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ON SMALL HYDROPOWER

World Small Hydropower Development Report 2022

South-Eastern Asia

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South-Eastern Asia

Countries: Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Thailand, Timor-Leste, Viet Nam

INTRODUCTION TO THE REGION

The region of South-Eastern Asia is undergoing rapid development and countries in the region have adopted different strategies with regard to the structure and developmental trajectory of their electricity sectors. The largest electricity producers in the region are Viet Nam and Indonesia. The electricity sector of Indonesia relies on a variety of energy sources and leads the region in installed geothermal power capacity, but is still dominated by fossil fuels. Viet Nam has a highly diversified energy mix and invests heavily in renewable energy sources, in part by attracting foreign renewable energy developers. Thailand is also focused on the development of renewable energy and leads the region in biomass capacity, which is also the country's leading energy source by installed capacity. Myanmar and Cambodia both employ a mix of hydropower and thermal power for generation, with Cambodia additionally having a significant solar power capacity. The electricity sectors of the Philippines and Malaysia are dominated by thermal power from fossil fuel-fired power plants, although both countries are making strides in the development of hydropower and other renewable energy technologies, including biomass, solar power and geothermal power. Timor-Leste is almost entirely dependent on diesel-fired thermal power plants, although solar power is beginning to make inroads in the country.

Hydropower is the leading energy source by installed capacity in Cambodia and the Lao People's Democratic Republic (Lao PDR) and a primary energy source for Viet Nam, Myanmar and Thailand. In practice, however, hydropower generation often lags behind that of thermal power by a significant margin, particularly in Thailand, with only the Lao PDR relying primarily on hydropower for electricity generation. In the Lao PDR, hydropower plays a unique role, as the country's generation capacity far exceeds current domestic demand. The Lao PDR is aiming to position itself as the leading electricity exporter in mainland South-Eastern Asia, with its electricity exports accounting for approximately two thirds of domestic electricity generation on average and reaching nearly 79 per cent in 2020. Much of this export-oriented generation in the Lao PDR is produced by hydropower plants of various sizes operated by independent power producers (IPPs), including foreign companies eager to invest in the country to take advantage of its abundant hydropower resources.

In other countries in South-Eastern Asia, hydropower plays an important but supplementary role. Viet Nam is the region's leading hydropower producer, but currently existing capacities are at near saturation relative to the remaining large-scale hydropower potential and further substantial expansion of the sector is unlikely. In contrast to other regional countries, the hydropower sector is almost non-existent in Timor-Leste and all existing hydropower plants in the country are operating at below capacity or are fully out of operation.

An overview of the electricity sectors of the countries in the region is provided in Table 1.

Table 1. **Overview of South-Eastern Asia**

Country	*Total population (million people)*	*Electricity access, total (%)*	*Electricity access, rural (%)*	*Total installed capacity (MW)*	*Electricity generation (GWh/ year)*	*Hydropower installed capacity (MW)*	*Hydropower generation (GWh/year)*
Cambodia	16	81	97	2,916	8,513	1,330	3,493
Indonesia	271	99	99	69,679	278,502	5,976	N/A
Lao PDR	7	100	100	10,328	39,967	8,304	N/A
Malaysia	33	100	100	26,030	168,906	6,245	26,296
Myanmar	54	56	N/A	6,977	23,532	3,262	10,107
Philippines	110	93	94	25,531	106,040	3,760	8,025
Thailand	70	100	100	39,760	186,503	3,110	6,310
Timor-Leste	1	96	94	305	604	0.4	2
Viet Nam	97	100	100	68,725	235,410	20,774	73,382
Total	-	-	-	**250,251**	-	**52,761**	-

Source: *WSHPDR 2022*[1]

Note: Data in the table are based on data contained in individual country chapters of the *WSHPDR 2022*; years may vary.

REGIONAL SMALL HYDROPOWER OVERVIEW

The definition of small hydropower (SHP) in South-Eastern Asia differs across countries. In Cambodia, Indonesia, Myanmar and the Philippines, SHP refers to hydropower plants with an installed capacity of up to 10 MW, while in the Lao PDR the threshold is 15 MW and in Malaysia and Viet Nam it is 30 MW. In Timor-Leste, the up to 50 MW definition is used. Thailand adheres to the up to 6 MW definition of SHP.

A comparison of installed and potential SHP capacities in the South-Eastern Asia region is provided in Table 2.

Table 2. **Small Hydropower Capacities by Country in South-Eastern Asia (MW)**

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed capacity (≤10 MW)*	*Potential capacity (≤10 MW)*
Cambodia	Up to 10 MW	1.7	300.0	1.7	300.0
Indonesia	Up to 10 MW	543.0	19,385.0	543.0	19,385.0
Lao PDR	Up to 15 MW	162.0	2,287.0	N/A	N/A
Malaysia	Up to 30 MW	296.0	1,500.0	N/A	N/A
Myanmar	Up to 10 MW	42.9	114.0	42.9	114.0
Philippines	Up to 10 MW	145.0	1,265.0	145.0	1,265.0
Thailand	Up to 6 MW	190.4	700.0	190.4*	700.0*
Timor-Leste	Up to 50 MW	0.4	N/A	0.4	219.8
Viet Nam	Up to 30 MW	3,600.0	7,200.0	N/A	N/A
Total	-	-	-	**923.4**	**21,983.8**

Source: *WSHPDR 2022*,[1] *WSHPDR 2019*[2]

Note: *Based on the local definition of SHP.

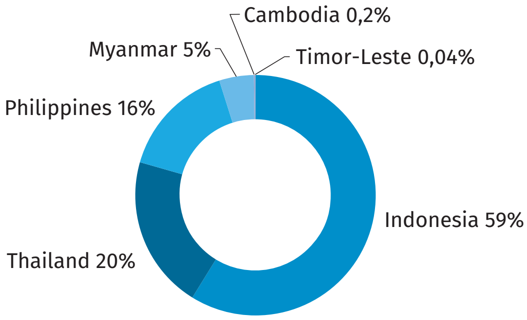
The total installed capacity of SHP up to 10 MW in South-Eastern Asia is 923.4 MW, while potential capacity is estimated at

21,983.8 MW. Relative to the *World Small Hydropower Development Report (WSHPDR) 2019,* the installed capacity has increased by approximately 9 per cent, while the estimated potential capacity increased by 34 per cent. The regional increase in capacities is primarily due to the expansion of installed capacity and a re-evaluation of potential capacity for SHP up to 10 MW in Indonesia. The largest expansion of installed SHP capacity in recent years has taken place in Viet Nam, but a direct comparison is complicated due to differing definitions of SHP.

SHP plays a major role in the energy strategy of many countries in South-Eastern Asia, variously forming a significant part of the domestic electricity supply to the national grid, attracting foreign investment, generating electricity for export and providing a means of rural electrification in remote areas. Viet Nam has the largest SHP sector in the region and one that is undergoing rapid development, having more than doubled its installed capacity in recent years. Active development of SHP is also taking place in Indonesia, Malaysia and Thailand, as well as in the Lao PDR, where the Government has had to adopt measures to reign in poorly-managed expansion of SHP projects. Myanmar has marginally increased its installed SHP capacity over the last few years but development is hampered by a number of factors including the ongoing conflict in the country. A number of new SHP plants have been built in recent years in the Philippines. By contrast, the SHP sector in Cambodia has stagnated as the country has focused on the development of large hydropower and other forms of renewable energy. Likewise, the few existing SHP plants in Timor-Leste have fallen into disrepair and no new projects are under consideration.

The national share of regional installed capacity for SHP up to 10 MW by country is displayed in Figure 1, while the share of total national SHP potential utilized by the countries in the region is displayed in Figure 2.

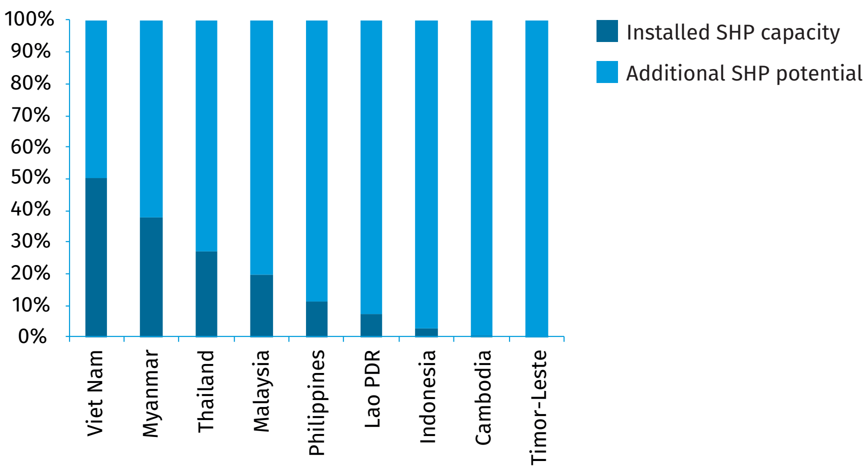
Figure 1. **Share of Regional Installed Capacity of Small Hydropower up to 10 MW by Country in South-Eastern Asia (%)**



Source: *WSHPDR 2022*[1]

Note: The Lao PDR, Malaysia and Viet Nam are not included due to lack of data.

Figure 2. **Utilized Small Hydropower Potential by Country in South-Eastern Asia (%)**



Source: *WSHPDR 2022*[1]

Note: For SHP up to 10 MW in the case of Myanmar, Philippines, Indonesia, Cambodia and Timor-Leste; data for the local definition of SHP used in the case of Viet Nam, Thailand, Malaysia and the Lao PDR.

As of 2020, the installed SHP capacity of **Cambodia** consisted of four plants with a total installed capacity of 1.7 MW constructed under grant aid from the Government of Japan and managed by the country's public electricity company. Several additional private micro-hydropower plants exist in different parts of the country, but data on their installed capacity is lacking. The country's potential capacity for SHP up to 10 MW is estimated at 300 MW, indicating that less than 1 per cent has been developed. There were nine SHP projects in the country in advanced stages of study as of 2021, in addition to 39 identified potential sites.

Indonesia has the region's second-largest SHP capacity at 543 MW (for SHP up to 10 MW) and the largest SHP potential, estimated at 19,385 MW, indicating that approximately 3 per cent has been developed. The country is actively pursuing SHP development, adding over 200 MW of additional SHP capacity in 2019–2020. New SHP plants have included both larger plants in the 1–10 MW capacity range as well as mini-hydropower plants with capacities below 1 MW, and have been constructed for both on-grid and off-grid operations. Multiple feasibility studies have been published in recent years, with the latest estimate of the country's SHP capacity dating to 2019.

The installed capacity of SHP up to 15 MW in the **Lao PDR** was 162 MW as of 2019, while potential capacity is estimated at 2,287 MW, indicating that 7 per cent has been developed. The country saw a burst of activity in the SHP sector following deregulatory reforms adopted in 2011, which delegated the approval process for SHP plants to provincial authorities, while also limiting investment in the SHP sector to local entities. Subsequent reforms adopted in 2017, following a string of disasters in the hydropower sector, again tightened central Government oversight of all hydropower projects but opened the SHP sector to foreign investment. As of 2019, there was a total of 252 MW of SHP projects in the development pipeline.

In **Malaysia**, the total installed capacity of SHP up to 30 MW was 296 MW in 2019 and potential capacity is estimated at 1,500 MW, indicating that 20 per cent has been developed. SHP development in the country has been very active, with over a dozen SHP plants build in 2017–2020 with capacities ranging from 2.2 MW to 24.5 MW. The construction of SHP projects has been spurred by the adoption of feed-in tariffs (FITs) in 2011. At the end of 2020, a total of 530 MW of SHP projects were in various stages of implementation.

The verifiable installed capacity of SHP up to 10 MW in **Myanmar** was 42.9 MW as of 2021, provided by nearly 350 SHP plants operated by the Ministry of Electricity and Energy as well as other government ministries. Additionally, over 2,000 privately-run micro-hydropower plants are estimated to exist across the country, but data on their cumulative capacity is not available. The potential capacity of SHP up to 10 MW in the country is estimated at 114 MW based on existing plants and identified sites, indicating that nearly 38 per cent has been developed. Two new SHP plants were constructed in Myanmar in 2018 and several projects were in the early planning stages as of 2021.

The installed capacity of SHP up to 10 MW in **the Philippines** was 145 MW as of 2021, while potential capacity is estimated at 1,265 MW, indicating that over 11 per cent has been developed. While the SHP sector in the country has seen active development in recent years, the total installed capacity of the country has decreased by a small margin due to the exclusion of non-operational SHP plants from government databases. A total of 17 new hydropower projects, primarily within the category of SHP, were in the early planning stages as of 2021.

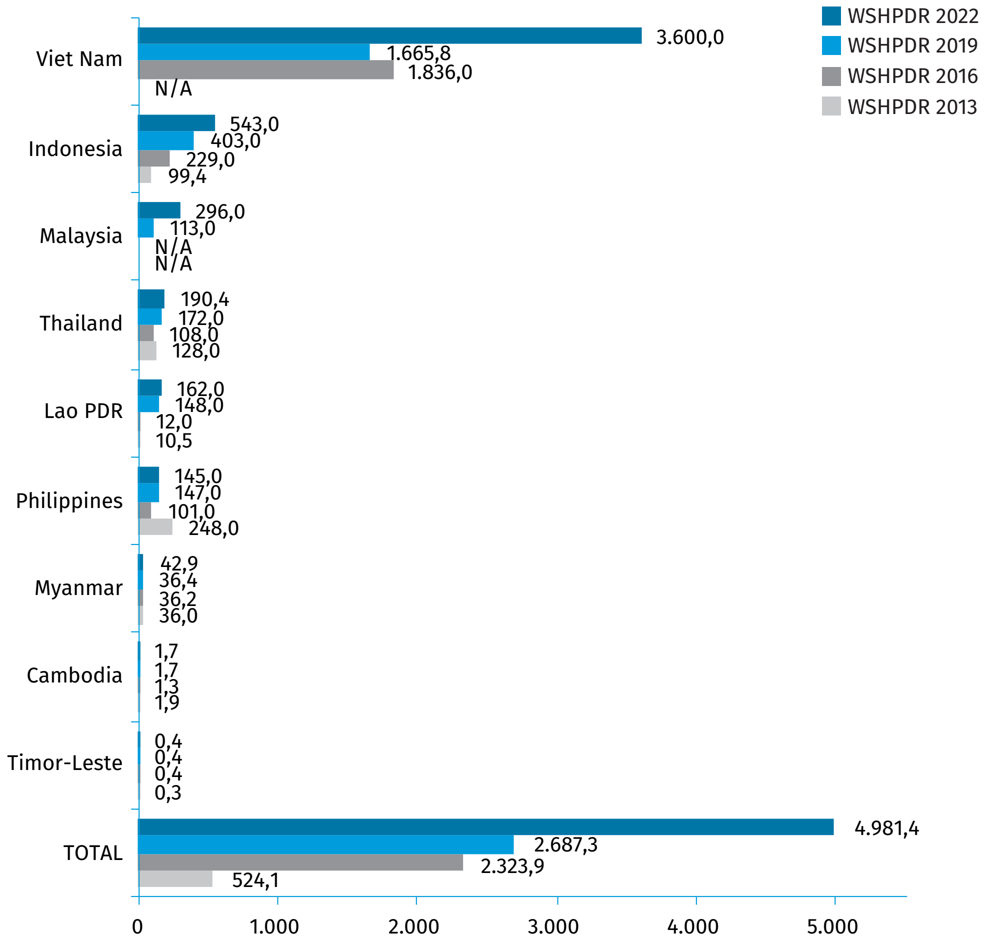
In **Thailand**, the installed capacity of SHP up to 6 MW was 190.4 MW as of 2020. The potential capacity for SHP up to 6 MW in the country is estimated at 700 MW, mostly concentrated in the northern part of the country, indicating that approximately 27 per cent has been developed. Several new plants have been constructed in recent years. The development of SHP in the country is promoted by the national Alternative Energy Development Plan (AEDP2018), which has set a goal of increasing the total installed capacity of SHP in the country to 376 MW by 2037. A total of 256 potential sites have been identified in the northern part of Thailand.

