable well-served means 99.9%-100% electricity access and annual electricity consumption per capita over 2,000 kWh. Singapore, Thailand, and Brunei Darussalam are at this level.

(2) Pre-development well-served means 95%-99.9% electricity access and annual electricity consumption per capita over 800 kWh. Malaysia, Vietnam, and Indonesia are at this level.

(3) On-going well served means 85%-95% electricity access and annual electricity consumption per capita over 500 kWh. Lao PDR and the Philippines are at this level.

(4) Priority served means electricity access less than 85% or annual electricity consumption per capita less than 500 kWh. Cambodia and Myanmar are at this level.

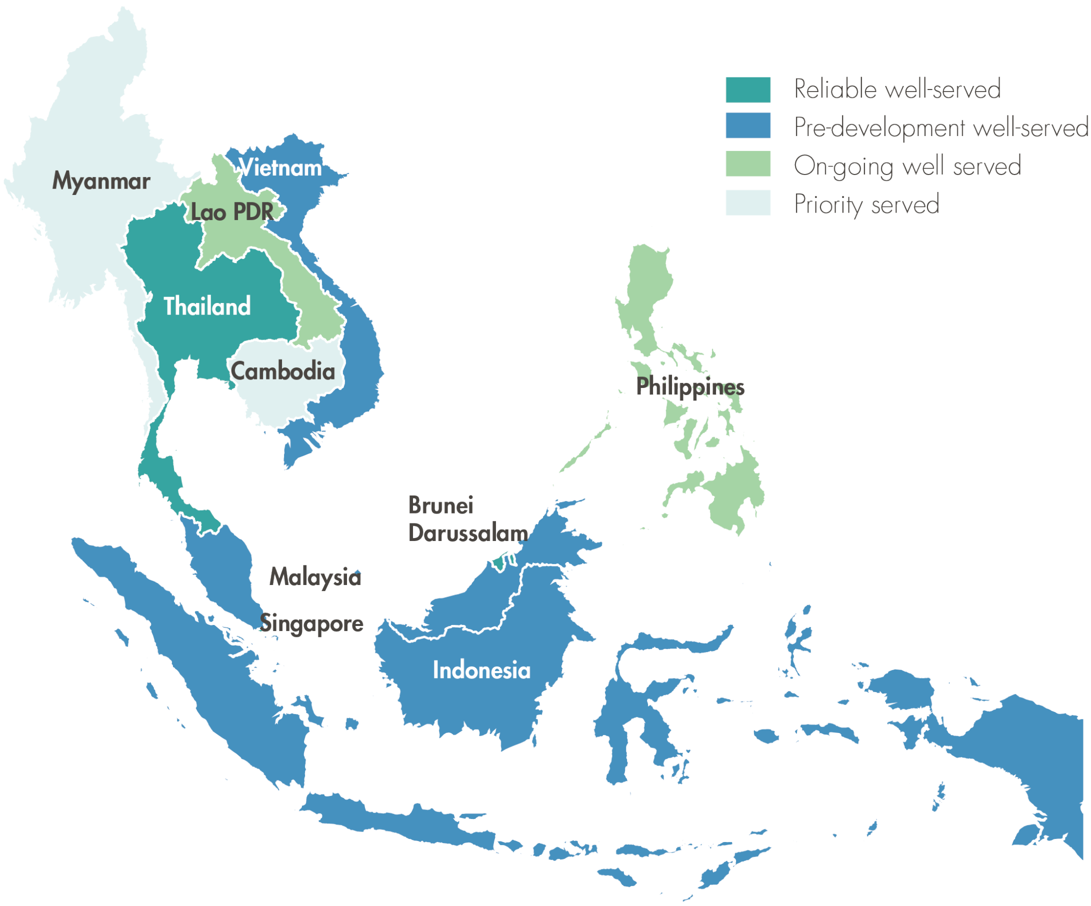


Figure 1-2 Classification of Energy Access among the AMS

1.3 Present Policies and Targets

The AMS have introduced many supporting and incentive policies to enhance electricity access. The main policies for each country are detailed in Table 1-3.

Table 1-3 Pertinent Incentive Policies for Energy Access

AMS	Policy	Remarks
Brunei Darussalam	No specific policy	It has almost 100% electrification ratio.
Cambodia	There are three main strategies for Cambodia to achieve a 90% household electrification rate target by 2023: •Continue development; production capabilities; transmission; distribution and connection of electricity grid. •Improve electricity supply delivery. •Strengthen power sector management mechanisms.	The Government of Cambodia established the Rural Electrification Fund (REF) in 2004 that focuses on three programmes: •Solar home system (SHS). •Power to the poor (P2P). •Programme for aiding improve existing or develop new electricity infrastructure in rural areas.
Indonesia	In 2017, the Government of Indonesia developed a regional-based Feed-in Tariff (FiT) based on a production cost approach. In addition, some special programmes are carried out to achieve Indonesia's energy access goals, as follows: •"Lampu Tenaga Surya Hemat Energi (LTSHE)"/"Solar Energy Lamp" by the Government. •Rural Electrification Programme by PLN (National State Electricity).	•"Lampu Tenaga Surya Hemat Energi (LTSHE)"/"Solar Energy Lamp". This special project was conducted by the Ministry of Energy and Mineral Resources for extremely isolated island and rural areas that are not only far from electricity infrastructure, but also have extremely challenging geographical conditions. The target of the project in 2019 was to help 1.094 villages, mostly located in East Nusa Tenggara Province and Papua Province. •PLN Rural Electrification Programme. For this project, PLN was to build electricity infrastructure to deliver electricity from isolated power plants or substations to rural and remote areas. The target of the project in 2019 was to help 1.728 villages in Papua, Maluku, and East Nusa Tenggara.
Lao PDR	There has no current subsidiary policy for energy access.	But there are other policies relevant to the grid extension which are aimed at raising the electricity rate. Lao PDR promoted investment in high-voltage transmission lines with different modes to reduce the pressure on the state budget: Engineering Procurement and Construction (EPC) and Build-Operate-Transfer (BOT).
Malaysia	The Ministry prepared the Rural Electricity Supply Project (BELB) in coordination with the sub-district main division in Sabah or PPU (Pencawang Pembahagian Utama [Main Division Substation]) and the Rural and Regional Development Ministry (KKLW).	KKLW allocated RM 1.6 billion to develop Sabah Infrastructure: diesel generation, solar hybrid 132 kV grid extension, and 33 and 11 kV grid line extension projects (as well as the village road lighting project). KKLW also plans to collaborate with the Public Works Department on the road preparation and land acquisition for some projects.

Country	Name of Policy	Remarks
Myanmar	To date there is no specific policy to support energy access. Myanmar's relevant ministries and authorities are jointly promoting renewable energy development to boost electrification in the rural areas.	In renewable energy, the Ministry of Electricity and Energy (MOEE) developed the Minbu Solar Project with 40 MW capacity (another 130 MW will be brought on line in three phases: 40+40+50 MW); a wind power project with China Three Gorges International Corporation (CTGI) that will have 30 MW capacity; 760 kW waste-to-energy (WTE) project with Japan that will provide solar energy to 500,000 households by 2020-2021; and a mini-grid for 35,000 households.
Philippines	The DOE launched a massive initiative to increase and accelerate access to electricity services for the country's unelectrified communities. •In 1999, the Accelerated Barangay Electrification Program (ABEP) was launched with the initial partnership of the relevant energy agencies. •The Expanded Rural Electrification Program (ER Program) was established, and an ER Program Team was created in April 2003	The ER Program Team is now spearheading the development of various innovative service delivery mechanisms towards achieving greater access to electricity services.
Singapore	There is no specific incentive policy.	-
Thailand	There is a supporting mechanism for developing very small power plants (VSPP) with additional FiTs varying from 3.7 to 4.24 THB/kWh.	• The VSPP tariff is only available to new RE power plants (biomass, biogas from wastewater, waste, and energy crops) whose existing capacity is lower than 10 MW. • Six months for firm-contract (100% power operation in peak time and lower than 65% in off-peak), which must cover the maximum power consumption period (Mar.-Jun.), and six months for NON-FIRM. • Energy Storage Systems can be supported. • Fossil fuel utilisation is prohibited (except for system start-ups). • Purchasing rate is FiT competitive bidding: a. Biomass: 4.24-4.82 THB/kWh b. Biogas (wastewater): 3.76 THB/kWh c. Biogas (energy crop): 5.34 THB/kWh d. FiT Premium for firm-contract (< six months): 0.30-0.50 THB/kWh e. FiT Premium for three provinces in the southern region: -0.50 THB/kWh (this is for rural areas in the southern part).
Vietnam	As 99% electrification has already been achieved, there are no current policies to support Vietnam's rural electrification.	The government confirmed that it is very challenging to implement grid extensions or solar PV farms in the remaining 1% of households as they are in mountainous areas. Solar home systems could be an option; however, there has been no implementation yet.

Table 1-4 Planned Goals of Energy Access

Category	ASEAN Member States	Document relating to electricity access	Planned goals of energy access
Reliable well-served	Brunei Darussalam	White Paper Blueprint	A 99.9% household electrification rate has been achieved. The government is now concerned about providing greener electricity supply. See their White Paper Blueprint.
	Singapore	–	Singapore has reached a 100% household electrification rate.
	Thailand	–	Thailand has reached a 100% household electrification rate.
Pre-development well-served	Malaysia	The 11th Malaysian Plan	Sabah and Sarawak aim to achieve a 100% electrification rate by 2025.
	Vietnam	–	The government plans to give most of the households in the rural and mountainous areas access to electricity in 2020.
	Indonesia	Appendix 1 of Presidential Decree No 22/2017 on General National Energy Planning	A 100% household electrification rate was planned to be achieved in 2020.
On-going well served	Lao PDR	Rural Electrification Master Plan	The government planned to attain a 94.7% electrification rate by 2020, an "at least 98%" rate by the end of 2025, and a 100% rate by 2030.
	Philippines	The Philippine Energy Plan (PEP)	The country plans to achieve a 100% national and regional electrification rate by 2022.
Priority served	Cambodia	Strategy and Plan for Development of Rural Electrification in the Kingdom of Cambodia (SPDR)	The target is a 90% household electrification rate by 2023.
	Myanmar	National Energy Plan (NEP)	The target was 75% household electrification rate in 2021/2022 and a 100% rate by 2030.

1.4 Financing Programme

The common financing means for energy access include public utility financing, governmental financing, private financing, and public-private partnerships (PPPs). During the practical operation of projects, any one of these means or a combination of two or more may be involved.

Governmental financing is applicable to non-commercial projects. It includes governmental budget allocations, Official Development Assistance (ODA), and international/local long-term preferential loans.

Private developers or Non-governmental organizations (NGOs) usually participate in the projects through a bidding process. The developer is responsible for development, construction, and commissioning of off-grid power systems, while the local community entity has ownership and oversees operation and maintenance.