Timor-Leste has 0.4 MW of SHP capacity provided by three plants, which are all either fully inoperable or operating at significantly reduced capacity. The potential for SHP up to 10 MW in the country is estimated to be at least 219.8 MW, suggesting than 1 per cent has been developed. Potential SHP sites in the country have been inventoried by several detailed studies, but no concrete plans for further development of the SHP sector exist.

The total installed capacity of SHP up to 30 MW in **Viet Nam** was approximately 3,600 MW as of 2020, while potential capacity is estimated at 7,200 MW, indicating that 50 per cent has been developed. The SHP sector of Viet Nam has been growing at a rapid pace, more than doubling in installed capacity since the publication of the *WSHPDR 2019*. While the country's rapidly growing economy has led to ever-increasing electricity demand, its commitment to decarbonizing the electricity sector has led the Government to reduce targets for the expansion of thermal power while pursuing a radical expansion of hydropower, wind power and solar power over the next decade. With much of the country's potential large hydropower capacity nearing saturation, the development of SHP is expected to play an ever-increasing role in the overall growth of the hydropower sector. Under the draft Power Development Plan published in 2022, Viet Nam is aiming to increase its total SHP capacity to 5,000 MW by 2030 and to 5,900 MW by 2045. At the same time, accidents and environmental concerns have caused the Government to increase scrutiny of the SHP sector, leading to the cancellation of hundreds of planned and ongoing projects over the last decade.

Changes in the installed SHP capacities of countries in the region compared to the previous editions of the *WSHPDR* are displayed in Figure 3.

Figure 3. **Change in Installed Capacity of Small Hydropower from *WSHPDR 2013* to *WSHPDR 2022* by Country in South-Eastern Asia (MW)**



Source: *WSHPDR 2022*,[1] *WSHPDR 2019*,[2] *WSHPDR 2013*,[3] *WSHPDR 2016*[4]

Note: For SHP up to 10 MW in the case of Myanmar, Philippines, Indonesia, Cambodia and Timor-Leste; data for the local definition of SHP used in the case of Viet Nam, Malaysia, Thailand and the Lao PDR.

Climate Change and Small Hydropower

The hydrological regime in the region is governed by monsoon precipitation that is influenced by the El Niño Southern Oscillation (ENSO) and many regional countries such as the Philippines are highly vulnerable to climate change impacts. Climate change models predict future increases in flood damage and water supply deficits across the region. Countries such as the Lao PDR are already experiencing the impact of climate change, with hydropower generation shortfalls of 13–22 per cent registered in 2020. Hydropower development policies in the region should prioritize dam safety and basin planning to mitigate risks to SHP associated with flash flooding events. Moreover, reservoir-based SHP plants should be considered for future water infrastructure development to avoid the elevated vulnerability of run-of-river plants to fluctuations in streamflow.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Cambodia has considerable untapped SHP potential, but the country's renewable energy strategy has prioritized the development of large hydropower and other renewable energy sources over SHP, with solar power taking the lead in providing electricity access to remote off-grid locations in rural areas. A lack of a policy and legal frameworks and high construction costs make SHP less competitive than solar power projects that can be implemented on an ad-hoc basis. Despite several studies identifying a number of SHP sites in various parts of the country, comprehensive scientific data on prospective sites are also lacking.

The prospects for SHP development in **Indonesia** are overall very promising, as the country has targeted the development of both large hydropower and SHP as a climate change adaptation measure and, in the latter case, a means of off-grid electrification of remote areas. Government policy provides support for SHP development both in the form of FITs and power purchase guarantees. It is hoped that the SHP sector can become a platform for foreign direct investment, although currently funding is largely provided by the Government and domestic private investors. Issues complicating the development of SHP in the country include vague and complicated regulatory frameworks and licensing procedures, while regulations on foreign investment in the country are still perceived as inflexible and discouraging of large-scale investment in SHP.

The **Lao PDR** is likewise a promising market for SHP development due to the country's established role as a regional exporter of electricity from hydropower and strong momentum in the SHP sector since 2011, despite a number of high-profile dam failures and increased regulation. The Government's commitment to improving the quality of hydropower operations in the country through transparent negotiation procedures, regulatory frameworks and elevated operational standards stands to contribute to greater investment in the SHP sector. Remaining outstanding issues include the absence of a financing scheme specifically targeting SHP, frequently changing legislative frameworks and low domestic demand for electricity.

In **Malaysia**, support for SHP development has been historically provided by FITs allocated to independent power producers by the national electricity utility under the renewable energy power purchase agreements (REPPA). For most SHP plants, purchase tariffs for electricity are now determined through a competitive e-bidding system rather than predetermined premiums. Support is also provided in the form of power purchase guarantees and priority of dispatch, significantly reducing demand risk, as well as by flexible operating requirements with regard to generation volume. Barriers to SHP development include seasonal and topographic constraints on construction, long licensing periods and lack of adequate inter-grid connectivity, which complicates the evacuation of power.

Development of SHP in **Myanmar** is hindered by the lack of a comprehensive regulatory framework providing support for SHP, limited financial resources as well as limited ability of the local population to pay for electricity, limited local technical capacity and overall economic and political instability in the country. Assuming external financing can be attracted, the most promising direction for SHP development in Myanmar lies in off-grid applications in rural areas in need of electrification.

In the **Philippines**, SHP is incentivized through the Mini-Hydro Law, which provides privileged tax rates for SHP investments as well as tax and customs waivers for imports of materials and equipment for SHP projects. Additional support options for SHP include FITs and net metering as well as several international programmes providing funds for SHP development alongside other renewable energy sources. The country has a large, mostly untapped potential for further SHP construction. At the same time, development of SHP is hindered by increasing public opposition to hydropower, particularly due to competition for water resources from the agricultural sector, as well as a lack of domestic financing opportunities, particularly from the private sector.

Thailand has actively pursued renewable energy development and provides incentives for SHP in the form of FITs. While the country has considerable untapped SHP potential in the northern part of the country, most of the identified sites in this region lie in protected areas and are likely unsuitable for development. Additionally, the legal framework regulating the ownership of SHP projects is currently seen as unattractive by potential investors.

There is a potentially significant untapped SHP capacity remaining in **Timor-Leste**. However, development of SHP in the country is complicated by an over-supply of electricity leading to low demand for additional capacities in the near future, as well as by unique geological conditions which make the impoundment of water in reservoirs particularly difficult. The high cost of power generation from imported fossil fuels, electricity demand in off-grid rural settlements and the need for rehabilitation of existing capacities may provide some future opportunities for investment in SHP projects in the country.

There are many favourable factors for SHP development in **Viet Nam**, including significant undeveloped SHP capacity, comprehensive data sets on potential SHP sites and concrete plans for the expansion of the SHP sector over the next decade. While no FITs for SHP are available, development in the sector is incentivized through avoided-cost tariffs, defined as the difference between the cost of generation from SHP and the cost of generation of an equivalent amount of electricity from thermal power. Barriers to SHP development in the country include an insufficiently robust institutional and regulatory framework leading to lax oversight and environmental risks, poor quality control and ongoing revisions to national development plans leading to uncertainty among potential investors.

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Cambodia

Naichy Sea, Panha Hok, Chhunleang Rorm and Piseth Chea, Electricité Du Cambodge (EDC)

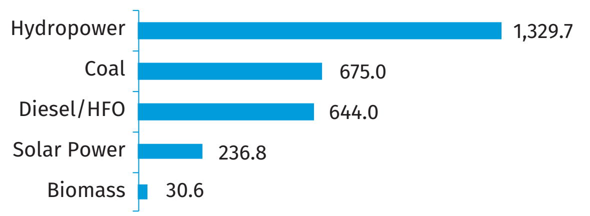
KEY FACTS

Population	16,486,542 (2019)[1]
Area	181,035 km[2]
Topography	Cambodia is characterized by four distinct topographical regions. The north is formed by an escarpment of the sandstone Dangrek Mountains. The south-west is dominated by the granite Cardamom Mountains, with the highest peak being the range of Phnom Aural. It reaches 1,813 metres above sea level and forms a watershed boundary between the rivers flowing down into Tonle Sap Lake and those flowing to the coastal area. The central flat lowland of Tonle Sap Lake is bounded by isolated hills. The east is dominated by mountain ranges.[2]
Climate	Cambodia has a tropical monsoon climate with two distinct seasons: six months of the dry season from November to April followed by six months of the rainy season from May to October Temperatures are the hottest in April with a monthly average of 29 °C (maximum 36 °C) and coolest in December and January (25.7 °C).[2]
Climate Change	The International Panel on Climate Change reported that Cambodia has already been experiencing long-term changes in climate and is plausibly vulnerable and exposed to this impact due to its low adaptive capacity and resilience.[3] In the future, the temperature in Cambodia is expected to get warmer, while changes in rainfall indicate an unclear trend and variability depending on the climate models used, geographical location and timeframe.[4] Changing rainfall patterns with warmer temperatures will lead to increased flooding, drought and storms which will also reduce resource productivity, especially in agriculture and fishery, and increase damage from extreme events, affecting electricity generation, roads, water supply and other infrastructure.[5]
Rain Pattern	The rainfall pattern of Cambodia is bimodal with two rainy seasons: in June/July and September/October. Average annual precipitation is 1,400 mm, but varies from 1,000 mm in the west to 4,700 mm in the south.[2]
Hydrology	The territory of Cambodia consists of three major watersheds: the Tonle Sap Lake/River, the Mekong River and the coastal area. Those represent 44, 42 and 14 per cent of the country's land area, respectively. The Cambodian section of the Mekong River has a length of 486 km with the drainage area of approximately 155,000 km[2]. Phnom Penh is located at the confluence of the Mekong and Tonle Sap Rivers and marks the beginning of the Cambodian Mekong floodplain. Downstream of Phnom Penh, the Mekong River splits into two: the mainstream Mekong River and the Bassac River tributary.[2]

ELECTRICITY SECTOR OVERVIEW

As of December 2020, the total installed capacity in operation in Cambodia was 2,916 MW. Hydropower, coal and diesel/heavy fuel oil (HFO) contributed 46, 23 and 22 per cent, respectively. Solar power and biomass accounted for the remaining 8 and 1 per cent of total capacity, respectively (Figure 1).[6]

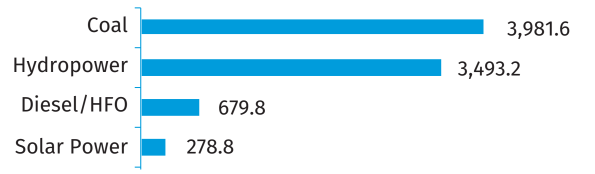
Figure 1. **Installed Electricity Capacity by Source in Cambodia in 2020 (MW)**



Source: EAC[6]

In 2020, total domestic generation amounted to 8,513 GWh with approximately 47 per cent supplied by coal, 41 per cent by hydropower, 8 per cent by diesel/HFO and approximately 4 per cent by solar power and biomass combined (Figure 2).[6]

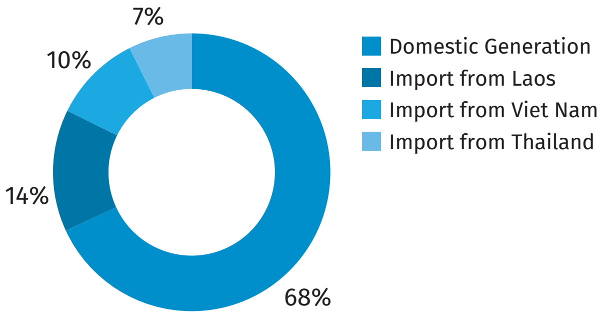
Figure 2. **Annual Electricity Generation by Source in Cambodia in 2020 (GWh)**



Source: EAC[6]

In order to meet the demand, in 2020 Cambodia imported approximately 3,986 GWh (32 per cent of total consumption) from the neighbouring countries, including Thailand, Viet Nam and Laos (Figure 3).[6]

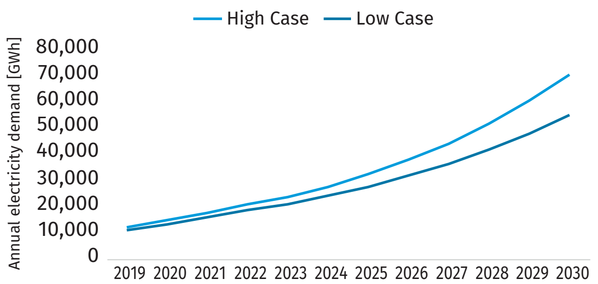
Figure 3. **Domestic and Imported Electricity in Cambodia in 2020 (%)**



Source: EAC[6]

The country's electricity demand has been growing fast. Between 2009 and 2019 the average annual growth rate of electricity supply was 19 per cent, whereas energy demand increased by approximately 18 per cent per year. Conservative forecasts (low case) estimate that the demand will rise from 13,494 GWh in 2020 to 27,766 GWh by 2025 and 54,804 GWh by 2030 (approximately a 400 per cent increase) (Figure 4).[7]

Figure 4. **Electricity Demand Forecasts in Cambodia 2015–2030 (GWh)**



Source: Chugoku Electric Power[7]

To meet the increasing demand, the Government of Cambodia has developed the Power Development Plan (PDP) for 2008–2021 and currently the new PDP and Electricity Supply Development Plan for 2020–2040 are under study. In line with the PDP, transmission lines are under construction and electricity has been imported from neighbouring countries. In 2011, the Government formulated the Promotion and Strategy Plan for Rural Electrification and set the target of at least 70 per cent of households to have access to quality grid-supplied electricity by 2030. As a result, by the end of 2020, the total household electrification rate reached 81 per cent, exceeding the Government's target.[6] By the end of 2020, 13,798 villages representing over 97 per cent of the total were electrified, while 370 villages representing less than 3 per cent were non-electrified.[6]

The Government also formulated the Electricity Supply Development Plan by 2020 aiming to increase the electricity generation from hydropower, coal and solar power in order to reduce generation from diesel and HFO as well as the country's dependency on imported fuels. As per the plan, seven new hydropower plants and three coal power plants were finalized and are currently operating. This allowed bringing the maximum capacity, including imported electricity, up to 3,897 MW in 2020.[6] The observed increase in installed capacity reflects the dramatic growth in demand, which resulted mainly from the stable political situation allowing the economic activity in all sectors to rapidly increase in the last decade. Moreover, the extension of the transmission network and the decrease in electricity prices for specific sectors are also factors that have contributed to the electricity consumption growth in the last few years.

At the end of 2020, the transmission network reached a total length of 3,130 kilometres combined of 500 kV, 230 kV and 115 kV transmission lines and 43 substations supplying directly to 24 cities and provinces. A further 2,133 kilometres of transmission lines and 15 new substations, capable of supplying directly to 25 cities and provinces, were planned or under construction.[6]

The power sector in Cambodia is administered and managed under the Electricity Law. Ratified in 2001, the law provides a policy framework for the development of an unbundled sector, facilitating substantial private sector participation on a competitive basis in generation and distribution. The Electricity Law also defines the roles of the Ministry of Mines and Energy (MME) as the policy maker, the Electricity Authority of Cambodia (EAC) as the regulator and supervisor and the Rural Electricity Enterprises (REEs) as the electricity service providers. MME is responsible for the planning and development of power projects through granting study rights and concessions for power generation to the REEs and Independent Power Producers (IPPs), development of related policies and strategies, promotion of the use of domestic energy resources, planning of electricity export and import as well as subsidies to specific classes of customers. In its turn, EAC is responsible for the control and regulation of the electricity sector, licences for the provision of electricity power services and tariffs.[8,9]

Electricité du Cambodge (EDC) is a state-owned limited liability company under the control of MME and the Ministry of Economy and Finance (MEF) and was authorized by a Royal Decree in 1996. In 2002, EDC acquired the consolidated licence from EAC and is responsible for electricity generation, transmission and distribution as well as electricity imports from, and exports to, the neighbouring countries. EDC is the largest of the REEs in the country. Other private REEs, such as Community Electricity Cambodia (CEC), are allowed to provide electricity to the national grid.

Due to the large hydropower potential being harnessed and additional coal power plants being developed, electricity tariffs are expected to decline in the future (Table 1). However, with the ongoing national power grid upgrade works, the tariffs will also have to compensate for the related costs.

Besides the regular electricity tariff rates, the Government also provides tariff reductions and subsidies.

Table 1. **Residential Tariff Rates in Cambodia in 2016–2021**

Type of consumption	*Tariff (USD/kWh)*					
	2016	*2017*	*2018*	*2019*	*2020*	*2021*
Electricity supplied by EDC in Phnom Penh and Takmao city						
>200 kWh/month, other than residents	0.195	0.193	0.188	0.185	0.183	0.183
51–200 kWh/month	0.180	0.180	0.180	0.153	0.153	0.153
11–50 kWh/month	0.153	0.153	0.153	0.120	0.120	0.120
< 10 kWh/month	0.120	0.120	0.120	0.095	0.095	0.095
Electricity supplied by EDC outside Phnom Penh and Takmao city						
>200 kWh/month, other than residents in provincial towns	0.195	0.193	0.188	0.185	0.183	0.183
>200 kWh/month), other than residents in rural areas	0.200	0.198	0.193	0.185	0.183	0.183
51–200 kWh/month in provincial towns	0.195	0.193	0.188	0.183	0.183	0.183
51–200 kWh/month in rural areas	0.200	0.198	0.193	0.183	0.183	0.183
11–50 kWh/month in provincial towns and rural area	0.200	0.183	0.183	0.120	0.120	0.120
< 10 kWh/month in provincial towns and rural area	0.120	0.120	0.120	0.095	0.095	0.095

Source: EAC[6]

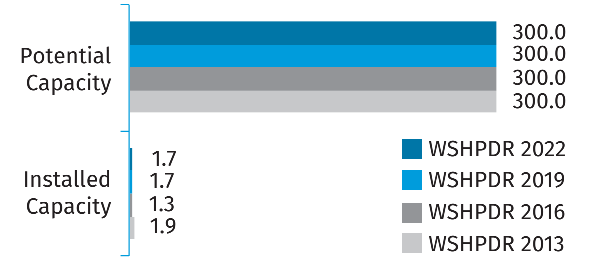
SMALL HYDROPOWER SECTOR OVERVIEW

Hydropower plants with an installed capacity of up to 10 MW are defined as small.

The current installed small hydropower (SHP) capacity is approximately 1.655 MW with an additional undeveloped potential of approximately 300 MW, indicating that 0.55 per cent of the potential has been harnessed.[10] In comparison to the *World Small Hydropower Development Report (WSHPDR) 2019*, both the installed and potential capacity have remained unchanged (Figure 5).

As of 2020, the installed SHP capacity of Cambodia consisted of four plants constructed under grant aid from the Government of Japan, and managed and operated by EDC (Table 2). There are also several privately-owned micro- and pico-hydropower plants in the northern part of the country, technically supported from Viet Nam and China, with individual installed capacities ranging between 1 kW and 30 kW. However, data on their installed capacity are not included in the total reported in this chapter.

Figure 5. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Cambodia (MW)**



Source: MME,[10] *WSHPDR 2013*,[11] *WSHPDR 2016*,[12] *WSHPDR 2019*[13]

Table 2. **List of Operational Small Hydropower Plants in Cambodia**

Name	*Location*	*Installed capacity (MW)*
O'Chum 1	Rattanakiri	0.265
O'Chum 2	Rattanakiri	0.960
O'Mleng	Mondulkiri	0.215
O'Romis	Mondulkiri	0.215
Total		**1.655**

Source: MME[14]

There are additional nine projects in an advanced study stage with a combined potential capacity estimated at almost 19 MW (Table 3).[14] A further 39 sites with a potential of 30 MW have also been identified and are in the reconnaissance stage (Table 4).[14] In 2006, the Ministry for Industry, Mines and Energy (now MME) and the Cambodian National Mekong Committee (CNMC) reviewed the country's hydropower potential and identified 63 potential sites for SHP and large hydropower projects throughout the country.[15] The total hydropower potential of Cambodia is estimated at approximately 10,000 MW, of which 1,321 MW was developed as of 2020.[16] Thus, only a small fraction of the country's total hydropower installed and potential capacity is from SHP. However, many large hydropower sites identified are highly controversial and unlikely to be developed due to such factors as negative impact on fishery, resettlements, land issues, limited environmental and social impact assessments as well as community consultations.

Table 3. **List of Small Hydropower Sites in Advanced Study Stage in Cambodia in 2021**

Name	*Location*	*Capacity (MW)*
Prek Por	Mondulkiri	4.80
Stung Kep	Kep City	4.10
O Phlai	Mondulkiri	3.40
O Sla Up Stream	Koh Kong	1.90
Stung Siem Reap 3	Siem Reap	1.70

Name	Location	Capacity (MW)
O Turou Trao	Kampot	1.12
O Kachanh	Ratanakiri	0.10
Stung Chikreng	Siem Reap	0.80
Prek Teuk Chhu	Kampot	0.76
Total		**18.68**

Source: MME[14]

Table 4. **List of Selected Potential Small Hydropower Sites in Reconnaissance Stage in Cambodia in 2021**

Name	Location	Capacity (MW)
O Sla Downstream	Koh Kong	4.48
Phnom Batau Down Stream	Koh Kong	4.20
Stung Sva Slab	Kampong Speu	3.80
Phnom Tunsang Upstream	Koh Kong	3.14
Phnom Tunsang Down Stream	Koh Kong	3.00
Phoum Kulen	Siem Reap	1.56
Tum Nup Garaing	Siem Reap	1.50
Stung Prey Klong	Pursat	0.89
Preak Antap	Kampong Cham	0.84
Stung Boribour	Kampong Chhang	0.81
Prek Toeuk Chhu	Kampot	0.7
Upper Stung SiemReap	Siem Reap	0.66
Preak Thum	Siem Reap	0.51
Stung Bannak	Kampong Chhang	0.40
Stung Moung 1	Battambang	0.40
Stung Moung 2	Battambang	0.40
O Sam Kaong	Siem Reap	0.33
Pteak Kaoh Touch	Kampot	0.32
Kball Chay	Sihanoukville	0.31
Stung Tras	Kampot, Kampong Speu	0.24

Source: MME[14]

RENEWABLE ENERGY POLICY

Although the Government has issued policies and regulations for the energy sector, some of which are linked to renewable energy including SHP, no national target for renewable energy utilization has been set yet.[15] According to the Power Development Plan, renewable energy is expected to account for more than half of the country's total energy production by 2020. In general, the renewable energy policy in Cambodia is directly related to rural electrification. In 2004, the Government issued a Royal Decree for the establishment of the Rural Electrification Fund (REF) to accelerate the development of electric power and renewable energy supply in rural areas. Among other objectives, REF aims to promote and encourage private sector participation in providing sustainable rural electrification services such as the development and economic application of technically and commercially proven new and renewable energy technologies.[17]

In 2006, the Government approved the Rural Electrification by Renewable Energy Policy with the main objective of creating an enabling framework for renewable energy technologies to increase access to electricity in rural areas. The Rural Electrification Master Plan (REMP) is the guiding document for the implementation of projects and programmes towards this goal.[17] To ensure power supply in the country in the future, MME has prepared two master plans titled the Power Development Master Plan in the Kingdom of Cambodia for 2020–2030 and the Long-Term Power Master Plan for 2020–2040, studied by Chugoku Electric Power Co., Inc and Intelligent Energy System Pty, Ltd, respectively.

The Government has provided guaranteed payments to several hydropower projects; however, such incentives are not available for other types of renewable energy such as biomass and solar power. The solar power market has been predominantly driven by the electricity needs of people who are unable to access on-grid electricity. Increased solar photovoltaic (PV) installation is also stimulated by the two programmes implemented by REF and MME, which are the Solar Home Systems (SHS) Programme and the Power to the Poor (P2P) Programme funded by the World Bank and the French Development Agency (AFD), respectively.[17]

It is reported that climate change will lead to an almost 10 per cent reduction of the Gross Domestic Product (GDP) of Cambodia by 2050. In response to this impact, a policy recommendation to climate change adaptation regarding renewable energy is to focus on investment into solar power for a total capacity of over 700 MW, including utility-scale, roof-top, solar battery mini-grid and solar home systems. It is estimated that this measure can directly abate 8.7 million tons of CO_2 by 2045.[18]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

The licensing system and procedure for hydropower projects in Cambodia is as follows:

- An IPP investor proposes a project plan to MME, the Cambodian Development Council (CDC) and MEF for obtaining a concession agreement for its development and providing an electricity service. The IPP also has to reach an initial agreement on the power purchase agreement (PPA) with EDC, after which EDC submits a draft PPA to EAC setting a power tariff and purchase conditions.
- After finalizing the agreement on the PPA between the IPP and EDC, EAC will issue a licence to the IPP to generate and sell electricity to EDC.

- Prior to the commencement of commercial operation of an electricity generating project, the IPP project, project operator and EDC jointly develop operating procedures.

However, all existing SHP plants in Cambodia were constructed with grant aid from the Government of Japan and were granted a generation licence and a consolidation licence by EAC.[19]

There are two regulations on the environmental impact assessment (EIA) in Cambodia: Initial Environmental Impact Assessment (IEIA) and Detailed Environmental Impact Assessment (EIA or Detailed EIA). For hydropower projects with a capacity of over 1 MW, the Detailed EIA is required.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

In general, SHP plants are more sensitive to climate change compared to larger hydropower due to their smaller scale. In 2014, the International Panel on Climate Change (IPCC) reported that South-Eastern Asia, and Cambodia specifically, has already been experiencing long-term changes in climate and is plausibly vulnerable and exposed to this impact.[3] Climate change imposes severe stress on ecosystems with far-reaching consequences, such as extreme climate events, including floods and drought among others. In turn, this influences the country's economic development, including electricity generation development. The impact of climate change on the development of SHP in terms of electricity generation are not uniform over different spatial scales such as local hydrological and geographic conditions. In comparison with other regions, the potential change in hydropower generation in Asia is linked to runoff. As such, small changes in climate conditions can lead to relatively large changes in SHP generation.

Hydropower operation and management should be properly optimized to correspond to any climate variations in the future. Particularly, an in-depth risk analysis of climate change impact on hydropower generation should be conducted and emergency plans for climate extremes should be prepared. Also, reservoir-based SHP plants should be considered for the future water infrastructure development as opposed to run-of-river plants.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

To attract more investors and reduce the risk of investment in SHP in Cambodia, there is need to refine investment costs, collect hydrological data and mitigate social and environmental impacts to make projects more technically and economically sustainable. To promote the decentralized, demand-driven approach in electrification and facilitate private sector involvement in SHP development, a number of barriers have to be overcome, including the following:

- High project costs. SHP is usually located in remote areas with limited access and far away from load centres, which implies the need for additional investment in infrastructure.
- Lack of a policy and legal framework. A policy and legal framework need to be created, e.g., concessionary duties and taxes concerning imports of SHP equipment.
- Access to financing for SHP projects. Banking and financial institutions operating in Cambodia provide credit for short periods with high interest rates ranging from 10 to 20 per cent per year, which impacts the financial viability of projects.
- Lack of energy market data. There is insufficient information available on the characteristics of the energy market, including the scope, potential and consumer characteristics. Few systematic studies exist for the potential of SHP resources in the country. There is also a need to conduct a more detailed financial analysis for investment purposes.
- Institutional capacity for planning, implementation and operation. There is a significant lack of technical knowledge and operational skills in the country. The lack of experience in operation and management as well as limited training possibilities are some of the factors causing institutional roadblocks. The lack of coordination among stakeholders (governmental agencies, development partners, non-governmental organizations, private investors and financial institutions) is another difficulty.

Taking into account that there remains untapped SHP potential in the country, further SHP development could be supported by the following:

- Grants from organizations and institutions;
- Lower interest rates for long-term loans from Cambodian banks and financing institutions;
- Lowering project costs via government support through REF if applicable and financeable, while EDC has so far supported private electricity suppliers in rural areas with accessing funds for investment in the expansion of electricity supply infrastructure in order to allow all rural households to have access to electricity;
- An improved policy and legal framework;
- Training of human resources with additional support from experts and relevant line ministries through either state or EDC funding;
- Capacity building in relation to SHP planning, construction, management, operation and maintenance;
- Ensuring that new SHP projects cause no or minor environmental and social impact, but rather improve the quality of life for communities living in vicinity of the projects.