PPPs combine both private and governmental fund-raising advantages, e.g. competitive tariff rates, short project development and construction times, and inclusion of considerable sustainability features.

1.5 Issues and Challenges

1.5.1 Extremely difficult geographical and environmental conditions

In the AMS that have energy access issues, most non-electrified households live on isolated islands and/or in remote and rural areas where grid expansion is extremely difficult and involves huge investment costs.

(1) Indonesia: the people without electricity are living on isolated islands, e.g. on Maluku Islands and East Nusa Tenggara Island. Some also live in remote and rural areas in Papua.

(2) Philippines: some non-electrified households are in small, isolated islands in the Southern Area surrounding Mindanao, while others live in remote areas on Mindanao Island.

(3) Malaysia: pockets of non-electrified households' dwell in the mountains of Sabah and Sarawak in Kalimantan.

(4) Myanmar: Myanmar has the lowest electricity accessibility rates in the ASEAN region. Most of the people without access to electricity live in remote areas.

(5) Lao PDR: the non-electrified households live in the steep mountains along the border between Lao PDR and Thailand.

(6) Vietnam: the 1% of households that still lack access to electricity live in mountainous areas. It is very challenging to extend the grid to these parts of the country.

1.5.2 Insufficient supporting policies

Several condition in the AMS that caused by the insufficient supporting policies are:

(1) Countries lack fundamental policy supports for their electricity infrastructure development.

(2) There are few incentives to develop renewable energy and the policies relating to renewable forms of energy are not attractive. The use of rooftop solar PV in some remote areas is limited.

(3) There is no long-term plan for energy development and inadequate continuity of policies.

1.5.3 Low business returns which affect the enthusiasm for investment and construction

For many cases, off-grid electricity systems are the prioritised options for electricity access to the non-electrified population. However, the huge investment but low return of off-grid projects usually affects the enthusiasm of investors. Hence, support in the form of governmental allocations or credit loans is needed.

1.5.4 High costs which dissuade electricity consumption

In the isolated islands, rural, and remote areas where income per capita is low, the people tend not to use the electricity made available to them because it is simply too expensive for them.

2 Electrification Programmes in the Isolated Islands

The economic and social conditions of the AMS' numerous islands vary considerably. As the isolated islands are often quite remote, it is hard to extend the existing grids to them. Hence, finding ways to provide electricity to the people living on isolated islands is a key challenge for the ASEAN governments.

2.1 Geographical Overview

An isolated island generally has the following characteristics:

(1) Geographically far from the economic activity on the mainland.

(2) Generally, it has few inhabitants (low electricity demand).

(3) Usually far from any electricity infrastructure or main grid on the nearest island or mainland.

Figure 2-1 gives a geographical overview of the AMS. While Lao PDR is a landlocked country, other AMS have some isolated islands, e.g. Cambodia, Malaysia, Myanmar, Singapore, Thailand, Vietnam, and Brunei Darussalam. However, these isolated islands generally constitute only a small part of their total areas. Indonesia and Philippines have large numbers of isolated islands. Indonesia is the world's largest archipelagic country, consisting of about 17,508 islands of different size between the Pacific and Indian Oceans. The Philippines has more than 7,000 islands, though it has 11 major islands like Luzon, Mindanao, and Samar which together account for 96% of the total area.

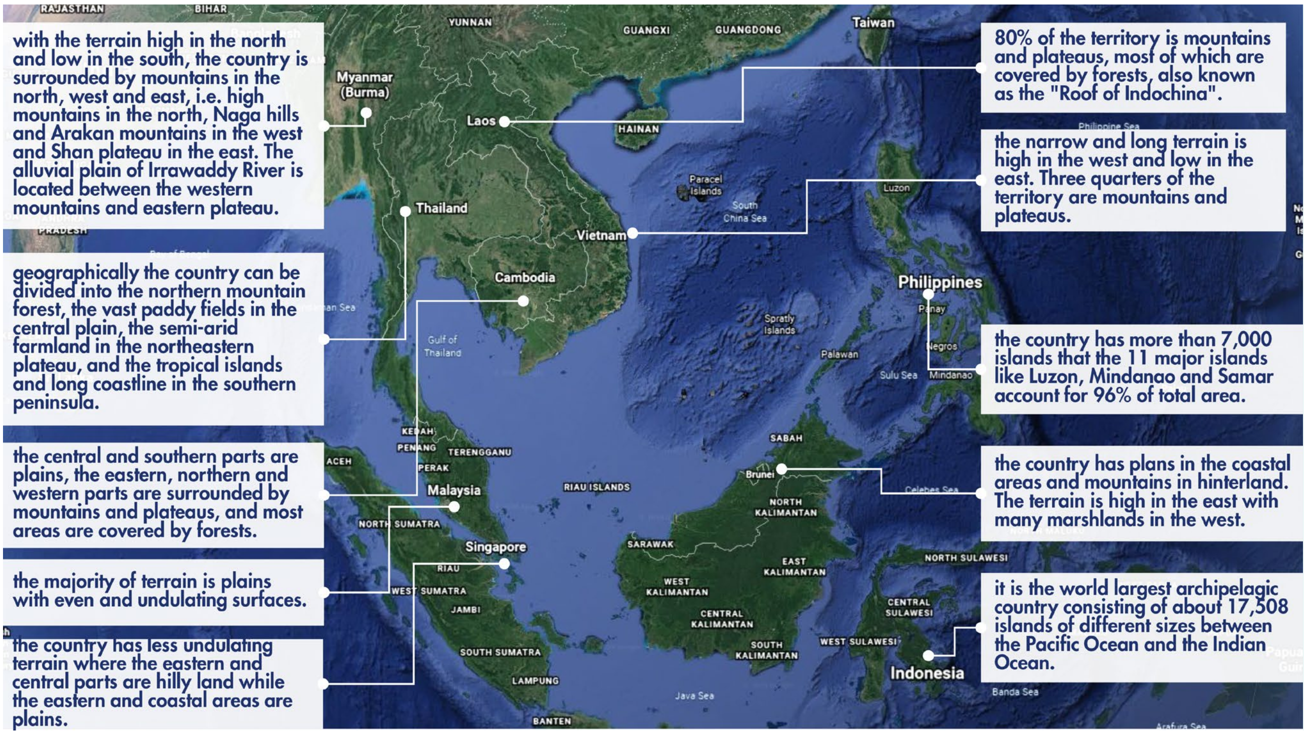


Figure 2-1 Geographical Overview of the AMS

2.2 Identified Solutions

Noting the electrification challenges faced by the isolated islands, Table 2-1 summarises some possible solutions that the AMS could pursue.

Table 2-1 Electrification Solutions for the AMS' Isolated Islands

Solution	Application scope	Detailed methods	Characteristics
Submarine cable	Large offshore archipelago.	Relating to the mainland through submarine cables, the island is powered by the main grid that guarantees high electricity quality and system stability for the island.	① Secured and sustainable electricity supply. ② Small area of land use, almost zero emissions and low tariffs. ③ High investment costs, difficult engineering, long construction periods, difficult operation and maintenance conditions, etc.
Off-grid connection through micro-grid or mini-grid	Isolated islands with economic potential, such as tourism.	Electrification by micro-grid or mini-grid to obtain higher investment returns, as well as energy conversion efficiencies as a whole at lower environmental costs.	① Higher electricity supply reliability and quality. ② Higher investment returns and energy conversion efficiencies at lower environmental costs. Enables full advantages stemming from local, diversified renewable energy supplies.
Stand-alone system	Less-populated island with no significant economic potential. Electricity demand is required for household use only.	The most common stand-alone system is off-grid PV consisting of solar panels, storage batteries, charging/discharging controllers, inverters, etc. to repeat the cycle of charging and discharging.	① With no geographical limits, these can operate separately without dependence on a grid. ② Off-grid PV can be used together with diesel generators and energy storage systems.

2.3 Typical Cases

Figure 2-2 Distribution of Typical Cases

2.3.1 Case of Karimun Jawa, Indonesia

a) Project overview

The Karimun Jawa Islands are a group of 27 tropical islands in the Java Sea incorporated into the Jepara Regency in Indonesia. The group is located 80 km north of Jepara City in Central Java. The total area of Karimun Jawa is about 71.200 km^2, and consists of four villages. The total population in Karimun Jawa is 9,514 and there are about 2,945 households. The tourism potential is important economically.

At the onset of electricity development, the local government installed three small diesel power plants consisting of a 500 kVA unit, a 250 kVA unit, and a 100 kVA unit. The electricity was delivered to the households through a medium voltage grid 20kV distribution system. However, since the capacity of the sources was limited, the electricity was provided for only 12 hours per day. This was the situation until 2016.

Figure 2-3 Karimun Jawa Islands, Central Java, Indonesia

b) Solution

- Technical solution: in 2016, the utility took over the electricity operations from the local government. Two 2.2 MW Diesel Power Plants were installed in Legon Bajak at the North of the Island to serve the 1.3 MW peak load through a 20kV distribution system. In 2019, 3 MWp solar PV and 4.5 MWh batteries were installed as alternative sources to the diesel power plants.
- Financing model: funding came from the Indonesian PLN rural electrification project budget. Thus, the PLN oversees investment, operations, and maintenance. The tariff for local residents is 10.1 cents/kWh and any shortages are covered by national budgetary subsidies.
- Generating cost: the operation and maintenance costs of a diesel generating unit are 43.87 cents/kWh, which is paid by electricity sales and governmental subsidies. The estimated operation and maintenance costs of the PV + energy storage system is 30.81 cents/kWh. Due to the falling operation and maintenance costs, the governmental subsidies will be reduced accordingly.
- Social and economic benefits: the project solves the electricity consumption issue for 7,795 residents in two villages. The residents and tourists alike enjoy a stable, 24-hour electricity supply. Each year, the project reduces the local government's electricity costs by about USD 413,700, leaving more funds available for the development of local infrastructure and tourism.

c) Summary of practical experience

Three stages were adopted to promote electricity access progress on the isolated islands. In the first stage, it was important to provide electricity to the inhabitants to meet their basic electricity needs. Bringing adequate and reliable electricity together with lowered tariffs was then considered in the second stage. During the third stage, the priority was to deliver electricity at optimal production costs. The combination of PV power generation systems, energy storage and diesel units as the main sources were the best solution because they greatly reduced the generating costs, the electricity tariffs for the residents, and the financial burden on the local governments. These projects required relevant governmental incentive policies, tariff subsidies, etc. A stable electricity supply greatly improved the livelihood and income of the local residents and propelled the development of tourism so that the local economy and infrastructure construction could begin to step into a virtuous cycle.

2.3.2 Case of Masbate Island, Philippines

a) Project overview

Masbate Island is one of the island provinces in the Visayas Area of the Philippines. There were about 550 barangays or villages with a total population of about 930,000 in early 2019. As recently as 2007, only 22% of Masbate barangays had access to electricity, but even that was intermittent and expensive. Without doubt, the power shortages were severely hindering the Island's development.