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Indonesia

Vicky Ariyanti, Indonesia National Committee on Large Dams and Ministry of Public Works and Housing

KEY FACTS

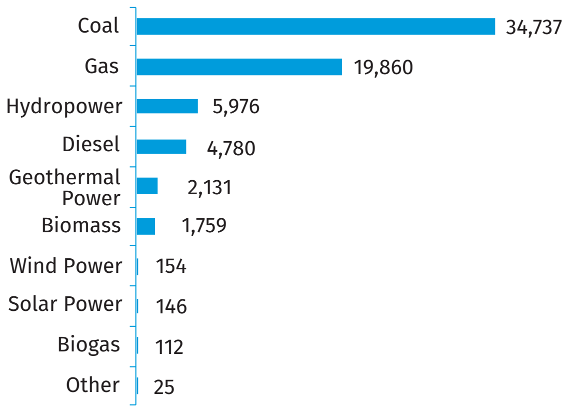
Population	270,625,568 (2019) [1]
Area	1,919,317 km² [2]
Topography	Indonesia is an archipelago made up of 13,667 islands, of which 6,000 are inhabited. The main islands are Sumatera, Java, Sulawesi, Kalimantan and Papua. The first three islands are located in the volcanic Pacific Ring of Fire, which stretches to the Philippines and Japan. The highest peak is Puncak Jaya (4,884 metres) located in the easternmost province of the country, Papua. Indonesia is affected by land subsidence in the cities of Medan, Jakarta, Bandung, Blanakan, Pekalongan, Bungbulang and Semarang as well as in the Sidoarjo Regency. The phenomenon is particularly worrying in highly populated coastal areas, which present the fastest subsidence rate and are also particularly vulnerable to flooding. The capital, Jakarta, is the fastest sinking city in the world by an average of 1–28 cm a year. The impact is most apparent in North Jakarta, with its lowest point at 4 metres below sea level.[2,3,4,5]
Climate	Indonesia is transected by the equator and has a tropical climate, with high humidity and high temperatures. Temperatures range between 23 °C and 31 °C, with the average being 28 °C. There are two seasons: the wet season which lasts from September to March and the dry season which lasts from March or June (depending on the area) to September. Indonesia is not often hit by typhoons, but does experience droughts caused by El Niño as a five-year-cycle periodic climate condition.[6]
Climate Change	Climate change impacts the Indonesian Archipelago, resulting in a shorter rainy season, which is characterized by more torrential downpours and an overall 12 per cent increase in rainfal.[7]
Rain Pattern	Precipitation patterns vary from island to island and are affected by the topography and wind patterns. Precipitation variations are usually from 1,300–3,200 mm in lowlands to 6,100 mm in the mountains, with the average annual rainfall of 2,700 mm.[2]
Hydrology	Water sources in Indonesia range from surface to groundwater. Rivers and springs are still mainly used for irrigation and drinking water supply. In the karst area in Java, underground rivers are also used as water sources. The country's main rivers are located in Kalimantan, Java, Papua and Sumatra. They are also used as a transport network. The longest river is the Kapuas (1,143 km) in Kalimantan, which flows from the northern-central mountains into the South China Sea.[2]

ELECTRICITY SECTOR OVERVIEW

In 2019, the installed capacity of Indonesia reached 69,679 MW, of which renewable energy sources accounted for 10,302 MW (15 per cent) and fossil fuels for 59,377 MW (85 per cent). Coal remains the main source of electricity generation in the country, accounting for nearly 50 per cent of the total installed capacity (Figure 1). In 2019, total electricity generation stood at 278,502 GWh. The state-owned company Perusahaan Listrik Negara (PT PLN) accounted for approximately 69 per cent (193,543 GWh) of the total, whereas 84,958 GWh was bought by the company from other producers.[8]

The goal of the Government is to reach a 99.7 per cent electrification rate by 2025.[9] In 2019, the electrification rate reached 98.9 per cent, which represents an 18.4 percentage point increase from the 2013 levels.[8] This has been achieved due to the emphasis placed on electrification by the Ministry of Energy and Natural Resources (ESDM), through the laws UU No. 30/2007 on Energy and UU No. 30/2009 on Electricity as well as the regulation Permen No. 4/2020.[10] Electrification

Figure 1. **Installed Electricity Capacity by Source in Indonesia in 2019 (MW)**



Source: ESDM[8]

inequality no longer represents a significant issue in Indonesia. However, in eastern Indonesia, in the East Nusa Tenggara and Maluku Provinces, the electrification rate is still lagging behind other regions at 85.8 per cent and 91.3 per cent, respectively. Nonetheless, these numbers are in stark contrast with the data reported in the *World Small Hydropower Development Report (WSHPDR) 2019*: 47.8 per cent and 58.9 per cent, respectively. On average, the rest of the regions have already reached an electrification rate of 95 per cent. Furthermore, the majority of the islands have a 100 per cent electrification rate and in rural areas nearly all villages in all provinces of the country have also reached a 100 per cent electricity coverage (Table 1).[8]

Table 1. **Rural Electrification Rates in Indonesia in 2015–2019**

Year	*Villages electrified*	
	Total	*Share of the total*
2015	79,680	96.95%
2016	79,689	96.96%
2017	79,808	97.10%
2018	81,683	99.38%
2019	83,003	99.48%

Source: ESDM[8]

The Government has established a target to add 35.6 GW of new installed capacity by 2025, which represents an additional 23 per cent increase from the 29 GW that have already been put into operation.[11] In 2016, the 2016–2025 Electricity Supply Business Plan (Rencana Umum Penyediaan Tenaga Listrik) set out the independent power producer (IPP) scheme to facilitate the development of the sector.[12] An independent assessment performed at the end of 2019, showed that there had been only a 10 per cent progress towards the set target (3.6 GW), with an additional 57 per cent of the target capacity being under construction (20.1 GW).[13] However, there are positive expectations for the results of the programme.

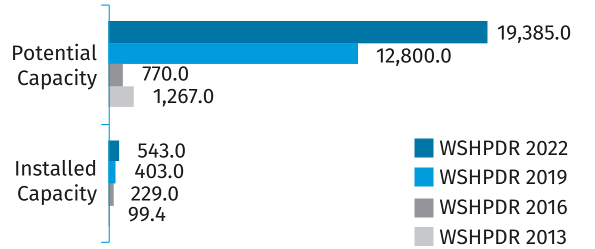
The Government plays an important role in setting electricity tariffs. The decision-making on tariffs is based on negotiations between the legislative and the executive bodies, rather than on objective decisions made by the PT PLN.[14] There are four groups of electricity consumers: residential, business, industrial and others divided into 12 subgroups.[13] The Government has heavily subsidized electricity tariffs, particularly for low-income households during the COVID-19 pandemic, and subsidies continue to be available. The Government provides subsidies of 100 per cent for 450 VA use and 50 per cent for 900 VA use.[15] The lowest tariffs are found in the Java-Bali power grid (0.07 USD/kWh), while the highest are in remote areas and small islands (0.21 USD/kWh).[16] In 2021, tariffs varied from 996.74 IDR/kWh (0.07 USD/kWh) to 1,444.70 IDR/kWh (0.10 USD/kWh). The subsidized tariffs since March 2021 are at 169 IDR/kWh (0.01 USD/KWh) for 450 VA and 274 kWh (0.02 USD/kWh) for 451-900 VA.[17] In 2019, tariff subsidies have slightly decreased from IDR 58.04 trillion (USD 4.02 million) in 2016 to IDR 51.71 trillion (USD 3.58 million).[8] The 2021 National Budget (APBN) also indicates that the subsidy allocations should be lower than in 2020.[18]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of small hydropower (SHP) in Indonesia is a combination of micro- (under 1 MW) and mini-hydropower (1–10 MW).[13] Most of SHP plants in the country are located on rivers or irrigation channels.[8]

In 2020, the total installed capacity of SHP was 543 MW from 185 listed SHP plants.[19] Compared to the *WSHPDR 2019*, the installed capacity increased by almost 35 per cent, whereas the potential grew by 51 per cent (Figure 2). The potential capacity of at least 12.8 GW reported in the previous edition was based on the PT PLN 2012 preliminary research.[20] Recently the ESDM published more detailed data from 2019, suggesting a higher hydropower potential: 74,656.5 MW for large hydropower and 19,385 MW for SHP.[21] It should be noted that the calculations do not account for off-grid SHP installations used on a small scale, from the village level to household generation, with capacity so low as to only light one house using the flow of an irrigation channel.

Figure 2. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Indonesia (MW)**



Source: PT PLN,[19] ESDM,[21] *WSHPDR 2013*,[22] *WSHPDR 2016*,[23] *WSHPDR 2019*[24]

Data on SHP development have improved as more attention has been paid on the policy level to developing renewable energy sources. In 2019, new SHP plants were installed across Indonesia with a combined capacity of approximately 162.2 MW. Due to increased interest in SHP, multiple feasibility studies have been conducted in recent years, with new SHP sites discovered.[21] In 2019, new mini-hydropower plants with capacity between 710 kW and 2,024 kW were built in several provinces.[13] In 2020, more projects were built, adding 58.8 MW to the total installed SHP capacity in the country, including: Lawe Sikap (7 MW), Wampu (9 MW), Kincang I (0.35 MW), Sinagma Unit 4 (0.2 MW) and Lakip.[25] Overall, in Indonesia SHP is considered to be a promising renewable energy source, especially for the development of off-grid locations, such as secluded islands or rural areas.

RENEWABLE ENERGY POLICY

The 2016 Nationally Determined Contribution (NDC) of Indonesia to reducing greenhouse gas emissions outlined the country's target of cutting the emissions by 26 per cent by 2020.[26] This target was later changed in 2017 to 29 per cent to be reached in 2020 and to 41 per cent in 2030.[27] The country has increased its budget for climate adaptation and mitigation efforts, including fiscal policies to reduce emissions in energy and land use. A 2017 study found that these efforts would not be enough to meet the country's climate commitments.[27] However, there is mitigation potential in the country's forest moratorium policy. Above all, the country needs to prioritize implementing renewable energy policies and improving private and public collaboration in this sector.

The renewable energy policy strategy is based on the ESDM Regulation No. 12/2017 concerning the utilization of renewable energy for electricity provisioning and improved electricity access in the coming 10 years. It is estimated that with the help of the IPP scheme 210 GW of total renewable energy potential could be developed. This potential consists of solar PV, biogas, large hydropower, waste, wind power, geothermal power, biomass, biogas and micro-hydropower. Renewable energy investment opportunities in Indonesia are largely dominated by the solar PV potential, whereas large hydropower is seen as the second key source. Conversely, SHP is not seen as a major contributor.[11] Incentives to support investment in renewable energy include financial loans with interest below market rates and fiscal incentives such as tax holidays, tax allowances, exemptions on import duties and VAT.

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

The recently-adopted ESDM Regulation No. 4/2020 stipulates that dams and irrigation channels built by the Ministry of Public Works and Housing (MPWH), regardless of size, are approved directly by the Minister under the commission of PT PLN and its subsidiaries.[28] This new policy was introduced in coordination with the MPWH strategic plan for 2020–2024, which establishes a progressive target. In 2019, it planned for the construction of 61 dams and 1 million ha of new irrigated lands. An additional 500,000 ha are planned by 2024, which will have an impact on irrigation channels all over the country as sources of SHP generation.[29] There are expectations that these policies will increase investment in SHP projects during the 2020–2024 period.

The current policy is geared towards the development of renewable energy, providing a significant tariff reduction due to a big price difference between the SHP plant's first and eighth years of operation. The ESDM's Regulation No. 4/2020 supports feed-in tariffs (FITs) for SHP up to 10 MW by PT PLN via the IPP scheme.[11] The Government also made open calls for these types of investment.[16] Furthermore, the prospect of the IPP scheme for SHP opened up possibilities for foreign direct investment in Indonesia. At present, funding comes from both the Government and private investors. Purchase obligation through direct selection for SHP-produced electricity is determined and uses a minimum capacity factor of 65 per cent.

COST OF SMALL HYDROPOWER DEVELOPMENT

Based on 2020 data from the ESDM, the investment cost for the development of SHP projects averages USD 2 million per MW.[25] The ESDM also stated that most SHP projects developed by PT PLN have a capacity between 0.2 MW and 10 MW, with an average of 3.9 MW. However, the higher the installed capacity, the lower the investment ratio per MW.

The high cost of SHP development results from the high imported content for the projects. However, Regulation No. 54/2012 of the Ministry of Industry, as amended by 5/2017 on Use of Domestic Products for Development of Electricity Infrastructure, stipulates the minimum domestic content requirement for renewable energy projects.[30] This regulation applies to all renewable energy projects carried out by state-owned enterprises, regional government-owned enterprises, cooperatives and private companies. However, according to the ESDM, the country's domestic industry cannot yet meet the above targets for local content. In 2018, for example, local content for hydropower projects between 15 MW and 150 MW only reached 33.8 per cent compared to the established target of 59.9 per cent.[31]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

There are different mechanisms available for funding SHP projects under the mini- (1–10 MW) and micro-hydropower (< 1 MW) categories depending on the location. For the former category, the Government provides investment. For the latter, private companies can participate in a bid. This arrangement provides opportunities for investors, especially to finance off-grid SHP plants in remote islands.

Nevertheless, Regulation No. 44/2016 on List of Business Areas Closed to Capital Investment and Areas Open with Conditions set out a very restrictive regulatory system for foreign players to invest in the Indonesian market. In relation to power generation, the regulation also sets different foreign investment restrictions based on the type of hydropower. Thus, no foreign investment is allowed for micro-hydropower (< 1 MW), a limitation of 49 per cent is set for mini-hydropower (1–10 MW) and a limitation of 95 per cent for large hydropower (> 10 MW).

Furthermore, all renewable energy projects that sell their electricity to PT PLN must be in a build-own-operate-transfer structure (BOOT). Developers must transfer their ownership to PT PLN at the end of the power purchase agreement (PPA), which forces developers to set higher prices during their PPA term. Therefore, it is important to compensate for the risk of negotiations with PT PLN to help deliver rapid deployment of renewable energy technologies in the country. One way could be to make it easier for developers to obtain long-term PPAs with guaranteed revenues.[31]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

The COVID-19 pandemic has highlighted the impact of the climate crisis on Indonesia — with a slowing pace of human activity, the speed of climate change reduced and resulted in on-time seasonal patterns in 2020. Consumption rates also decreased in 2020, notably due to a reduction of the industrial sector activity.[32] This context has served as a wake-up call for the Indonesian Government to increase the share of renewable energy sources in the country's energy mix. PT PLN, as the lead of SHP development, showed consistent will for acquiring all kinds of power generation, especially those coming from renewable sources and, thus, set a successful example for other smaller and local companies or IPPs to pursue SHP development.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

Despite the policies supporting SHP development in Indonesia, there are still significant barriers in place:

- Institutional frameworks that are still too general and institutional capacities that are not yet developed. The mechanism of receiving SHP permits still lacks transparency. In practice, the management of institutions is susceptible to changes in the political situation. The renewable energy policy framework established in 2020 will demonstrate whether it is sufficiently strong to put forward an agenda to support SHP initiatives.
- Unclear procedures for obtaining SHP development permits for private companies, especially for micro-hydropower, which might be explained by permit overlaps in the river basin management. For example, if the surface water resource is from an irrigation channel or weirs, it is complicated to determine which level of authorities will offer a mandate and release a permit for technical recommendations.[32]
- The quality of efforts in implementing the financial mechanism is also rather discouraging, with the fiscal and incentive mechanisms not yet implemented effectively. The lack of such mechanisms is, basically, due to the inflexibilities of budgeting schemes in the Government sectors. The investment of USD 2.0–2.5 million per MW is required; however, this amount is too low for project financing and too high for most actors in the private sector.
- The conditions for foreign investment need relaxation, especially for micro-hydropower. The investment for SHP projects at USD 2 million per MW is too high for most Indonesian start-up companies, but low for national level companies. The limitation on foreign ownership (49 per cent for SHP of 1–10 MW) is also making such investment less attractive.[19]
- Lack of standardization of PPAs and procurement processes. Although the current policy setting already indicates the mechanism, it still results in unbalanced agreements and reduces the reliability for investors.
- There is little incentive to develop SHP due to low awareness of the country's SHP potential, as well as limited equipment availability and limited infrastructure in rural areas. Overall, the benefits of off-grid electricity generation remain untapped in the Indonesian power system. The production by remote SHP plants lacks social support, and grid interconnection points are still insufficient for off-grid generation. Therefore, more effective power system planning is required, i.e., using an application that could back up the monitoring of the power grid scheme and off-grid generation in a single system.
- The current requirements of the BOOT scheme for project management are counterproductive, as are the procurement and contracting processes, negotiation practices as well as ownership restrictions, which should be changed towards a flexible modality of project financing.
- Aside from the restriction on foreign investment, the high local content requirements limit the ability of direct and fast implementation of SHP projects, especially in the case of latest technologies, which may not be produced in Indonesia.
- Access to basic data such as hydrometeorology, topography or geology should be made publicly available for any stakeholders. Furthermore, the available data sometimes lack reliability, especially in remote areas where data for precipitation are still manually recorded and can only cover a period of the last 20 years.

Despite these barriers, since 2017, the SHP sector has experienced a positive increase from 403 MW to 543 MW of installed capacity in 2020. The main obstacles identified are complex permitting procedures, the restriction of foreign investment as well as limited mechanisms for the further development of projects.

Nonetheless, with the enforcement of new regulations, it is expected that more attention will be paid to the benefits of SHP and the interest of the private sector to invest in hydropower will increase. The key enabling factors for SHP development in the country are:

- Significant undeveloped potential;
- Policy system conducive to further SHP development, including the FIT programme.

Further SHP development in the country could be facilitated by ensuring the following:

- Better data availability on SHP potential, especially in remote areas and smaller islands in the archipelago;
- A healthier investment atmosphere provided by the Government, including social stability and support to foreign investors in collaborating with local investors, which will enable the BOOT scheme to run, but with some flexibilities in terms of ownerships;
- Higher transparency in relation to technical requirements and the process of obtaining water usage permits.

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Lao People's Democratic Republic

Julian Chin, M8 Partners - Mekong Eight Group Co. Ltd

KEY FACTS

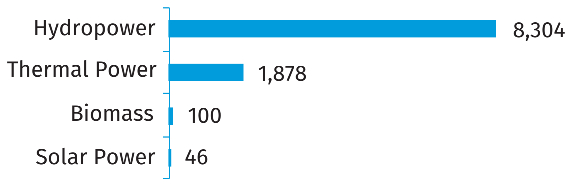
Population	7,275,556 (2020)[1]
Area	236,800 km^2 [2]
Topography	The topography of Laos is mountainous in most parts of the country. The Annam Range extends along the border with Viet Nam, rising to 2,817 metres at Phou Bia, the highest point in the country. The Tran Ninh Plateau in the north-east reaches heights of between 1,020 metres and 1,370 metres and the Bolaven Plateau in the south rises to 1,070 metres. Plains predominate in the south and central parts of the country along the Mekong River on the country's western border.[3]
Climate	Temperatures in Lao PDR are high throughout the year in most parts of the country, reaching a maximum of 35–38 °C and a minimum of 16–18 °C, with average daytime temperatures of 29–35 °C. In the subtropical northern regions, the temperature range is wider due to the occasional penetration of cold air from China and Siberia during the dry season and temperatures may occasionally drop to 0 °C in the highlands.[2,4]
Climate Change	Impacts of climate change are already being observed in Lao PDR in the form of more frequent extreme weather events and an increasing length of the dry season. Decreases in rainfall have been observed in many parts of the country, reaching 41 per cent in the Nam Ou basin during the first six months of 2019 relative to the same period in 2018. At the same time, a future increase in rainfall of 10–30 per cent is expected throughout the region, with wider differences in precipitation between wet and dry years.[5,6]
Rain Pattern	Rainfall in Lao PDR is driven by the monsoon climate, with two distinct seasons: a rainy season from May to October and a dry season from November to April. The average annual rainfall ranges between 1,400 mm and 2,500 mm in most parts of the country and exceeds 3,500 mm in the central and south-western regions.[4]
Hydrology	The largest river in the country is the Mekong, with 90 per cent of the territory of Lao PDR located within its drainage basin and contributing 35 per cent of the river's total flow. There are 39 tributaries of the Mekong within the country, of which 11 have a basin area of over 2,000 km^2 and a watercourse length of over 100 km. The total renewable water resources of the country are estimated at 333.5 km^3/year.[7]

ELECTRICITY SECTOR OVERVIEW

The electricity sector of Lao PDR is dominated by hydropower generation and national energy policy is oriented towards electricity exports. Total installed capacity of Lao PDR amounted to 10,328 MW as of January 2021, with hydropower providing 8,304 MW (80 per cent), thermal power from one coal-fired power plant providing 1,878 MW (18 per cent), biomass providing 100 MW (1 per cent) and solar power providing an additional 46 MW (less than 1 per cent) (Figure 1).[8,9]

The key public players in the energy sector are the national electricity regulator Électricité du Laos (EDL) and its spinoff company EDL-Gen, overseen by the Ministry of Energy and Mines (MEM). EDL oversees the domestic supply of electricity generated by plants operated directly by EDL and EDL-Gen as well as by independent power producers (IPPs) who contract with EDL-Gen. In recent years, most electricity generated in the country has been produced by IPPs, primarily for export. Lao PDR exports approximately two thirds of its domestic electricity production, although licensed IPPs are required to reserve a minimum of 10 per cent of their installed capacity for domestic markets.[10,11,12]

Figure 1. **Installed Electricity Capacity by Source in Lao PDR in 2021 (MW)**



Source: Chin,[8] Vientiane Times[9]

Total generation amounted to 39,967 GWh in 2020. Of this total, EDL and EDL-Gen were responsible for 2,821 GWh, while IPPs produced 37,145 GWh, with 16 IPPs under contract with EDL-Gen accounting for approximately 3,747 GWh.[11,13] Electricity exports in 2020 amounted to 31,468 GWh, with 2021 exports expected to reach 33,400 GWh.[9] Electricity demand has been increasing continuously since 2010 and is expected to reach 24,057 GWh by 2025 and 32,923 GWh by 2030.[14,15] Access to electricity in Lao PDR reached 100 per cent in 2019.[16]

The export of electricity is a key strategic direction for Lao PDR. The landlocked nation shares immediate borders with Myanmar, Thailand, Cambodia, Viet Nam and China, benefiting from the growth dynamics of those economies. For the last two decades, the Government of Lao PDR has actively used its policies and public statements to position Lao PDR as the premier electricity exporter in the South-Eastern Asia region, aiming to capitalize on the country's abundant hydrological resources.[17]

As the country lacks domestic financial infrastructure and human resource capacity to undertake complex engineering projects, recent developments in the power generation sector have relied on foreign direct investments, mostly through build-operate-transfer (BOT) concessions awarded to IPPs. However, transmission infrastructure remains predominantly Government-controlled, with limited connectivity between the country's four key subgrids (northern, southern and central No. 1 and No. 2). Policy on transmission infrastructure investment continues to evolve, with the China Southern Power Grid Company becoming the first foreign partner to establish a strategic relationship with the national regulator in this area.

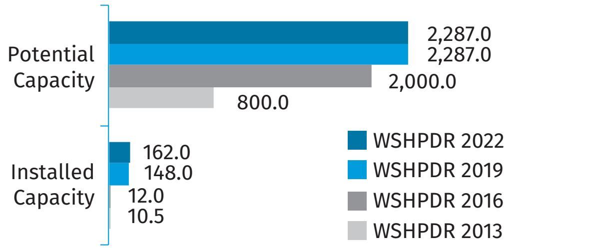
Recent development of the power sector in Lao PDR has included the completion of four new hydropower plants in 2020 despite the ongoing Covid-19 pandemic, adding 537 MW of installed capacity and a further annual generation potential of 2,139 GWh.[9]

Electricity tariffs in the country are set by EDL, with input from MEM as well as the Central Bank of Lao PDR. The current tariff structure stems from a 2008 study by SNC-Lavalin and was due for a review in 2018. However, the results from the review have not yet been formalized, partly due to the disruptions caused by the Covid-19 pandemic. End-user tariffs remained at 2017 levels as of 2021, with residential users paying approximately 50 USD/MWh.[18]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of small hydropower (SHP) in Lao PDR historically includes hydropower plants with installed capacity of up to 15 MW.[19] As of 2019, the total installed capacity of SHP up to 15 MW in the country amounted to 162 MW, while the estimated potential capacity equalled 2,287 MW.[10,20] Compared with the *World Small Hydropower Development Report (WSHPDR) 2019*, installed capacity increased by nearly 10 per cent due to the commissioning of new SHP plants, while potential capacity has remained the same as no new estimates have been produced.[20]

Figure 2. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Lao PDR (MW)**



Source: JICA,[10] *WSHPDR 2019*,[20] *WSHPDR 2013*,[21] *WSHPDR 2016*[22]

The active policy of the Government on promotion of electricity exports and hydropower development has had a marked effect on the growth of SHP in the country. As part of the attempts to balance development priorities, the Law on Electricity, as amended in 2011, decreed that hydropower projects below the 15 MW threshold would be classified as SHP and could be approved by provincial authorities. Furthermore, access to such projects would be effectively limited to local developers.[19] This created momentum in the SHP market, and led to a flurry of unsolicited SHP project proposals submitted by developers to provincial authorities and the issuing of a large number of development mandates.[23] Most of these mandates were confirmed following rushed feasibility studies, attached to power purchase memorandums signed with EDL. In contrast, development of pico- and micro-hydropower projects below 5 MW remained under the authority of the Government, along with the promotion of biomass and other renewable energy sources (RES). Table 1 provides a partial list of SHP plants constructed in Lao PDR in recent years.

Table 1. **List of Selected Existing Small Hydropower Plants in Lao PDR**

Name	*Location*	*Capacity (MW)*	*Type of plant*	*Operator*	*Launch year*
Nam Pheuk	Saysomboun	5	Run-of-river	NCG	2018
Nam Jao	Oudomsay	5	Run-of-river	DPS	2018
Champilik 35	Champassak	5	Run-of-river	Pasakon	2017
Nam Phai 2	Vientiane Province	3	Run-of-river	PCC	2016
Senamnoy 6	Champassak	5	Run-of-river	Phongsubthavy	2015
Nam Sen	XiengKhouang	5	Run-of-river	Bothong Inter	2014
Tadslane	Savannakhet	3	Run-of-river	SIC Manufacturing	2012

Nam Yone	Bokeo	3	Run-of-river	Nam Yone PC	2011

Source: Chin,[8] JICA[10]

In 2012, approvals for SHP spiked by a factor of five over the previous year. Of the total identified SHP potential capacity of 2,287 MW, approvals for projects totalling 1,140 MW were issued between 2012 and 2014.[24] As of 2019, a total of 252 MW of SHP projects was under construction.[10] Tables 2 and 3 provide some examples of ongoing SHP projects and still undeveloped potential SHP sites in Lao PDR, respectively.

Table 2. **List of Selected Ongoing Small Hydropower Projects in Lao PDR**

Name	*Location*	*Capacity (MW)*	*Type of plant*	*Developer*	*Planned launch year*	*Development stage*
Nam Ngum Keng Kaun	Xieng khuang	1	Run-of-river	N/A	2022	Under construction
Houykapheu 1	Saravan	5	Run-of-river	Vientiane Automation	2022	Under construction
Nam Karp	Saysomboun	12	Run-of-river	PSG Group	2023	Under construction
Nam Samouy	Vientiane Province	5	Run-of-river	Sana Construction	2023	Under construction
Nam Ngom	Bolikhamxay	5	Run-of-river	SDCC Co Ltd	2024	Seeking financial close

Source: Chin,[8] JICA[10]

Note: Data as of 2019

Table 3. **List of Selected Potential Small Hydropower Sites in Lao PDR**

Name	*Location*	*Potential capacity (MW)*	*Type of site*
Houychampi Pakang	Champassak	15	New
Nam Sanan	Luangprabhang	5	New
Nam Song Sieng	XiengKhoang	5	New
Houychampi	Champassak	5	New
Donsom	Champassak	5	New

Source: Chin,[8] JICA[10]

Note: Data as of 2017

A catastrophic failure of the main dam at the partially completed Nam Ao SHP plant (12 MW) in 2017 set off a re-evaluation of the hydropower sector by the Government. A year later, another dam failure at the Xepian-Xenamnoy hydropower plant (410 MW) cemented the Government's resolve to review and enhance safety standards at all hydropower project sites.[25] These events culminated in the 2017 amendments to the Law on Electricity, which effectively disbanded the classification of SHP within the hydropower sector, mandating that all hydropower projects, including those with an installed capacity of 5 MW and above, be developed under the unified central authority of EDL.[10]

The key legislative policy which directly governs the development of the hydropower sector in Laos is the Law on Electricity. While the 2011 amendments to the Law on Electricity arguably completed the deregulation of the hydropower sector for mid-scale IPPs, they also had the effect of limiting access to SHP projects up to 15 MW to local developers only. The subsequent amendments adopted in 2017, by removing the specially-regulated SHP designation, opened up hydropower projects of up to 15 MW to foreign investment, while concurrently elevating the standards for hydropower risk management. The amendments also triggered a revision of the key protocols for project development – the Lao Electric Production Technical Standards (LEPTS-2018). The revisions were carried out as part of a concerted effort by multilateral donors to address concerns about dam safety standards in Lao PDR highlighted by the 2017 and 2018 dam failures.[26]

RENEWABLE ENERGY POLICY

Development of RES in Lao PDR falls under the national Renewable Energy Development Strategy (REDS-2011). The policy was drafted under the purview of MEM's Institute of Renewable Energy Promotion (IREP) with the support of multilateral donor agencies and intended to run until 2025.[27]

While one of core aims of REDS was to promulgate the diversification of the national energy mix, much of its focus was directed towards meeting rural electrification targets. Nonetheless, the policy provided a platform for the Government's promotion of new variable renewable energy sources (VRES), which included SHP below 5 MW.