Figure 2-4 Masbate Island, Visayas, Philippines

b) Solution

- Technical solution: off-grid power generation and upgrading of the distribution network.
- Financial model: international funding with an investment of up to USD 23 million through PPPs.
- Social and economic benefits: through grid rehabilitation and upgrading, the new system brought substantial efficiency gains; energy loss reductions from 27% to 17% and generation cost cut of 50%. The electricity is now much more affordable for the citizens. The new, guaranteed generation capacity of 13 MW contributed to the government's goal of attaining a 90% household electrification rate by 2019.

c) Summary of practical experience

The financial model was drawn up to attract the participation of social capital by PPPs, and introduce direct investment of international capital in construction to advance the energy access project. The higher efficiency of the generating system and the lower electricity energy losses of the distribution network were also important in alleviating the energy access problems.

2.3.3 Case of Langkawi Island, Malaysia

a) Project overview

As the largest island group in Malaysia, Langkawi consists of 99 islands in the Strait of Malacca north of Penang Island with a total area of 526km^2. As one of the most renowned tourist attractions in Malaysia, the economy is dominated by tourism. A local power plant supplied the islands with electricity, but the supply was very unstable and suffered from high energy losses.

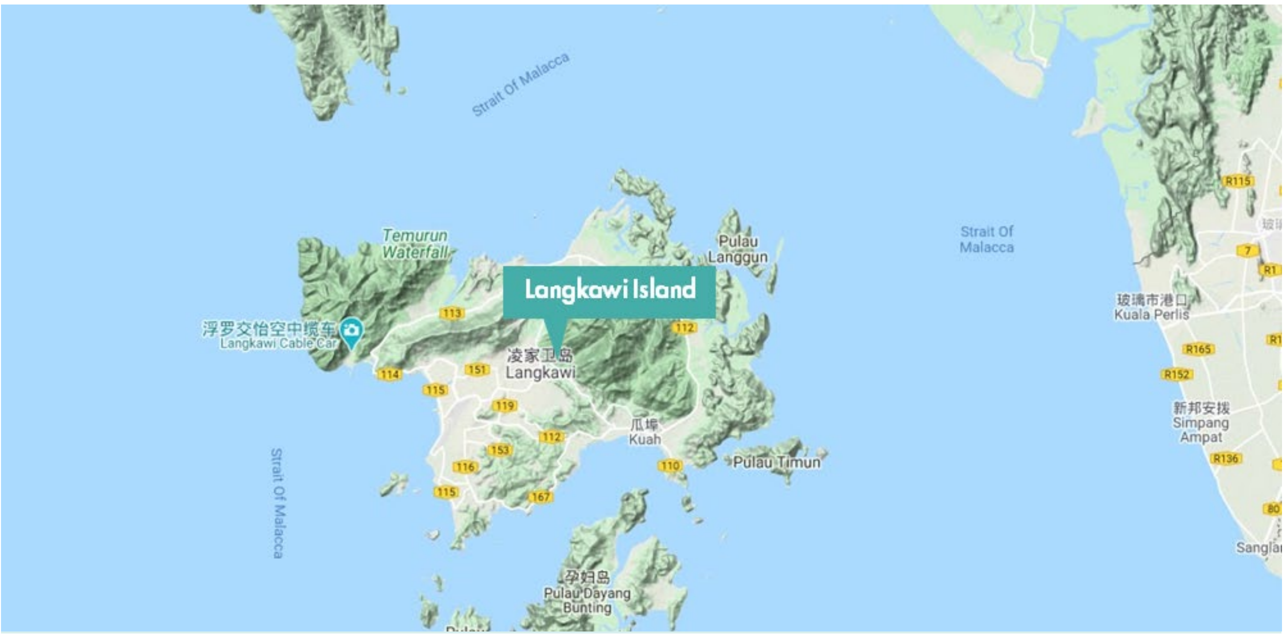


Figure 2-5 Langkawi Island, Malaysia

b) Solution

- Technical solution: a 26.5km submarine cable was laid by LS Cable & System to extend the national grid to the islands. Construction began in 2018 and was completed in 2019.
- Financial model: invested by Tenaga Nasional Berhad (TNB).
- Investment amount: USD 35.79 million.
- Social and economic benefits: the project provides a stable electricity supply to 90,000 residents living on Langkawi Island and significantly boosts local economic development.

c) Summary of practical experience

Grid extension by submarine cable improved the quality, reliability, stability, and efficiency of electricity supply to the Island with considerable economic gain. By investing in the energy access project, the national utility not only increased the local electricity supply but also spurred economic growth. A stable electricity supply can effectively propel local economic development and increase the income of local residents thereby making the tariff more affordable. The electricity sales revenue is also bringing considerable economic benefits to TNB.

3 Electrification Programme in Rural and Remote Areas

The rural and remote areas are far from load centres and are hard to be covered by main grids. Meanwhile, the weak infrastructure in rural and remote areas makes energy access problems more challenging. The electrification of rural and remote areas is among the key goals of the AMS' governments.

3.1 Geographical Overview

The rural and remote areas are usually located far from the normal infrastructure (roads, electricity grids, etc.) and from economic centres. The geographic conditions greatly hinder the access to electricity. The characteristics of rural and remote areas are:

(1) The site locations are inaccessible and have no proper infrastructure.

(2) There are such geographical difficulties such as undulance, mountains, or forests.

(3) The electricity network is challenging to build.

In Cambodia, Lao PDR, and Myanmar, the rural and remote areas are in the mountains where the construction of access roads is generally not possible. In Indonesia, the rural and remote areas are mostly in the mountain areas of Papua, Kalimantan, and Sulawesi. Similarly, the rural and remote areas in the Philippines are in the mountains of Visayas and Mindanao.

3.2 Identified Solutions

Table 3-1 Electrification Solutions for Rural and Remote Areas

Solution	Detailed methods	Application scope	Characteristics
Prioritised source construction of load centres and synergetic development of both grids and power sources	Prioritised development of power source construction, e.g. large hydropower resources surrounding the load centre to propel grid construction by power source development and realise synergetic development of both grid and source.	To provide electricity to remote areas with restricted development.	Quick expansion of power source scale can effectively solve the issue of electricity shortages.
Grid extension	Main grid extension.	To provide electricity to regions with higher electricity requirements and to ensure reliability of supply.	Better guaranteed electricity supply with lower cost per kWh.
Off-grid system	Solar PV, wind power, hybrid system of wind and solar, small hydropower, etc. that is immediately used or stored for use when needed.	To provide electricity to less densely-populated regions.	Small investment, quick returns, less land occupancy, and easy maintenance.
Micro-grid	Small generation and distribution system consisting of distributed sources, energy storage apparatus, energy conversion devices, load, monitoring and protection devices, etc.	To provide electricity to remote areas.	Higher stability and security of electricity systems, better cost efficiency and flexibility, lower electricity energy losses, and improved energy efficiency.

3.3 Typical Cases

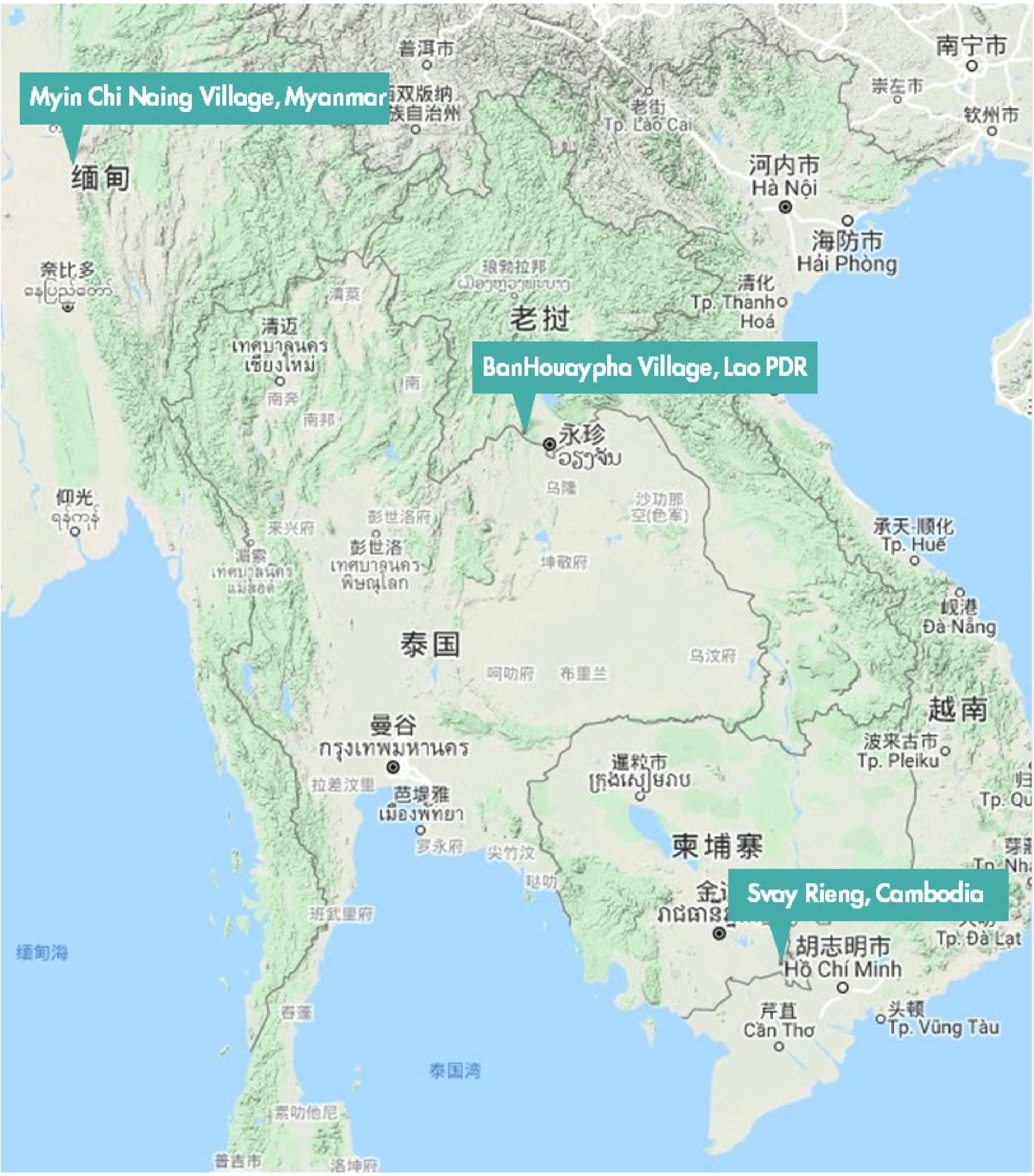


Figure 3-1 Distribution of Typical Cases

3.3.1 Case of rural electrification in Svay Rieng, Cambodia

a) Project overview

Lying in the south-eastern part of Cambodia and bordering Vietnam, Svay Rieng has an area of 2,966 km^2 and a population of 352,000. The national grid covers only the cities and towns. Most of the villages have no access to electricity.