As the national conversation was overshadowed by hydropower generation for export purposes, the position on VRES pivoted on how competitively such resources could be developed in the country. Due to the insufficient integration of the domestic transmission infrastructure and the lack of an effective feed-in tariff ecosystem, the traction of VRES on the energy market in Lao PDR has been limited. However, issues with seasonal supply of electricity due to climate change and increasing international pressure to commit to the decarbonization of the energy sector is forcing the Government to consider RES more seriously.[28,29]

COST OF SMALL HYDROPOWER DEVELOPMENT

Access to locations remains a fundamental issue for project development in Lao PDR, particularly during the wet season, when construction is often suspended. The remoteness of potential SHP sites as well as the historical context of rural development in Lao PDR have also meant that collecting baseline hydrological and geological data is often the responsibility of potential project developers themselves. As these data are not publicly available, meaningful cost benchmarking for SHP plants is not easily done. However, projects already in commercial operation broadly indicate a cost range of USD 1.3–2.0 million per MW of installed capacity. The parameters driving cost variability in Lao PDR include degrees of civil engineering complexity due to geological issues, project head profile, engineering and maintenance, choice of electro-mechanical (E&M) supplier and other factors.[8]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

Options for financing SHP projects in Lao PDR are offered by a number of locally domiciled banking institutions. Such facilities are traditional non-recourse loans, backed by assets separate from the project itself, and typically offer up to 70 per cent of the project's developmental value, drawing a fixed interest in the range of 9–11 per cent (as of 2020). There is generally some scope for negotiation of preferential terms, however, and approvals are often tied to the contract for build construction. It is therefore commonplace for SHP projects in Lao PDR to follow the engineering, procurement and construction plus financing (EPC+F) models of larger hydropower plants.[8]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

The impact of climate change on generation from hydropower in Lao PDR is already being felt. Drought conditions at the end of 2019 and delayed rains in 2020 led EDL-Gen to fall short of its generation plan for 2020 by approximately 13 per cent, while IPPs contracting with EDL-Gen experienced a generation shortfall of over 22 per cent.[11]

As a key riparian state in the centre of the Mekong River, Lao PDR is subject to the climatic effects of upstream flows from China, while being held responsible for the downstream effects flowing into Cambodia and Viet Nam (the greater Mekong subbasin). Due to the position of Lao PDR as a critical food bowl for multiple population centres, coupled with the country's ambitious transboundary power development plans, geopolitics related to water resources development in the region is necessarily complex and a multitude of competing influences vie for control over water. To address competing demands, the contemporary approach is to view water within the nexus of food security, energy and developmental needs.[30,31,32]

Particular urgency is given in Lao PDR to mitigating the direct risks to SHP plants associated with flash flooding events. Indirect risks include acute water shortages having an adverse impact on power production, agricultural harvest and community water demands. To this end, the Government is actively prioritizing the quality of construction and dam safety modelling, as well as hydrological modelling and basin-wide planning to mitigate these risks.[33,34]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

While there remains some potential for new greenfield sites, a large portion of the potential capacity for SHP up to 15 MW has already been earmarked for development. Many of these concessions are pending investment. However, as the Government enhances its level of planning and solicitation of project proposals, quality of partnerships with local parties, contract conditions and construction standards will play an increasingly important role in SHP development in Lao PDR. And while deregulation persists, there remain structural barriers within the sector which need to be overcome, including:

- Lack of sophisticated financing options available through the domestic financial system;
- Lack of integration between transmission networks to support project risk mitigation;
- Ongoing ambiguity relating to the rights of legacy projects;
- Limited domestic demand, with EDL being the single domestic power purchaser;
- Frequently changing legislative frameworks around asset ownership and securitization to facilitate loans and project financing;
- Absence of a targeted investment scheme specific to SHP, due to the removal of hydropower classification from the national framework.

Enabling conditions for SHP development in the country include:

- Strong momentum in the domestic hydropower sector as of 2021, with an increasing number of de-risked projects coming to the market seeking financial close;
- The Government's strategy to make hydropower a cornerstone industry;
- Integration of the national grid remains a key focus;
- Future energy demand growth remains strong as domestic and Greater Mekong Subregion grids integrate, bringing in new partnerships in the energy sector;
- Financial and technical support from donors and multilateral organizations are accessible;
- There are increasing technical resources and support services available in the domestic market, further driving down the cost of project development;
- Improved data collation will further refine the national power development plan, leading to greater clarity in project prioritizations;
- Ongoing consolidation of the national regulator EDL will lead to improvements in the quality of contracts and operational standards;
- There is growing appetite for multipurpose water resource applications vis-a-vis integrated water re-

source management projects within the scope of the developmental nexus. As such, SHP plants must also play a critical role in water and food security, conservation of biodiversity and rural development.

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Malaysia

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KEY FACTS

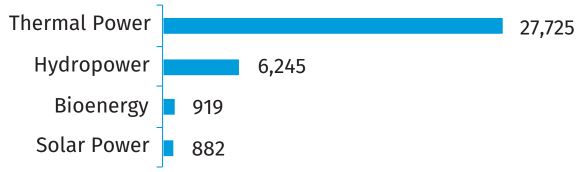
Population	32,720,000 (2019)[1]
Area	330,345 km^2 [2]
Topography	Malaysia is divided into three main regions: Peninsular Malaysia, Sabah and Sarawak. Sarawak and Sabah are located on the island of Borneo and are separated from Peninsular Malaysia by the South China Sea. Peninsular Malaysia shares a land border with Thailand and a maritime border with Singapore, while Sabah and Sarawak share land borders with Indonesia and Brunei. The topography of Malaysia is generally dominated by a mountainous core with half the land area lying at more than 150 metres above sea level. Elevations generally are less than 300 metres, but isolated groups of hills reach heights of 750 metres or more. The most prominent of these ranges is the Main Range, with peaks exceeding 1,200 metres. The highest peak is Mount Kinabalu of the Crocker Range, with an elevation of 4,101 metres. The terrain in the region is usually irregular, with steep-sided hills and narrow valleys.[3]
Climate	Malaysia has a tropical climate, without extremely high temperatures. Throughout the year, the average temperature ranges from 20 °C to 30 °C. Humidity is a common feature. Nights in Malaysia are fairly cool. Winds are generally light with mean annual speed of 1.8 m/s. However, towns in the east coast of Peninsular Malaysia, such as Mersing, Kota Baharu and Kuala Terengganu, experience stronger winds with monthly speed sometimes exceeding 3 m/s. Situated in the equatorial doldrums area, the territory extremely rarely enjoys a full day with a completely clear sky even during periods of severe drought. On the other hand, it is also rare to have a stretch of a few days with completely no sunshine except during the north-eastern monsoon season (November to March).[4,5,6]
Climate change	Temperature records in the past 30–50 years have shown changes in the range from 0.7 to 2.6 °C, while precipitation changes range from -30 to +30 per cent. Climate change in Malaysia has resulted in negative impacts such as changes in rain patterns, rising sea levels and subsequent coastal flooding and more frequent extreme weather events.[5]
Rain pattern	The seasonal wind flow patterns coupled with the local topographic features determine the rainfall distribution patterns over the country. The main rainy season in East Malaysia is characterized by heavy rains and runs between November and February, while August is the wettest period in Peninsular Malaysia. While Peninsular Malaysia receives an average rainfall of 2,500 mm, East Malaysia receives 5,080 mm of rain.[6]
Hydrology	Malaysia is drained by an intricate system of rivers and streams. The longest river, the Pahang, is only 563 km long. Streams flow year-round because of the constant rains, but the volume of transported water fluctuates with the localized and torrential nature of the rainfall.[7]

ELECTRICITY SECTOR OVERVIEW

In 2019, Peninsular Malaysia was 99.9 per cent electrified, with electricity being generated by power plants with a total installed capacity of approximately 26,030 MW (26,132 MW including the regional interconnection). The generation mix consisted of coal (12,066 MW), gas (11,000 MW), large hydropower (2,240 MW), solar power (429 MW) and small hydropower (SHP) (296 MW).[8] In 2020, Sarawak, the largest state in Malaysia, was 98 per cent electrified with an installed capacity of 5,222 MW. The energy mix in Sarawak was dominated by hydropower (3,452 MW), coal (1,102 MW) and gas (585 MW), with a further 84 MW from off-grid diesel and alternative energy sources.[9] Sabah, which is the second largest state in Malaysia, was 98 per cent electrified in 2019 with a dependable capacity of 1,277 MW from gas (968 MW), diesel (150 MW), large hydropower (81 MW), biogas/biomass (28 MW) and solar power (50 MW).[8] Total installed capacity in all states of Malaysia amounted to 35,771 MW in 2019 (Figure 1).[10] In 2019, Malaysia also benefited from a fully functioning regional power grid receiving 100 MW of power transfer from the Lao PDR via the Lao–Thailand–Malaysia (LTM) interconnection grid that is part of the ASEAN Power Grid.[8]

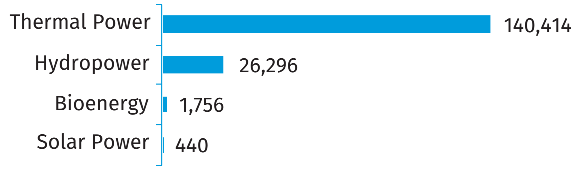
In 2018, electricity generation in Malaysia from all sources reached 168,906 GWh (Figure 2).[10] In 2019, the total electricity generation in Peninsular Malaysia increased by 2.54 per cent, to 130,009 GWh as compared to 126,790 GWh in 2018.[8]

Figure 1. **Installed Electricity Capacity by Source in Malaysia in 2019 (MW)**



Source: IRENA[10]

Figure 2. **Installed Electricity Generation by Source in Malaysia in 2019 (GWh)**



Source: IRENA[10]

In 2019, growth of the Malaysian economy slowed to 4.3 per cent compared to 4.7 per cent in 2018.[11] However, peak electricity demand increased by 1.2 per cent to 18,566 MW in Peninsular Malaysia, while in Sabah, demand grew by 4.8 per cent, reaching 1,001 MW.[8] The spike in demand in Peninsular Malaysia and Sabah was mainly attributed to hot weather conditions due the El Niño phenomenon.[8]

The country's continuing efforts to enhance energy security, affordability and sustainability have led to the implementation of a variety of initiatives that are also aligned with the national decarbonization and energy market liberalization goals. Since 2018, the country has seen an increase in renewable energy capacity as a result of the commencement of operations of Large-Scale Solar (LSS) and mini-hydropower projects, which contributed 429 MW and 296 MW, respectively. As of the end of 2019, a total of 21 large solar power plants had started commercial operations. In Peninsular Malaysia, renewable energy capacity recorded a fourfold increase from 179 MW in 2018 to 725 MW in 2019. Overall, as of 2019, renewable energy sources (excluding large hydropower) accounted for approximately 7 per cent of the total installed capacity in the country. This increase in the share of renewable energy in the energy mix is in line with the national target of achieving a 20 per cent share by 2025.[8]

As of 2019, a total of 1,449 MW of additional solar power capacity was awarded to 63 companies to develop large solar farms under the LSS Programme.[8] Solar power development was further boosted by a pricing policy revision for solar power produced by prosumers through the Net Energy Metering (NEM) scheme, which took effect on 1 January 2019. Under the revised scheme, prosumers can sell excess solar photovoltaic (PV) electricity to the grid on a one-on-one offset basis at Tenaga Nasional Berhad's (the national electric utility company) retail electricity tariff rates instead of on a displaced cost basis with lower tariff rates. As a result, 125 licences were issued in 2019 as compared to 37 licences in 2018.[8]

To facilitate renewable energy consumption, a premium tariff scheme for consumers wanting to buy green energy was introduced in 2019. The scheme provides consumers with the option of buying green energy from renewable energy sources with a premium of 0.08 USD/kWh without the need to install their own renewable energy generation system. Renewable energy capacity is also expected to be boosted following the Government's approval of a 10-year generation plan known as Malaysia Electricity Supply Industry 2.0 (MESI 2.0) for Peninsular Malaysia and Sabah, covering the period of 2020 to 2030. MESI 2.0 aims to liberalize the generation and distribution components of the power industry in Peninsular Malaysia as well as to better promote the use of green energy in Malaysia. The emphasis is on the promotion of solar power in Peninsular Malaysia and hydropower in Sabah.[8]

The share of fossil fuel-based generation is projected to decline from 82 per cent in 2020 to 70 per cent in 2030. While gas is expected to dominate the capacity mix for the period leading up to 2030, the prominence of coal in the energy mix will decline from 42 per cent in 2020 to 35 per cent in 2025. The share of gas in the energy mix by 2030 is projected to reach 41 per cent, compared to 29 per cent of coal, 7 per cent of hydropower and 23 per cent of other renewable energy sources.[8]

The electricity tariffs in Malaysia are determined by the Government through the Energy Commission. When it comes to residential tariffs, the rates in Malaysia are the lowest among five ASEAN countries (Malaysia, Singapore, Philippines, Indonesia and Thailand). For commercial consumers, only Singapore and Indonesia have marginally lower rates.[12] The residential tariffs can be seen in Table 1.

Table 1. **Electricity Tariffs in Malaysia in 2018**

Consumption category	*Tariff (MYR/kWh)*	*Tariff (USD/kWh)*
1 – 200 kWh per month	0.2180	0.053
201 – 300 kWh per month	0.3340	0.081
301 – 600 kWh per month	0.5160	0.13
601 – 900 kWh per month	0.5460	0.13
≥ 901 kWh	0.5710	0.14

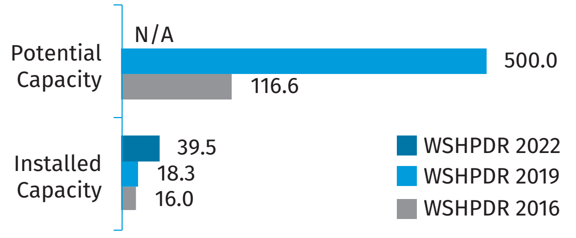
Source: Tenaga Nasional Berhad[12]

SMALL HYDROPOWER SECTOR OVERVIEW

Malaysian regulations classify SHP as run-of-river plants up to 30 MW in installed capacity.[13] In 2019, hydropower accounted for 17 per cent (6,245 MW) of total installed generation capacity in Malaysia, in which 4.7 per cent (296 MW) was contributed by SHP.[8] Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity of SHP up to 30 MW increased 162 per cent as a result of the commissioning of new plants in recent years (Table 2).

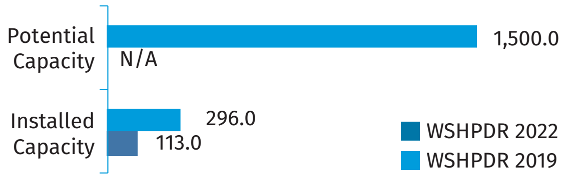
Additionally, new data on the estimated potential capacity of SHP up to 30 MW became available from the Malaysian Small Hydro Industry Association (Figure 3). No current data is available on the installed and potential capacities of SHP up to 10 MW (Figure 4).

Figure 3. **Small Hydropower Capacities up to 30 MW in the WSHPDR 2019/2022 in Malaysia (MW)**



Source: Energy Commission,[8] *WSHPDR 2013*,[14] *WSHPDR 2016*,[15] *WSHPDR 2019*,[16] SEDA[17]

Figure 4. **Small Hydropower Capacities up to 10 MW in the WSHPDR 2013/2016/2019 in Malaysia (MW)**



Source: *WSHPDR 2013*,[14] *WSHPDR 2016*,[15] *WSHPDR 2019*[16]

The development of major hydropower projects in Malaysia is generally undertaken by utility companies such as Tenaga Nasional Berhad (TNB) in Peninsular Malaysia, Sarawak Energy Berhad (SEB) in Sarawak and by Sabah Electricity Sdn Bhd (SESB) in Sabah. The adoption of SHP has been making progress in Malaysia, which has been spurred on by the implementation of the feed-in tariff (FIT) scheme under the Renewable Energy Act 2011.[18] Spearheaded by the Sustainable Energy Development Authority (SEDA), the FIT scheme offers investors in mini-hydropower plants the opportunity to sell electricity to the utility through the distribution grid system owned by the national utility company TNB through the standardized Renewable Energy Power Purchase Agreement (REPPA).[19]

From 2019, the FIT is to be limited to generation based on biogas, biomass, mini-hydropower and geothermal energy. In December 2019, under its e-bidding FIT programme for mini-hydropower projects, SEDA awarded quotas to 15 bidders for a total installed capacity of 176.79 MW, at an average bid tariff of USD 0.061 (MYR 0.259) per kWh. These projects are expected to start commercial operations in late 2025.[19]

Table 2. **List of Selected Operational Small Hydropower Plants in Malaysia**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Plant type*	*Operator*	*Launch year*
Kota 2	Lawas region, Sarawak	12.00	222	Run-of-river	-	2020
Sungai Tersat Mini Hydro	Hulu Terengganu	4.00	-	-	TNB	2019
Sungai Pelus Small Hydro	Sungai Siput Perak	24.50	-	-	Pelus Hidro Sdn Bhd	2019
Sungai Selama Mini Hydro	Selama Perak	9.00	-	-	Selama Hidro Sdn Bhd	2019
Sungai Geruntum Mini Hydro	Kampar Perak	2.00	-	-	Conso Hydro renewable energy Sdn Bhd	2019
Sungai Korbu Mini Hydro	Sungai Siput Perak	7.00	-	-	Kuasa Sezaman Sdn Bhd	2019
Sungai Kampar Mini Hydro	Kampar Perak	5.25	-	-	Koridor Mentari Sdn Bhd	2019
Sungai Slim Mini Hydro	Batang Padang Perak	6.00	-	-	Zeqna Corporation Sdn Bhd	2019
Sungai Benus Mini Hydro	Bentong Pahang	5.00	-	-	Pasdeq Mega Sdn Bhd	2019
Bintang Hydroelectric	Selama Perak	14.00	-	-	Kerian Energy Sdn Bhd	2019
Sungai Gelinting Mini Hydro	Behrang Perak	2.20	-	-	Gelinting Hydro Sdn Bhd	2019
Lower Liang Mini Hydro	Raub Pahang	10.00	-	-	Contour Mechanism Sdn Bhd	2018
Upper Liang Mini Hydro	Raub Pahang	10.00	-	-	Trident Cartel Sdn Bhd	2018
Tembat Hydropower	Hulu Terengganu	15.00	-	-	TNB	2017
Sungai Perting Mini Hydro	Bentong Pahang	6.60	-	-	Amcorp Perting Hydro Sdn Bhd	2015
Sungai Rek Mini Hydro	Kuala Krai Kelantan	3.20	-	-	I.S. Energy Sdn Bhd	2013
Sungai Kerling Hydropower	Hulu Selangor	2.00	-	-	Renewable Power Sdn Bhd	2012

Name	Location	Capacity (MW)	Head (m)	Plant type	Operator	Launch year
Sungai Pangapuyan Mini Hydro	Kota Marudu Sabah	4.50	-	-	Esajadi Power Sdn Bhd	2011
Sungai Kadamaian Mini Hydro	Kota Belud Sabah	2.00	-	-	Esajadi Power Sdn Bhd	2011

Source: Energy Commission,[20] International Journal on Hydropower & Dams[21]

Table 3. **FIT-Awarded Small Hydropower Projects under Construction**

Name	Location	Capacity (MW)	Operator	Planned launch year
Sungai Singor Mini Hydro	Hulu Perak	27.0	Singgor Hydro Sdn Bhd	2021
Bengkoka Lower River	Kota Marudu Sabah	13.5	One River Power Sdn Bhd	2021
Bengkoka Upper River	Kota Marudu Sabah	10.0	One River Power Sdn Bhd	2021
Togohu River Small Hydropower	Kota Marudu Sabah	5.6	One River Power Sdn Bhd	2022
Geroh River Mini Hydro	Kampar Perak	2.0	Kundor Hydro renewable energy Sdn Bhd	2022

Source: SEDA[19]

An inventory survey of hydropower resources of the country was conducted in the mid-1970s and has since been used as indicative information of available hydropower resources within the country. The total gross potential for hydropower development is estimated at approximately 414,000 GWh per year, of which approximately 123,000 GWh per year is technical potential. Seventy per cent of this potential is located in Sarawak (87,000 GWh), 20,000 GWh in Sabah and 16,000 GWh in Peninsular Malaysia.[22]

According to the Malaysian Small Hydro Industry Association (MASHIA), the SHP potential capacity of the country is approximately 1,500 MW, of which 530 MW were in various stages of implementation as of the end of 2020. In the near term, given the focus on enhancing renewable energy generation in the country, SHP projects, such as pumped-storage hydropower and, to some extent, off-river storage systems, will make inroads into the market.[17]

RENEWABLE ENERGY POLICY

At the 2015 United Nations Climate Change Conference (COP 21), Malaysia is committed to reduce the greenhouse gas (GHG) emissions intensity of its Gross Domestic Product (GDP) by 45 per cent by 2030 as compared to 2005. The sources of GHG emissions in Malaysia comprise mainly conventional power plants and vehicles. In order to achieve the COP 21 target, Malaysia is actively pursuing initiatives on developing sustainable energy, substitution to cleaner fossil fuels and adoption of electric vehicle technologies.[17]
In developing sustainable energy, since the early 1980s Malaysia has taken several initiatives to diversify its energy sources and revenue streams away from oil. The country's first National Energy Policy adopted in 1979 was aimed at paving the way for an efficient, secure and environmentally sustainable supply of energy in the future.[23] In 1980, the National Depletion Policy was established to conserve the country's resources by limiting the utilization of crude oil and gas. Since oil remained the main source for energy supply, the Four Fuel Diversification Policy of 1981 was formulated to balance the contribution of other resources, including gas, hydropower and coal, into the energy mix.[24]

The Five Fuel Diversification Strategy was formulated under the Eighth Malaysia Plan (2001–2005), in which biomass, biogas, municipal waste, solar PV and SHP were recognized as potential renewable energy resources for electricity generation. Renewable energy was introduced as the fifth fuel in the energy mix as a key initiative to ensure the development of a sustainable energy sector and to encourage the growth of renewable energy in Malaysia.[24]

To promote renewable energy as the fifth fuel, the Government launched the Small Renewable Energy Power (SREP) programme in 2001. Within the scope of this programme, small renewable energy power plants were regulated in order to contribute to the electricity grid network. In 2010, the Government launched the National Renewable Energy Policy and Action Plan (NREPAP), which incorporates the elements of the planned energy, industry and environmental policies to make them more convergent in nature. Subsequently, in 2011, the Renewable Energy Act was established to introduce a FIT and mechanisms for managing its implementation including the setup of SEDA to administer the overall process. The introduction of the FIT catalyzed a rapid growth of renewable energy as it minimizes the investment risk with the guarantee that developers will have access to the electricity grid network and long-term power supply contracts with the power utility company. The eligible renewable energy sources within this scheme are biogas, biomass, SHP, solar PV and geothermal power.[24]

The Eleventh Malaysia Plan (2016–2020) described a new energy policy with a major focus on exploring new renewable energy sources and further intensifying the development of renewable energy through the Net Energy Metering (NEM) and Large-Scale Solar implementation.[24] The NEM programme was updated to NEM 2.0 three years later by adopting the true net energy metering concept, which allows excess electricity generation with solar PV power to be fed back into the grid on a "one-on-one" offset basis. This has managed to reduce the period for return of investment to a mere three years especially for commercial and industrial installations, which also benefited from the various tax incentives provided by the Government. The initiatives are bearing fruit. Thus, SEDA approved a cumulative NEM programme quota of 108 MW as of the end of November 2019, which indicates a 7.8-fold increase compared with the previous three years, when the quota stood at only 13.86 MW. As of November 2019, a total of 751.21 MW of capacity had been installed under the FIT and NEM programmes.[19]

Besides the NEM programme for rooftop solar power, the Government introduced a Large-Scale Solar (LSS) programme in 2016. The total capacity allocated for LSS is 1,000 MW and is capped at 250 MW annually (200 MW for Peninsular Malaysia, 50 MW for Sabah). The programme lasted from 2017 to 2020. As of the end 2019, 21 LSS projects with a total installed capacity of 250 MW had been successfully installed and commercially operated.[25]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

The outlook for the SHP sector is highly linked to the FIT system, which was legislated under the Renewable Energy Act 2011. The FIT system has dramatically improved the commercial viability of SHP in Malaysia by supporting the investors via a premium tariff range for electricity generated from SHP plants.

In 2019, SEDA moved away from a system of predetermined rates per kilowatt hour for SHP to an e-bidding system to distribute quotas based on competitive bidding. The aim of e-bidding is to facilitate price setting for renewable energy generated from SHP through competition. The first e-bidding exercise was held in September 2019 for a total quota of 160 MW of installed capacity. Successful bidders secured quotas within a price range of 0.23–0.26 MYR/kWh (0.056-0.063 USD/kWh).[22]

A company that has obtained a FIT approval from SEDA for SHP plants may apply to the Energy Commission, the regulator of the energy sector in Peninsular Malaysia and Sabah, for a provisional licence issued under the Electricity Supply Act (ESA). This is typically done to facilitate the development of a renewable energy project and to enable the operator to apply for financial incentives and programmes prior to the construction and operation of the facilities and is intended to ease the entry of new participants into the renewable energy market.[26] The ESA licence relates to the construction of power plants and power installations and to the supply, sale, distribution and transmission of electricity. Other ancillary licences and certifications from the Department of Environment of Malaysia and the Malaysian Department of Occupational Safety and Health may also be required in the process of obtaining the ESA licence and approvals from the Energy Commission.[26]

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

There are a number of fiscal incentives in place that are specifically targeted at potential entrants into the renewable energy market in Malaysia including SHP project investors. For example, the Ministry of Energy, Science, Technology, Environment & Climate Change (MESTECC) has approved a budget of MYR 5 billion (USD 1.22 billion) under the Green Technology Financing Scheme (GTFS) to help fund new energy efficiency projects in Malaysia for the period of 2018–2022. Additionally, on 6 March 2019, the Ministry of Finance approved an upgraded scheme, GTFS 2.0, for companies that are majority Malaysian-owned, allocating MYR 2 billion (USD 490 million) for the period between January 2019 and the end of 2020. GTFS 2.0, which is to last for two years, offers successful applicants an interest/profit rate subsidy of 2 per cent per year on loans and financing for the first seven years of the financing term and a Government-issued financial guarantee of 60 per cent of the green component cost. As of the end of 2020, the official GTFS website listed 655 projects approved and certified for the GTFS scheme.[26]

The Malaysian Investment Development Authority (MIDA) also offers tax incentives for green technology projects and services. Subject to any other conditions imposed by MIDA, a Malaysian company that undertakes a green technology project, including an SHP one, or a company that purchases green technology assets as listed in MIDA's MyHijau Directory, may be eligible for an investment tax allowance of 100 per cent of the qualifying capital expenditure incurred from the year of assessment 2013 until the year of assessment 2020. Similarly, a Malaysian company that provides green technology services is eligible for an income tax exemption of 100 per cent of its statutory income from the year of assessment 2013 until the year of assessment 2020.[26]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

While solar power receives overwhelming attention in Malaysia, other investors look into other resources to boost their renewable energy portfolios. Of all the other renewable sources, SHP is rising to have the next best potential after solar power. Despite the overall benefits, Malaysia also appears to be facing a number of specific challenges in developing SHP including:

- Longer gestation period compared to other renewable sources due to difficult terrain and limited working season;
- Lack of hydrological data for analyzing the reliability of the plants;
- Construction challenges are present as projects may demand extensive civil works, especially if they are located in remote areas;
- Lack of adequate inter-grid connectivity, which poses obstacles for the evacuation of power;
- Control and diversion of water flows is subject to federal and state regulations, resulting in long periods

required for obtaining the many authorities and agencies' approvals.[27]

Notwithstanding the challenges and difficulties, the existing SHP potential is already translating into bidding interest. The enablers for SHP development in Malaysia include the following:

- In the current regulatory framework, SHP developers are not exposed to demand risk as fixed energy payments are their current sole source of revenue;
- The off-takers must accept and purchase all the electricity generated, up to a pre-specified quantity, known as the maximum metered renewable energy for SHP, as stipulated in the REPPAs. This priority of despatch enjoyed by SHP energy producers moderates the absence of fixed availability-based revenue, which is typically earned by thermal power plants;
- The operating requirements are also undemanding as SHP energy producers will only be penalized if they fail to deliver 70 per cent of their declared annual quantity.[28]