Figure 3-2 Svay Rieng, Cambodia

b) Solution

- Technical solution: a combination of national grid extension and construction of a mini-grid was adopted. The plan was for the national grid to increase by 215 km of MV lines, the installation of 390 km of LV lines and voltage regulators, expansion of the capacity of the 6.43 MVA distribution transformer, and establishment of two MV metering systems and two capacitor banks. For the mini-grid, a diesel generator was adopted as the power source in the grid connection programme for isolated villages.
- Financing model: with a budget of USD 9.735 million financed by the Asian Development Bank, the system was implemented by Ministry of Industry, Mines and Energy (MIME), Electricite du Cambodge (EDC), Electricity Authority of Cambodia (EAC) and Renewable Energy Fund (REF). The mini-grid project was completed in 2015 and the grid extension to the rural areas was planned to be completed by the end of 2020.
- Investment amount: the total investment is USD 9.735 million.
- Social and economic benefits: the project provides 24-hour electricity to 88,000 households (about 352,000 residents) locally and meets their basic demand for electricity. The users of the extended grid pay a tariff of 17 cents/kWh, while the users of the mini-grids powered by diesel generators pay a tariff of USD 1/kWh.

c) Summary of practical experience

International financing supported the extension of a local grid and the construction of mini-grid for villages, in line with the rural electrification programme.

3.3.2 Case of community PV power in Ban Kuay Village, Lao PDR

a) Project overview

Owing to its remote location, Ban Kuay Village in Lao PDR cannot be connected by grid extension. At present, the local residents must charge their appliances using the batteries of an electrified village that is 16 km away, while for lighting they mainly rely on kerosene and candles. Hence, the government is trying hard to provide electricity access for the households living there.

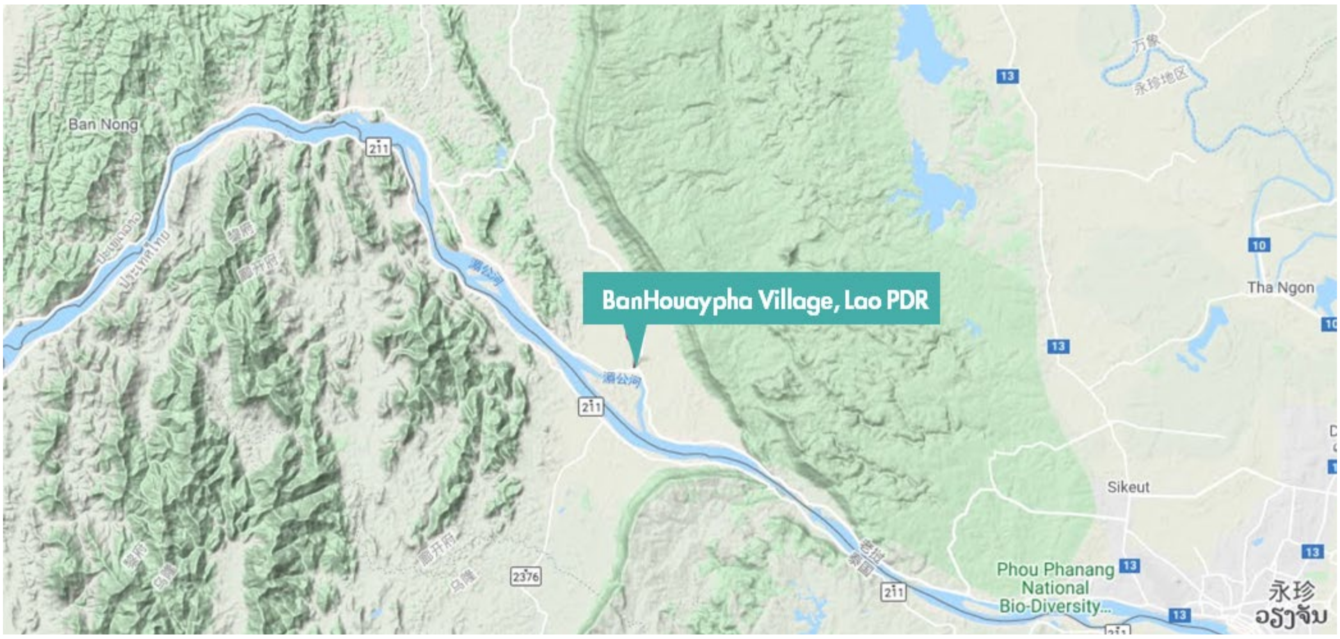


Figure 3-3 BanHouaypha Village, Lao PDR

b)Solution

- Technical solution: the community solar PV (with batteries) was built in the vicinity to supply electricity and public charging equipment. The residents use home batteries for charging and usage.
- Financing model: Sunlabob Rural Energy System Company raised the investment funds and the users pay for charging as the return on investment and operation costs.
- Investment cost: each power source unit cost USD 2,890. The batteries must be replaced every five years while the charging controllers need to be replaced every eight to ten years.
- Social and economic benefits: the project provides a charging service to 509 local residents. Lighting is now available for three to four hours each day and refrigerators can now operate 24 hours per day

c) Summary of practical experience

Enterprises can play a role in investing and building up the rural solar PV charging systems, recovering the investment through tariffs and by maintaining the project operations.

3.3.3 Case of mini-grid in Myin Chi Naing Village, Myanmar

a) Project overview

Owing to its remote location, Myin Chi Naing Village in Kyaukse Township, Mandalay cannot be connected by grid expansion. The residents mainly use candles for lighting. The government decided to expand electricity access by building an off-grid system.

Figure 3-4 Myin Chi Naing Village, Kyaukse Township, Mandalay, Myanmar

b) Solution

- Technical solution: several 3.6 kW solar PV mini-grids were built in the vicinity, and various batteries and diesel generators were installed to supply electricity to the village and meet the basic electricity demands of households. This was planned and designed in 2016 and launched into operation in 2017.
- Financing model: investment was from the Japan Fund for Poverty Reduction (JFPR) of the Asian Development Bank. SolaRiseSys provided the equipment and built it. The local Village Electrification Committee (VEC) oversees operations.
- Investment amount: around USD 100,000.
- Social and economic benefits: the project supplies electricity to 200 households (about 797 residents) locally, as well as a temple and rural library.

c) Summary of practical experience

A mini-grid system in a rural area was built through foreign financing. The local authorities operate and maintain it autonomously. The investment is covered by collecting tariffs and maintaining operations. This project has improved electricity access without governmental funding or subsidies.

4 International Experience

4.1 Cases in China

At the end of 2012, there were 2.73 million people without electricity in China, mainly in remote minority regions such as Xinjiang, Tibet, Sichuan, and Qinghai. To comprehensively solve the issue of electricity access for these regions, in 2013 the National Energy Administration (NEA of China) formulated the Three-year Action Plan (2013-2015) for *Comprehensively Solving the Issue of Electricity Access for Unelectrified Population* that offered strong support for energy access progress through state-level strategic planning.

In setting the targets, the plan broke them down into detailed indicators of investment and percentage of electrified population and allocated them to the relevant provinces and regions. For example, Xinjiang Autonomous Region was required to make a total investment of CNY 4.43 billion to provide electricity access to 870,000 people from 2013 to 2015. During the implementation process, a joint force was formed through stronger support of the central government, earnest performance of duties and responsibilities by the local governments at all levels, and proactive fulfilment of social responsibility by enterprises to accelerate the pace of electricity infrastructure construction in the unelectrified areas.

China has developed energy access policies in accordance with national and local conditions. There are mainly three types of energy access projects. The first type is to actively develop electricity for the access of unelectrified population. The second is to implement the projects of rural grid upgrading and transformation to improve the production and livelihoods level of the rural people and boost the electrification of the countryside. The third is to advance PV power projects for poverty alleviation that combine solar PV power with targeted poverty alleviation, reflecting the new concept of "green development", and accelerating the pace of poverty eradication.

4.1.1 The wind-PV-storage-diesel multi-energy utilisation project on Dongfushan Island, Zhejiang

4.1.1.1 Background

As the easternmost inhabited island in the eastern sea of Putuo District, Zhoushan, Zhejiang Province, Dongfushan Island has one village with around 300 permanent residents who are mostly fishermen and migrant workers. The island has spiral mountain roads and a ferry terminal. With the open sea to the east, the island is 45 km away from Shenjiamen Town, Putuo District in the southwest and has a land area of 2.95 km2.

Figure 4-1 Geographic Location of Dongfushan Island

Far from the mainland, the garrison stationed on Dongfushan Island consumes costly diesel oil to generate electricity. Before the implementation of the project, the garrison used a diesel generator to supply small amounts of electricity for residential lighting. The water consumption came mainly from the rainfall collected by the existing reservoir (with a capacity of about 10,000 m3) and the water shipped from Zhoushan Island, resulting in extremely high costs for water. As tourism develops on the island, the provision of adequate and reliable water and electricity are the most urgent issues facing Dongfushan Island.

4.1.1.2 Solution

(1) Case overview

As a micro-grid system for an isolated island, the project is known as "One System and Two Networks" where the former refers to a comprehensive energy supply system and the latter refers to a grid and water supply network.

With a total installed capacity of 510 kW, the project consists of seven 30-kW wind power generators, a 100-kWp solar generator, a 2000 AH new energy battery, a 200-kW diesel generator, and a seawater desalination system with a daily treatment capacity of 50t. The 300 kW off-grid dual-way inverter for project control is the first of its kind in China. The total investment of CNY22.16 million was mainly raised from investors. The project was planned to deliver 470 MWh of designed annual electricity output and an annual water supply of 18,000t. The electricity tariff is CNY1.2/kWh and price of the water is CNY5/t.

(2) Project results

As a micro-grid power generation system for an isolated island, the wind-PV-storage-diesel multi-energy utilisation project depends mainly on renewable energy that is supplemented by a diesel generator. Featuring high reliability of electricity supply, automated and unattended service, the project takes full advantage of the automated design with coordinated and optimised solar and wind power, and offers a clean-energy-based model of electricity and water production to the remote island from the mainland. The project effectively guarantees sufficient water and electricity for the local residents and tourists, and also the garrison.

4.1.1.3 Technical characteristics

1) The project consists of a 210-kW wind power generator, a 100-kWp solar generator, a 200-kW diesel generator, two sets of 1000 AH new energy batteries, and a seawater desalination plant with a daily capacity of 50t. With 510 kW of capacity, this project is by far the largest wind-solar-diesel-storage grid with seawater desalination on an isolated island in China. The project harnesses renewable and clean energy on the island, with wind and solar as the main sources, and builds up a wind-solar complementation system with a diesel generator as the auxiliary source. It also makes use of the new energy battery and automatic control technology to achieve load balance and voltage and frequency stability of the grid. The redundant clean energy is used for seawater desalination, effectively guaranteeing the local residents' demand for water and electricity.
2) The project achieved a breakthrough in the DC grid building technology applied in the traditional wind-solar complementation system, and applies AC grid building technology. For the first time it applies the newly developed 300 kVA DC/AC dual-way invertors in the isolated grid in China. The automatic control technology and dual-way inverter also maintains the electricity balance and grid stability of the isolated grid.

4.1.2 Regional grid of renewable energy in Shuanghu County, Tibet

4.1.2.1 Case overview

Located in the northwest of Naqu, Tibet Autonomous Region, Shuanghu County borders Anduo County in the east, Bange and Shenzha counties in the south, Nima County in the west, and Xinjiang Uygur Autonomous Region in the north across Hoh Xil, with the altitude averages over 5,000 m and the area spans 116,700 km2. Before 2015, the downtown area of Shuanghu County depended on electricity supplied by a 220 kW PV power plant and a 450-kW diesel generator. Not surprisingly, the electricity supply was limited by the small installed capacity and could meet only the basic needs of key authorities and entities such as government, the public health service centre, public security bureau and gas station. The unstable voltage caused so many problems that residents had to rely on diesel generators and butter lamps for lighting.

Figure 4-2 Geographic Location of Shuanghu County

4.1.2.2 Solution

(1) Case overview

The renewable-energy-based regional grid at Shuanghu County, Tibet is a large off-grid PV storage micro-grid project with construction aided by funds from the national government. It consists of four parts, namely a 13 MW PV power plant, a 24 MWh energy storage system, a 1.5 km transmission line, and a distribution network. The annual guaranteed electricity is 6.6 GWh. The power sources include a 13 MW PV power generation system and 7MW/23.5MWh lithium-ion battery energy storage system that includes two types of lithium-ion batteries, i.e. a lithium iron phosphate battery (3M/10.08MW) and ternary polymer lithium battery (4M/13.44MWh).

The power system is also equipped with two 1000kW/10kV diesel generators as the standby power source of the whole electricity system. The transformation of the distribution network includes the incremental capacity transformation of the existing 10 kV urban overhead circuits, transformation of 0.4 kV cables for users, and the installation of household electricity meters for household billing. The renewable energy regional grid in Shuanghu County is funded through national aid to Tibet

(2) Project results

1) The mode of establishing a stand-alone grid beyond the coverage of the main grid can meet the local demand for electricity.
2) The construction of a fully functioning electricity facility promotes economic and social development in remote minority regions;
3) Through the use of renewable resources, the local ecological environment is preserved.

4.1.2.3 Technical characteristics

The renewable energy regional grid in Shuanghu County, Tibet is the largest regional renewable energy grid project in China, with the largest energy storage scale of any such project in China. The PV project stands at the highest altitude in the world. While significantly improving the local electricity access and livelihoods of thousands of Tibetan people, this unprecedented high-altitude project has overcome extreme difficulties in engineering, thus boasting irreplaceable industrial value in terms of exploring application of standalone regional grids, improving PV poverty alleviation models, testing of equipment reliability, etc.

4.2 Cases in Africa

Sub-Saharan Africa has the largest unelectrified population in the world. Thanks to the joint efforts of national governments and international organisations over the past several years, the electrification rate in Sub-Saharan Africa has made remarkable progress rising from 33% in 2010 to 45% in 2018. With the Atlantic Ocean to the west and the Indian Ocean to the east, most of the people without electricity in sub-Saharan Africa are living in rural and remote areas. The AMS countries can learn from the experience of this part of Africa. Over the years, countries such as Kenya, Ethiopia, and Nigeria have made considerable progress in energy access as the following case studies of these three countries reveal.

4.2.1 Kenya

4.2.1.1 Development overview

The Government of Kenya has long been committed to solving the problem of energy access and has made great achievements with the support of international organisations and PPPs. By the end of 2018, Kenya achieved an electrification rate of about 75%, a remarkable increase of 34% compared with 2015. In December 2018, the Kenyan Government initiated the Kenya National Electrification Strategy (KNES) with a target of overall electricity access by 2022. The Kenya Off-grid Solar Access Project (K-OSAP) is a significant part of this project.

4.2.1.2 Project overview

The plan was for the K-OSAP to supply electricity to 1.3 million households located in the northeast and northern parts of the country. Jointly implemented by the Ministry of Energy, the Kenya Power and Lighting Company (KPLC) and the Rural Electrification Agency (REA), the project was to run for six years from July 2017 to June 2023 with a total investment of around USD 150 million, the majority of which is from the World Bank.

4.2.1.3 Technical characteristics

The K-OSAP is to build 120 micro-grids in 14 counties in Kenya that consist of a PV unit, battery, and diesel generator. The user types (family, enterprise, community facility, etc.) will be finalised based on user numbers and service level.

4.2.1.4 Financing model

The micro grids are to be built under PPPs in which the private investment and part of the governmental funds are used to build the power plants while the rest of the governmental funds are used to construct distribution networks. The Private Service Provider (PSP) oversees the construction (and partial financing) of the power generation system and distribution network. When the private investment is recovered, the ownership of all assets (including generation units and distribution network) will belong to the Government of Kenya. For effective implementation of the national tariff policy, the micro grid tariffs are priced according to the national charging standard.

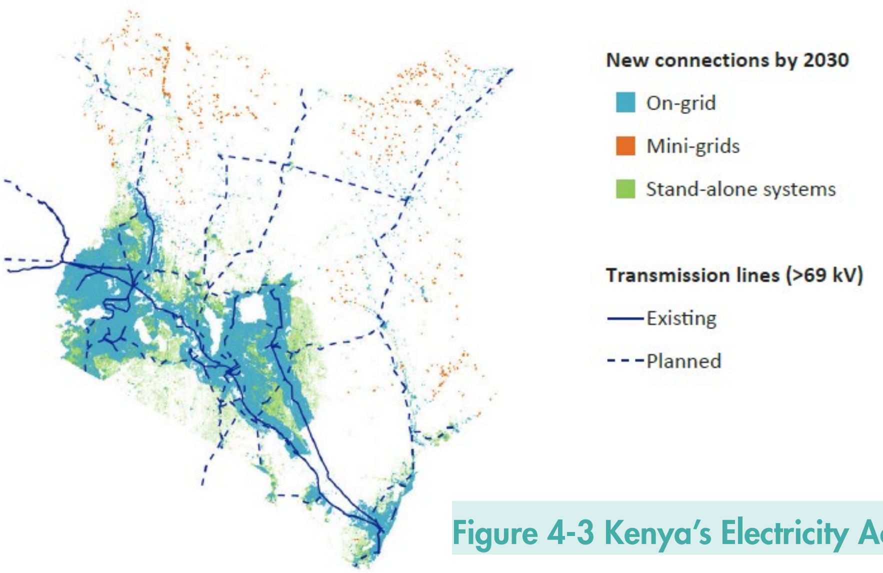


Figure 4-3 Kenya's Electricity Access Solution

4.2.2 Nigeria

4.2.2.1 Development overview

Nigeria is largest economy and top crude oil producer in Africa, but still suffers from electricity shortages. According to the Africa Energy Outlook 2019 published by the International Energy Agency (IEA), Nigeria had about 196 million people in 2018 and the population with electricity accounted for about 60% (about 118 million people), implying that there were 78 million people without electricity. Fortunately, the Government of Nigeria has been vigorously promoting electricity access and has made good progress with the support of international organisations and financial institutions in recent years. It has huge potential for renewable energy development.

4.2.2.2 Project overview

In 2014, the German Ministry for Economic Cooperation and Development (BMZ) and the European Union (EU) jointly initiated the Nigerian Energy Support Programme (NESP) with a total investment of about EUR 24.5 million. This programme spanned from March 2013 to February 2018. In 2017, the Nigerian Energy Support Programme II (NESP II) was launched and is to run from 2017 to 2021 based on the initial programme.

4.2.2.3 Solving path

Over the past five years, measures have been taken and investments have been made in the fields of renewable energy, energy efficiency, and rural electrification under the NESP. NESP II is being implemented with the EU's aid of EUR 20 million, and aims to provide advisory services in energy policy and management. In the on-grid regions, the necessary framework conditions have been established to encourage investment in grid-connected renewable energy power generation. In the off-grid regions, the rural electric bureaux and federal states are being supported in their plan to expand the coverage of off-grid renewable energy solutions to 100,000 people.

4.2.2.4 Project results

By the end of 2017, the following achievements had been made:

(1) About 16,000 rural residents had electricity generated by solar energy. Funded by PPPs, six off-grid rural power plants (micro-grids) had been set up that benefit 3,147 households in five states.

(2) Eleven laws and regulations had been promulgated, e.g. the national decree on renewable energy and energy efficiency, and regulations on mini-grids and energy conservation in buildings. In addition, an energy efficiency tagging system for home appliances, etc., was implemented.

(3) More than 600 people had attended training courses on PV and micro-grid design. Special attention was paid to gender equality. Thirty-three women received grants for the aforesaid training courses and another 74 women took local training in energy consulting services.

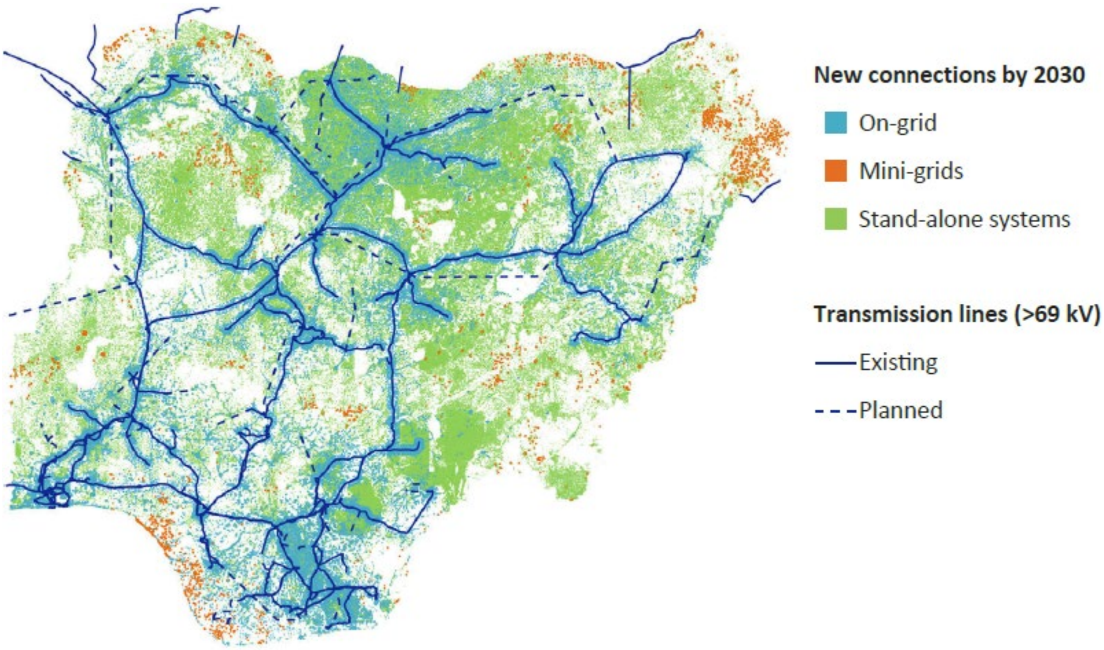


Figure 4-4 Nigeria's Electricity Access Solutions

4.3 Experience Summary

Governmental general planning and development of guarantee measures. Reflected by the energy access cases and practical experience, both China and some African countries have attached great importance to the guiding role of planning. The governments have comprehensively developed national and local plans for energy development to clarify the energy access targets, tasks, and implementation bodies. They also adopted corresponding guarantee measures to guide the effective implementation of projects through project subsidies, financial support, tax exemption and reduction, etc.

Expanded financing channels and innovative cooperation models. The practical experience of China and African countries indicates the necessity of expanding financing channels to build a multilateral cooperative platform of "government + international organisation + energy enterprise + financial institution", and of actively applying diversified forms of PPPs. The stable and sustainable cooperation mechanism has helped maximise the benefits to all stakeholders. It is apparent that the collaboration mechanism of normalised partnership and institutionalised development should be cultivated to achieve a balance among different stakeholders and push forward the sustainable development of energy access.

Strengthened policy guidance to encourage enterprises to fulfil their social responsibility. Through policy guidance and certain project subsidies, the state-owned energy and power enterprises and competent private entities are encouraged to participate in the engineering, operation, and maintenance of energy access projects to fulfil their social responsibility. As the main implementer of energy access projects, enterprises that play an increasingly important role in the market-oriented economy can give full play to their own strengths of capital, technology, and scale so as to propel the energy access evolution and secure the smooth implementation of energy access projects.

5 Selected Case in ASEAN Member States

5.1 Indonesia

5.1.1 Development Status

Indonesia's electrification rate rapidly improved from 84.35% in 2014 to 98.86% in 2019. Most households that are not yet electrified are on Maluku Islands, East Nusa Tenggara Islands, and in isolated areas in Papua.

Figure 5-1 Distribution of Unelectrified Villages in Indonesia

Indonesia's development of energy access can be divided into two stages. In the first stage from 2000 to 2018, energy access was rapidly developed by governmental measures including main grid expansion. In the second stage from 2018 to the present, energy access has steadily progressed. At this time, most of the unelectrified households are those which are located on isolated islands and in remote areas.

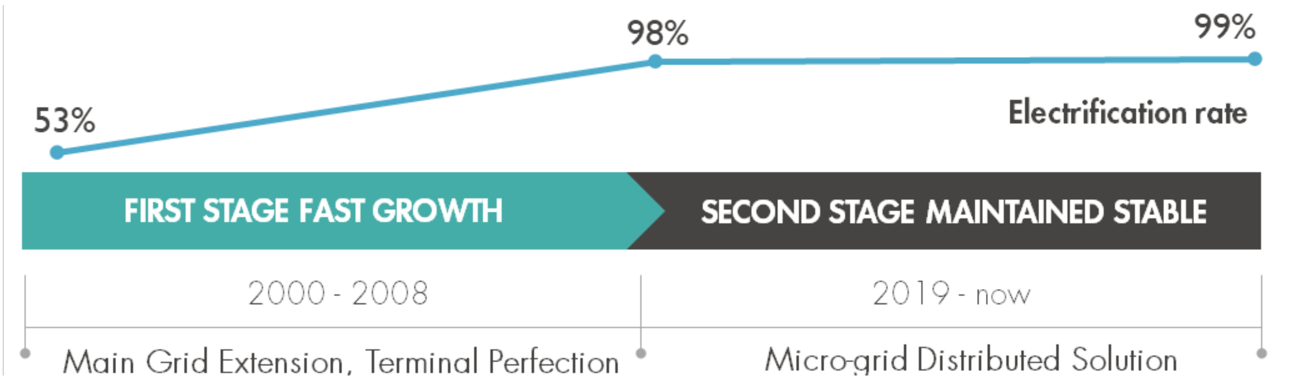


Figure 5-2 Indonesia's Energy Access Development

5.1.2 Planned Target

According to Indonesia's General National Energy Planning, there is to be 100% household electrification by 2020.

5.1.3 Existing Problems

Based on various literatures, there are some identified existing challenges in Indonesia on electrification programme.

(1) Technical innovation ability needs to be improved.

(2) Difficulty of obtaining financial support.

(3) Electricity access to islands in the outer ring is extremely challenging.

5.1.4 Proposed Measures

There are some possible measures that could be considered to enhance the electrification programme in Indonesia.

(1) Enhance the support for energy access policies.

The government should issue more incentive policies for the regions suffering serious energy access issues, making the development of renewable energy more attractive. Various national financial subsidies could be granted for the development of renewable energy in remote areas and on isolated islands.

(2) Actively participate in international cooperation on renewable energy.

Indonesia can participate in the formulation of international technical regulations and standards on renewable energy and new energy, set up demonstration projects for advanced technology application with foreign partners, establish an international science and technology cooperation base for renewable energy, and cooperate to cultivate a senior talent team devoted to renewable energy research and development.

(3) Expand financing channels.

Indonesia could issue financial policies to attract renewable energy projects and strive for funding from international financial institutions and the private sector to mitigate the shortage of its own financial resources.

(4) Establish demonstration projects to promote energy access.

For islands that have economic potential in terms of tourism, consideration should be given to multi-energy complementation technology to ensure high quality electricity supply. A system of modules could be established for distributed deployment in line with the local conditions. For islands that have smaller populations and lower electricity demand, the residents' electricity supply could be ensured through means such as Solar Home Systems (SHS).

5.2 Vietnam

5.2.1 Development Status

Over the last two decades, the development of electricity in Vietnam has been rapid. In 2010, a third of its power supply was generated by coal, gas, and hydropower. In 2019, Vietnam experienced a solar boom in which 4.5 GW of capacity was installed in only one year. The significant power development meant that Vietnam reached 99% of its electricity access goal (with the urban electrification rate reaching 100% and the rural electrification rate reaching 99%, both above the world average level and that of developing countries). The remaining unelectrified areas in Vietnam are mostly located in extremely remote mountains which are very challenging to electrify. Since 2000, Vietnam has undergone three stages in energy access development, namely rapid development, slow development, and stable development.

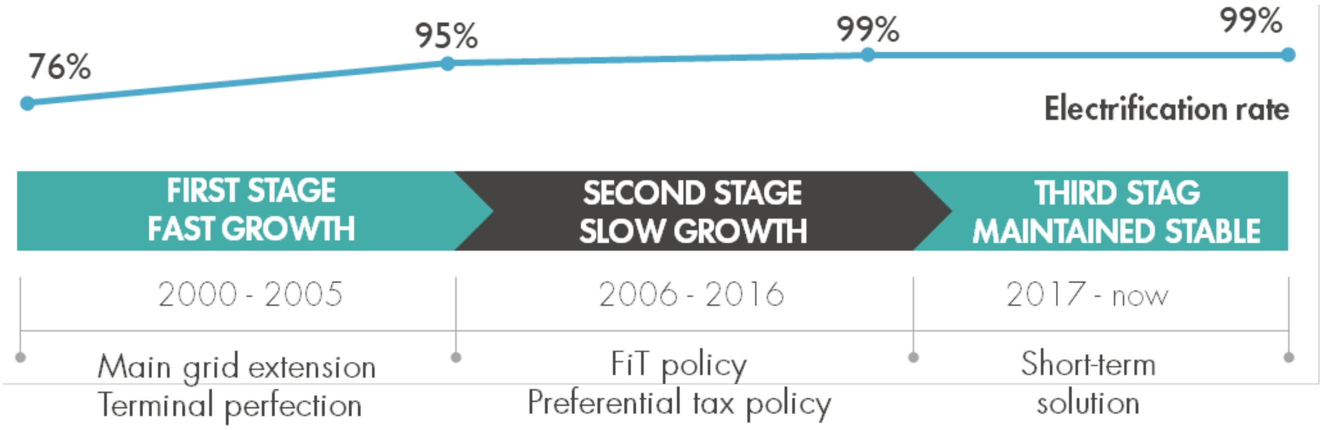


Figure 5-3 Vietnam's Energy Access Development

5.2.2 Existing Problems

Based on various literatures, there are some identified existing challenges in Vietnam on electrification programme.

(1) The quality of electricity supply and electricity construction need to be further improved.
(2) The supportive policies for renewable energy lack consistency and continuity.
(3) Project financing is difficult with no mechanism to introduce social capital.
(4) Solving the energy access problems for the remaining population without electricity is challenging.

5.2.3 Planned Target

Going forward, Vietnam will carry out comprehensive planning of technical feasibility, capital operability, etc. to further advance the construction of distributed power sources and micro-grids, and provide electricity access to the remaining 1% of the population. Meanwhile, the grid resilience will be consolidated and a stronger electricity supply system will be built to improve the national electricity supply quality.

Vietnam planned to realise electricity access to all households by 2020 and meanwhile reduce greenhouse gas emissions by about 5% by 2020, about 25% by 2030, and about 45% by 2050. The compilation of a new version of Vietnam's electricity development plan is underway (expected to be published in 2021).

5.2.4 Proposed Measures

There are some possible measures that could be considered to enhance the electrification programme in Vietnam.

(1) Develop scientific and rational supportive policies of consistency.

Vietnam needs to develop scientific, rational, and vigorous supportive policies with sustained continuity and effectiveness so as to guarantee the uninterrupted progress of energy access and sound development of renewable energy.

(2) Innovate project financing modes and expand financing channels.

Vietnam needs to innovate project financing modes in accordance with project characteristics, consider PPPs to attract social capital, and introduce international assistance funding or government direct investment and construction to address the "last mile" issue of electricity access.

(3) Strengthen regional grid connectivity.

The cooperation and connection projects with the AMS and GMS (Greater Mekong Sub-region) grids should be implemented by steps. The seven northern provinces could be connected with China's Yunnan Grid to obtain electricity via six transmission lines of two voltage levels (110 kV and 220 kV) as well as electricity supply to Vietnam at the 500 kV level.

(4) Implement a Solar Home System (SHS) plan.

Vietnam could actively popularise the demonstration project of solar power, make use of international funds such as loans from the World Bank and international aid funds to develop SHS, and give subsidies to users for the purchasing and leasing of equipment like diesel generators and energy storage batteries.

5.3 Lao PDR

5.3.1 Development Status

As a main power exporter to other ASEAN members, Lao PDR increased its electricity consumption per capita from 391 kWh in 2010 to 724 kWh in 2017. The household electrification rate rose from 71% in 2010 to 96% in 2019. Most households without electricity are in the mountains in central Lao PDR, on the border with Thailand, and around the Mekong River. The Government of Lao PDR has been able to significantly increase the electrification in the numbers of rural households through the strong engagement with the private sector and development partners in their rural electrification projects.

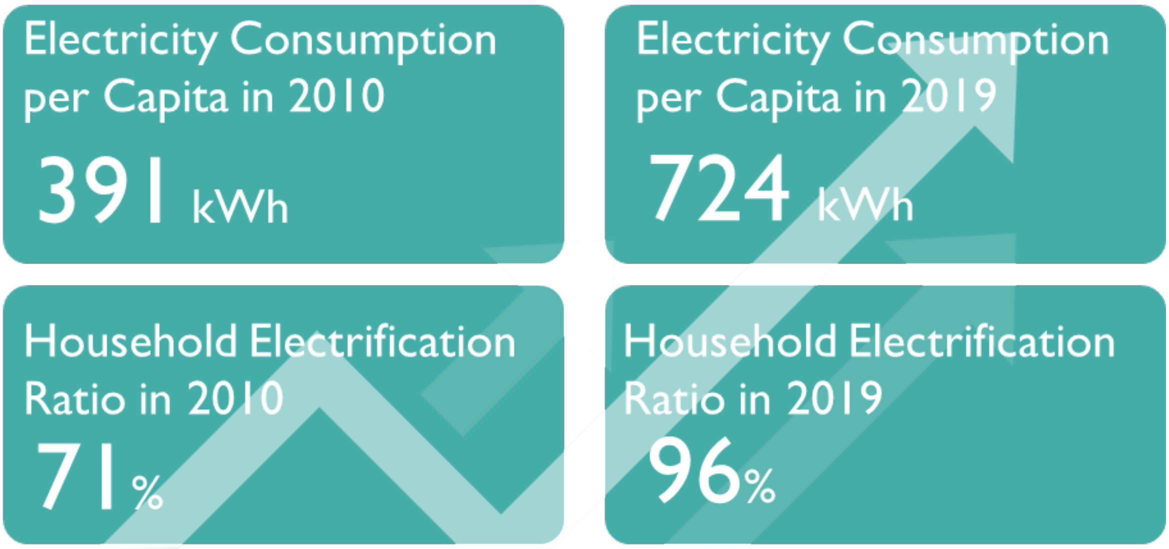


Figure 5-4 Lao PDR's Energy Access Development

5.3.2 Planned Target

Under the Rural Electrification Master Plan, the government hopes to meet a rural electrification target of at least 98% by the end of 2025 and 100% by 2030. To meet these targets, Lao PDR plans to further extend the grid and develop renewable energy, such as solar energy and small hydropower, in the rural areas.

5.3.3 Existing Problems

Based on various literatures, there are some identified existing challenges in Lao PDR on electrification programme.

(1) Extreme difficulties in grid extension to unelectrified areas due to the unaffordable investment costs.

(2) High losses from the distribution networks, and aged circuits and equipment. Hence, the

grid needs to be updated and upgraded urgently.

(3) Lack of a market-oriented mechanism in tariff pricing. This hinders the progress and growth of electricity enterprises.

(4) High investment costs and insufficient incentive policies make energy access projects less attractive.

5.3.4 Proposed Measures

There are some possible measures that could be considered to enhance the electrification programme in Lao PDR.

(1) Develop incentive policies for energy access to lower investment costs.

Lao PDR needs to improve the policy system for electricity access to the unelectrified remote areas and increase the financing of the public and private sectors for off-grid solutions. Lao PDR also needs to develop regional policies and tax exemption/reduction for SHS and mini-grid equipment so as to lower the investment costs and support the development of distributed energy by preferential taxes, loans, etc. to the domestic equipment manufacturers.

(2) Seek assistance from international capital and optimise the investment and financing environment.

Lao PDR needs to optimise the investment and financing environment to attract domestic and foreign investors; reduce the administrative examination and approval processes; simplify the licensing procedures on investment; and improve relevant laws, regulations, and mechanisms so as to provide investors in renewable energy with policy and legal protection, as well as encourage and attract more investment in the electricity projects in remote areas.

(3) Take proactive measures for the general planning of the domestic industrial chain of renewable energy suppliers and support the manufacturers of renewable energy equipment.

The government should give preferential treatment, such as tax concessions and loans, to the domestic equipment manufacturers, and attract domestic and foreign investment in energy development in remote areas by granting the franchise of electricity sales or preferential policies on tariffs, taxes, etc.

(4) Establish a multi-layer international cooperation mechanism and train professional technicians.

Lao PDR also needs to set up a special fund for international science and technology cooperation, specifically for science and technology planning. It also needs to attract transnational companies to establish energy research and development institutes in Lao PDR, in order to continue its public education efforts and the training of professional talents engaged in renewable energy business.

5.4 Myanmar

5.4.1 Development Status

At present, Myanmar has the lowest electrification rate among the AMS. According to the Ministry of Electricity and Energy (MOEE), a total of 5.206 million households in Myanmar were electrified in October 2019 with an electrification rate of 47.85%, accounting for only half of the world average. The electrification rates among different states and regions varied considerably. Kayah had the highest electrification rate of about 96.7%, followed by Rangoon. The household electrification rates in nine states and regions were lower than the national level.

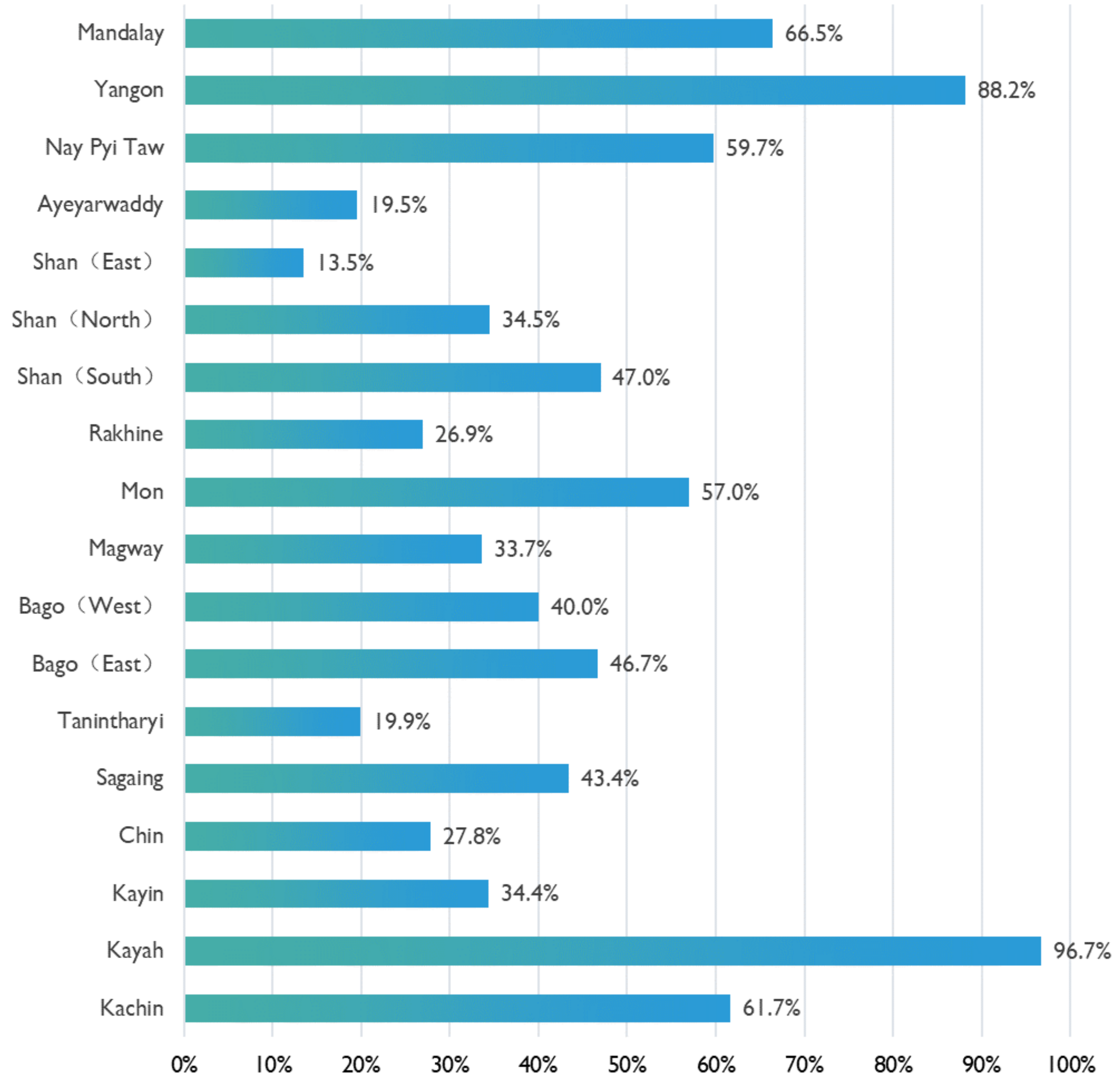


Figure 5-5 Myanmar's Household Electrification Rates by Region

5.4.2 Planned Target

The MOEE sets household electrification rate goals of 75% in 2021/2022 and 100% by 2030.

According to Myanmar's National Energy Plan (NEP) 2014, 7.2 million households will get electricity access in the coming 16 years. In 2020/2021, 500,000 households will be provided with SHS and 35,000 households will be provided with micro-grids.

5.4.3 Existing Problems

Based on various literatures, there are some identified existing challenges in Myanmar on electrification programme.

(1) Incomplete development of resources and unreasonable power source structure make it difficult to meet the electricity demand.
(2) The development of a main grid has been slow.
(3) Off-grid policies and legislation have not been officially enacted and the incentive policies are not clear.
(4) The low tariffs charged by the main grid increase the financial burden on the government.

5.4.4 Proposed Measures

There are some possible measures that could be considered to enhance the electrification programme in Myanmar.

(1) Utilise local energy resources in line with local conditions and properly develop other power sources with peak regulating capacity.

Myanmar needs to use its abundant renewable energy resources, such as natural gas, water, wind, and solar energy in line with local conditions; emphasise the regulating capacity building of the electricity system; adopt measures with respect to load, source, and grid; strengthen planning and construction of peak regulating power sources; and endeavour to consolidate system flexibility and adaptability.

(2) Optimise the grid structure, as well as upgrade and transform the distribution network.

While developing hydropower resources in the northern and eastern parts of the country, the government also needs to work on the construction and upgrading of backbone grids in the southern, northern, and eastern parts, and accelerate the construction and transformation of the distribution network for wider coverage. After the urban electricity supply is satisfied, the grid should be extended to rural areas to meet both urban and rural load demands.

(3) Clarify the connection mechanism of the main grid extension to the micro-grid or the off-grid vicinity to protect the rights and interests of all stakeholders.

Myanmar should establish a connection mechanism for the main grid extension to the micro-grid or the off-grid vicinity. It should also improve the relevant implementing rules to balance the interests of micro-grid or off-grid investors and the state grid and propose guidelines and specific rules under different business models. Moreover, it should safeguard the rights and interests of investors, equipment manufacturers, community, users, and other stakeholders, and thus promote the sustainable development of rural electrification.

(4) Enhance capacity building.

Myanmar also needs to focus on capacity building by regularly organising energy access training sessions to share advanced technology, as well as effective policies and financial operations, and best practices relating to energy access. It is imperative to improve the proficiency and management capability of the public, private sectors, and the community, and cultivate a local management team for the implementation of energy access solutions.

6 Conclusions and Recommendations

6.1 Conclusions of the Research

Based on the review on the condition in various AMS and also the lesson learned from other countries, there are several conclusion points.

(1) Energy access in ASEAN needs to address the "last mile".

To address the issue of the "last mile" of energy access, all countries should consider their own conditions to develop meaningful policies and measures, apply advanced energy technologies, and innovate project financing models to attract social capital and utilise international funds so as to attain the goal of energy access.

(2) Strong supportive polices guarantee energy access.

More than 70% of worldwide energy investment will be driven by governments. Therefore, the right policies and appropriate incentive measures are essential to guarantee energy supply, reduce carbon emissions, improve air quality in downtown areas, and expand basic energy access to rural and remote areas such as isolated islands and mountains.

Appropriate electricity tariffs present the most powerful policy tool. In the countries that have low electrification rates, such as Myanmar, Cambodia, and Lao PDR, scientific and reasonable fixed FiTs could be studied and developed to speed up the growth of renewable energy.

Use of the operation mode of project investment and financing is also critical to the expansion of electricity access. The government should develop rational operation modes of project investment, use social capital, international capital, government investment, user purchase, and other modes reasonably in accordance with different project properties so as to inspire enthusiasm for project engagement and broaden the coverage of energy access.

Innovative energy technologies are crucial. The new energy technologies, such as smart micro-grid, PV + energy storage, and distributed power, can quickly advance energy access progress in rural areas and on the remote islands.

(3) General case on isolated islands.

Among the AMS, most of the isolated islands belong to Indonesia and the Philippines. So far, the AMS have no specific policy for electricity access to isolated islands. Instead, they weave policies pertaining to isolated islands into the overall plans for improving the household electrification rate.

There are three ways to achieve electricity access to isolated islands, namely submarine cables, off-grid connections by micro- and mini-grids, and standalone systems. The use of submarine cables is suitable for the large archipelagos in coastal waters where the demand for electricity is high, and it is important that the supply is highly reliable. Off-grid connection programmes are suitable for isolated islands that have potential for higher economic development. Standalone systems are suitable for sparsely-populated islands that have no economic potential, and for which the only electricity demand is household consumption.

The government should carry out general planning in accordance with the resource characteristics of the islands and simultaneously push forward island development and energy development. As the islands of Indonesia and the Philippines have rich tourism potential, the governments could carry out their planning by focusing on the needs of tourism development, and start with energy access development in some key areas to advance the reasonable allocation of tourism and energy resources. The islands with development potential could adopt off-grid connection programmes under public-private partnership or solely-funded modes such that the off-grid system is operated and maintained by the private sector. PPP combines both governmental and private strength terms of funding, thereby not only offering more affordable electric tariffs, but also shortening the project development and construction periods.

(4) General case in rural and remote areas.

Most households without electricity access in Malaysia, Cambodia, Myanmar, Lao PDR, and Vietnam are located in rural and remote areas that are geographically hard to reach and have no proper infrastructure, causing challenges to grid construction.

The electrification of rural and remote areas can be realised by grid extension, off-grids, micro-grids, etc. By taking into account the natural and resource conditions, as well as the distribution of people without electricity, and in light of grid planning, energy utilisation conditions and investment costs, various electrification methods could be adopted in accordance with local conditions such as grid extension, PV, wind-solar complementation, and mini hydropower. Grid enterprises could try their best to extend the grid to the unelectrified households. Households that are scattered and not covered by the main grid could obtain electricity access through off-grid and micro-grid construction.

Restricted by geographical conditions, the rural and remote areas face very high costs for electricity access and therefore need governmental financial support. A few of the AMS (Indonesia and the Philippines) have issued relevant governmental financial and taxation policies specific to the rural and remote areas, e.g. the local policies and tax exemption, and reduction for SHS and micro-grid equipment. The practical cases show that full governmental engagement through a subsidy system can effectively lower the investment costs, spur enthusiasm for project participation and broaden the coverage of energy access.

(5) Absorb advanced experience to promote energy access.

The AMSs have gained plenty of successful experience in energy access. For example, despite the limited government budget, Sumba Island in Indonesia has made use of international assistance funds to develop an innovative plan that meets the local conditions and realises electricity access to the island. Through PPP, Masbate Island in Philippines has introduced an international investment of USD 23 million for the rehabilitation and upgrading of the electricity service. The result has been a halving of the generating costs and making it possible for the residents to afford clean electricity.

China's successful experience in energy access includes strategic planning, policy guidance, encouraging enterprises to fulfil social responsibility, etc. Under the comprehensive planning by government agencies, the leading role of planning is highlighted with clarified energy access targets and tasks, determined implementing parties, and well-established guarantee measures so as to ensure the overall consistency of the plans at all levels. Similarly, the government at all levels has attached importance to the development and construction of energy access projects, developed relevant instructive policies, and effectively implemented them through project subsidies, funding support, tax exemptions and reduction, etc. The electricity and energy enterprises directly under the central government and the competent private entities were encouraged to participate in the investment, construction, operation, and maintenance of the multi-energy complementation project on Dongfushan Island which served as a new impetus for energy access and guaranteed the smooth progress of the energy access project.

The African countries have been successful at using international aid and cooperative models to promote energy access. Kenya's K-OSAP is a significant part of a national electrification strategy with a total investment of around USD 150 million, the majority of which has been funded by the World Bank. The Government of Ethiopia and international organisations jointly conducted the Universal Electricity Access Program (UEAP) with a total investment of around USD 1 billion, 20% of which was funded by Ethiopia Electric Power through a credit loan while the remaining 80% was funded by government or international donators. Under the Nigerian Energy Support Program (NESP) jointly launched by BMZ and EU, Nigeria has achieved satisfactory results in renewable energy development, energy efficiency, and rural electricity access.

6.2 Recommendation for Further Work

(1) Orientation

Priority should be given to the utilisation of renewable energy. In the contest of a common response to global climate change, many countries are developing energy transition strategies to promote the development of renewable energy. The ASEAN region has abundant resources and types of renewable energy. To meet the regional renewable energy development targets, the AMS have developed short- and long-term plans for renewable energy development where the prioritised utilisation of renewable energy is the orientation of energy access across ASEAN. The distributed power sources should be developed in line with local conditions. Directly facing users, the distributed power source systems produce and supply electricity locally as per the users' demand. The localised development of distributed energy is critical to solve the "last mile" issue of energy access for isolated islands as well as rural and remote areas, which is the orientation of energy access in ASEAN.

(2) Policy support

Scientific and reasonable tariff policies should be developed to guide the power source restructuring and propel the development of renewable energy. Incentives through tax policies need to be issued including delayed payment of VAT, zero customs duty, tax-free periods, and soft loans for the import of renewable energy and energy protection equipment. National financial subsidies should be given for the development of renewable energy on isolated islands as well as in rural and remote areas. Rational project investment and operation modes need to be developed on the basis of project nature so as to reasonably make use of social capital, international funds, governmental investment, etc. to spur a passion for project engagement and broaden the coverage of energy access. The government should study and compile farsighted plans for renewable energy development, formulate feasible development goals, and issue scientific, rational, and strong supportive policies.

6.3 Realisation Path

(1) Reliable well-served

Build smart grids, join international cooperation, and boost high-quality development of electricity. Singapore, Thailand, and Brunei Darussalam have achieved 100% electrification rates and are thus able to build smart grids that can provide high-quality electricity supply. The measures include better energy usage management on the demand side for higher efficiency and accuracy of electricity use, information collection, establishment of intelligent and efficient grids, plus well-proven market-oriented operation mechanisms of electricity supply. In addition, there could be adoption of new methods of grid operation and maintenance such as drone patrol inspection, robot servicing, and video monitoring to guarantee the normal operation of all equipment. These countries should actively participate in international cooperation and global energy governance to reduce carbon emissions and pollution and use clean alternatives.

(2) Pre-development well-served

Stabilise preferential policies, develop distributed power sources, and overcome the "last mile" challenge. Indonesia, Vietnam, and Malaysia have basically realised universal energy access with only a few isolated islands as well as rural and remote areas still not yet electrified due to geographic limitations. These countries should develop strong policies and appropriate incentive measures to guarantee energy supply such as FiT policy, tax exemption and reduction, capital subsidy, etc. The development of distributed energy considering local conditions is critical to address the issue of "last mile" energy access in rural and remote areas. Proactive introduction of international capital to develop SHS or mini-gird in remote areas is suggested. A combination of government engagement, international financial support, and community engagement can give full play to their respective proficiency and efficiency which will help achieve 100% energy access as scheduled.

(3) On-going well served

Focus on rural areas and islands for development of energy access. The Philippines and Lao PDR have an electrification rate of around 95% and all their cities are electrified. The most challenging energy access issue in Lao PDR is the rural areas, while in the Philippines it is the isolated islands. Lao PDR should scientifically plan grids in accordance with the distribution of the unelectrified population, i.e. extension of the main grid in the densely-populated areas plus smart micro-grid or distributed solutions in sparsely-populated areas. Tax exemption and reduction policies for grid enterprises are also required and users are encouraged by financial subsidies to develop distribute power. For electricity access to the Philippines' isolated islands, those with significant tourism potential could attract foreign or social investment to address the electricity access issue, while those with little economic potential must rely on governmental investment, and meanwhile actively apply for international assistance.

(4) Priority served

Optimise the investment and financing environment, consolidate electricity infrastructure, and prioritise the development of energy access. The electrification rate of Myanmar and Cambodia is less than 85% and thus the two countries are in urgent need of accelerating the construction of nationwide grids, strengthening regional grid interconnection, and expanding the layout of exclusive electricity supply. Relying on the traditional financing channels such as governmental investment or international organisation aid can no longer meet the demands of energy access development.

The governments should optimise the investment and financing environment, shorten the administrative examination and approval processes, simplify the investment licensing procedures, and improve the legal system to attract investors both at home and abroad. They also need to improve the financing capability by continuous expansion of financing channels and innovation of financing models. A multilateral collaboration platform of "government + international organisation + energy enterprise + financial institution" should be built up to effectively create the ecology of energy access, dismantle key bottlenecks, realise mutual complementation of advantages, and spur resource integration, and thus quickly advance the construction and development of energy access.