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Myanmar

Thet Myo, UNIDO Myanmar; Aung Thet Paing, Federation of Myanmar Engineering Societies

KEY FACTS

Population	54,409,794 (2020)[1]
Area	676,590 km^2 [2]
Topography	Topographically Myanmar can be divided into four main parts: the eastern highland region, the central valley region, the western hills region and the south-western costal region. The eastern highland region is dominated by the Shan Plateau, which reaches altitudes of 900–1,200 metres. The central valley region consists of a broad basin draining into the Ayeyarwady River. The western hills region is an extension of the Himalayan Range and is known as the Anout Yoma. Mount Khakabo Razi is a part of Anout Yoma and is 5,881 metres high. The south-western costal region, consisting of the Rakhine, Ayeyarwady and Taninthayi regions, is 1,930 kilometres long.[3]
Climate	Myanmar has a tropical monsoon climate. Climatic conditions vary widely depending on the location due to differing topographic characteristics. Myanmar has three seasons: the hot season from March to May, the wet season from June to October and the cool season from November to February. On average, temperatures in central Myanmar during the hot season can reach highs of over 40 °C, with highs of less than 30 °C in the north.[3]
Climate Change	Myanmar is widely considered one of the most vulnerable countries in the world in terms of the impacts of climate change. Climate change impacts have included more frequent and severe floods, cyclones and droughts, leading to tens of thousands of deaths and billions of dollars' worth of economic damage from extreme weather events in recent decades. Between 1981-2010, temperatures in the country had risen between 0.14 °C and 0.35 °C per decade, with climate change models projecting a 0.8-2.6 °C increase in maximum temperatures by 2100 under a moderate climate change scenario.[4,5,6]
Rain Pattern	Rainfall in Myanmar varies widely across seasons as well as regionally and is influenced by both the South Asian and East Asian monsoons. The nationwide annual precipitation average is estimated at 2,000 mm, while in the south-western costal region (the Rakhine coast) annual precipitation averages 3,200 mm and in the eastern highland region 1,400 mm.[3]
Hydrology	Myanmar has a favourable situation with respect to water resources. There are only a few transboundary rivers, with virtually all water resources located within the national borders. The Ayeyarwady River is the longest in the country at 2,063 kilometres and flows from north to south. The other major rivers are the Thanlwin (1,660 kilometres), the Chindwin (1,151 kilometres) and the Sittaung (310 kilometres).[3]

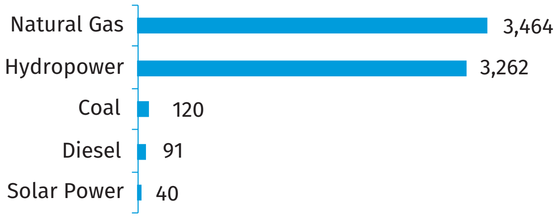
ELECTRICITY SECTOR OVERVIEW

Myanmar is endowed with abundant energy resources, particularly hydropower and natural gas, which are the main energy sources for electricity generation. Electricity demand has steadily increased in recent years, exceeding the available generation and transmission capacity. Consequently, Myanmar has the lowest electric power consumption among the member states of the Association of South-East Asian Nations (ASEAN).[2]

The total installed electricity capacity of Myanmar was 6,977 MW in 2020, consisting of 3,464 MW (50 per cent) from natural gas power plants, 3,262 MW (47 per cent) from hydropower plants, 120 MW (2 per cent) from coal power plants, 91 MW (1 per cent) from diesel power plants and 40 MW (less than 1 per cent) from solar power plants (Figure 1).[7] Other renewable energy sources (RES), such as biomass, geothermal power and wind power, are not significantly developed in the country and their installed capacity is negligible.

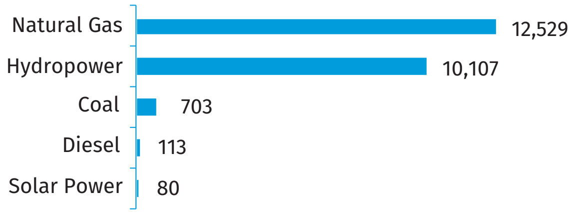
Total electric power generation in 2020 was 23,532 GWh.[8] Of this total, 12,529 GWh (53 per cent) came from natural gas power plants, 10,107 GWh (43 per cent) from hydropower plants, 703 GWh (3 per cent) from coal power plants, 113 GWh (less than 1 per cent) from diesel power plants and 80 GWh (less than 1 per cent) from solar power plants (Figure 2).[8] Generation has increased dramatically in recent years due to the commissioning of new natural gas power plants, which now form the largest single source of generation in the country, in addition to some growth of generation from solar power.

Figure 1. **Installed Electricity Capacity by Source in Myanmar in 2020 (MW)**



Source: MOEE[7]

Figure 2. **Annual Electricity Generation by Source in Myanmar in 2020 (GWh)**



Source: MOEE[8]

In recent years, Myanmar has experienced accelerated development of generation capacities from RES. The first solar power plant in the country (40 MW) became operational in June 2019. An additional 29 solar power plants with an installed capacity of 1,030 MW had been planned for construction by 2021, however, implementation of these projects has been delayed by political instability. Solar power was expected to provide 14 per cent of the country's generation mix by 2022, but has fallen short of this target.[9]

The nationwide electrification rate in Myanmar increased from 34 per cent in 2016 to 56 per cent in 2020. Earlier plans provided for 100 per cent electrification in the Yangon region and 75 per cent in the Mandalay region by 2021, but it is unclear whether these targets have been met.[9] In order to achieve universal electricity access by 2030, it is estimated that the installed generation capacity must double compared to 2020.[10]

The Government has implemented several policy and institutional reforms in the electricity sector since 2013. These include the adoption of the National Energy Policy in 2013, the National Electrification Plan in 2014, the National Electricity Master Plan in 2017 and the preparation of rules and regulations for off-grid electrification. The National Electrification Plan aimed to achieve a national electrification rate of 75 per cent by 2025 and 100 per cent by 2030, respectively. As a part of the National Electrification Plan, the Government launched the Myanmar National Electrification Project in 2015 with funding from the World Bank, aiming to guarantee universal electricity access through the establishment of a nationwide distribution grid.[10] The project was still ongoing as of 2022.

Additionally, in 2018 the Government of Myanmar launched the Myanmar Sustainable Development Plan 2018–2030 (MSDP), which prioritized reliable and affordable electricity to support economic development and poverty reduction, and universal electricity access by 2030. In order to reach these goals, the Government has focused on the development of power generation, transmission and distribution and on advanced policy and institutional reforms to improve the efficiency of investment in, and operation and management of, the energy sector. These reforms have included establishing a transparent mechanism for setting and implementing cost-reflective electricity tariffs, developing a public-private partnership (PPP) mechanism to mobilize private investment and corporatizing electricity supply entities to increase efficiency. Development partners in implementing these reforms, policies and projects have included the World Bank, the Asian Development Bank, the Japan International Cooperation Agency, the German Agency for International Cooperation (GIZ), the Department for International Development of the United Kingdom, the Italian Agency for Development Cooperation (AICS), KfW and the Governments of Norway and Australia.

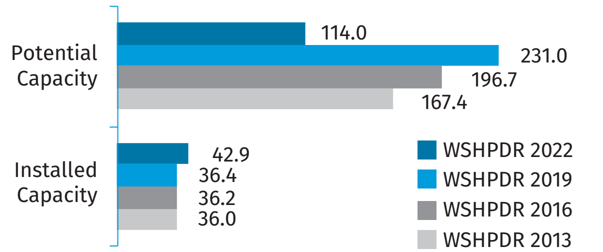
Electricity tariffs in Myanmar are low, compared to those of other ASEAN members. In 2019, the Government raised electricity tariffs for the first time in five years, with rates as much as tripling for residential consumers and nearly doubling for business consumers. Under the new tariff scheme, the rate for residential consumers remains at 35 MMK/kWh (0.02 USD/kWh) for usage up to 30 kWh, after which the price rises to as much as 125 MMK/kWh (0.09 USD/kWh). For business consumers, the rates rose to 125–180 MMK/kWh (0.09–0.12 USD/kWh) from 75–150 MMK/kWh (0.05–0.10 USD/kWh). The Government is subsidizing the cost of electricity, at an estimated cost of MMK 630 billion (USD 434 million) during the 2018–2019 financial year.[11]

SMALL HYDROPOWER SECTOR OVERVIEW

Myanmar has no official definition of small hydropower (SHP), although the definition of up to 10 MW is usually applied. Comprehensive information and statistics on SHP in Myanmar are difficult to acquire, as there is no dedicated government department or institution focused on SHP. Key players involved in SHP development in Myanmar include the Department of Hydropower Implementation at the Ministry of Electricity and Energy (MOEE), the Department of Rural Development and the Department of Irrigation and Water Utilization at the Ministry of Agriculture, Livestock and Irrigation and the Department of Research and Innovation at the Ministry of Science and Technology as well as the private sector organizations: Small Hydropower Association of Myanmar (SHPAM) and Renewable Energy Association of Myanmar (REAM).

As of 2021, there were a total of 36 SHP plants up to 10 MW included in the MOEE SHP database, with a total installed capacity of 38.67 MW. In addition, there were over 300 SHP plants overseen by other ministries with an estimated capacity of 4.2 MW. There are also over 2,000 privately owned SHP plants with capacities ranging from 10 kW to 3 MW in operation in the northern and north-western regions of the country (Kachin, Shan and Chin states), but their total installed capacity is not known.[12,13] The verifiable total SHP installed capacity in Myanmar thus amounted to 42.87 MW in 2021. Additionally, 119 potential SHP sites have been identified across the country with a total undeveloped potential capacity of 71.17 MW, bringing the total potential SHP capacity of Myanmar to 114.04 MW.[12] Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, installed SHP capacity has increased by nearly 18 per cent due to the construction of new SHP plants (Figure 3). Meanwhile, potential SHP capacity has decreased by nearly 51 per cent as a consequence of revised MOEE data that substantially reduced both the number and total capacity of potential SHP sites listed in the MOEE database.[14] Table 1 summarizes the total installed and potential SHP capacities by region. A partial list of existing SHP plants in Myanmar is displayed in Table 2.

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Myanmar (MW)**



Source: MOEE,[12] REAM,[13] *WSHPDR 2019*,[14] *WSHPDR 2013*,[15] *WSHPDR 2016*[16]

Table 1. **Operational and Potential Small Hydropower Projects by Region in Myanmar**

State/ Region	*Operational*		*Planned/Potential*		*Total*	
	Number of SHPPs	*Capacity (MW)*	*Number of SHPPs*	*Capacity (MW)*	*Number of SHPPs*	*Capacity (MW)*
Kachin	4	9.66	17	24.47	21	34.13
Kayah	1	0.12	2	0.22	3	0.34
Kayin	1	0.06	5	0.62	6	0.68
Chin	8	3.91	25	14.77	33	18.68
Mon	1	0.19	-	-	1	0.19
Rakhine	-	-	4	0.29	4	0.29
Shan	11	15.23	6	8.58	17	23.81
Sagaing	5	2.61	17	21.34	22	23.95
Tanintharyi	2	0.44	5	0.60	7	1.04
Bago	1	2.00	-	-	1	2.00
Mandalay	2	4.45	2	0.31	4	4.76
Total	**36**	**38.67**	**83**	**71.17**	**119**	**109.84**

Source: MOEE[12]

Note: Does not include 4.2 MW of SHP plants overseen by ministries other than MOEE.

Table 2. **List of Selected Existing Small Hydropower Plants in Myanmar**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Operator*	*Launch year*
Ahtet Nant Htwan	Putao, Kachin State	3.20	40.6	MOEE	2018
Tine Khan	Nan Yoon, Sagaing Region	1.00	28.0	MOEE	2018
Kya Lwe	La Hae, Sagaing Region	0.15	100.0	MOEE	2015
Ma Tu Gi	Lae Shee, Sagaing Region	0.15	44.0	MOEE	2015
Don Var	Haka, Chin State	0.60	64.0	MOEE	2014
Pa Kyet Haw	Chin Shwe Haw, Shan State	0.30	4.3	MOEE	2014
Nga Sit Var	Phalan, Chin State	1.50	121.9	MOEE	2013
Chi Chaung	Mindat, Chin State	0.16	12.8	MOEE	2011
Pa Thi	Taungoo, Bago Region	2.00	18.0	MOEE	2008
Nant Hou Mon	Kaung Khar, Shan State	0.15	37.5	MOEE	2005
Htwee Saung	Tonzaung, Chin State	0.20	39.6	MOEE	1998
Nan Khan Kha	Moe Kaung, Kachin State	5.00	128.0	MOEE	1996
Nant Saung Ngoung	Kyauk Mei, Shan State	4.00	148.0	MOEE	1996
Zee Chaung	Kalay, Sagaing Region	1.20	41.0	MOEE	1996
Nant Hmyaw	Lashio, Shan State	4.00	30.5	MOEE	1996
Ga Hlaing Chaung	Ho Pin, Kachin State	1.20	190.5	MOEE	1991
Mogoak	Mogoak, Mandalay Region	4.00	118.2	MOEE	1989
Hway Ka Pu	Phar Saung, Kayah State	0.12	61	MOEE	1988
Zar Lwee	Tedim, Chin State	0.40	141.7	MOEE	1984
Zin Kyaik	Paung, Mon State	0.19	109.3	MOEE	1984

Source: MOEE[12]

There were a number of planned SHP projects in Myanmar as of 2021, most in the early stages of planning. In addition, there are potentially hundreds of SHP sites that could be developed across the country, depending on the availability of a stream nearby and community needs. However, only a fraction of these sites has been properly identified and assessed. Table 3 provides a list of some planned SHP projects, while Table 4 lists several potential SHP sites.

Table 3. **List of Selected Ongoing Small Hydropower Projects in Myanmar**

Name	*Location*	*Capacity (MW)*	*Head (m)*	*Devel-oper*	*Development stage*
Hwuay Htike	La Hal, Sagaing Region	3.00	27	MOEE	Feasibility study in 2019
Phon In Kha	Sumprabum, Kachin State	1.70	18	MOEE	Feasibility study in 2020
Laung Maw	Sault Law, Kachin State	1.20	62	MOEE	Feasibility study in 2020
Kerlay	Kyi Khar, Chin State	0.55	54	MOEE	Feasibility study in 2014
Nant Nan	Mat Mum, Shan State	0.40	58	MOEE	Feasibility study in 2018

Source: MOEE[12]

Table 4. **List of Selected Potential Small Hydropower Sites in Myanmar**

Name	*Location*	*Potential capacity (MW)*	*Head (m)*	*Type of site (new/refur-bishment)*
Tanine Kha	Tanine, Kachin State	2.30	10	New
Phon Kyan Kha	Sumprabum, Kachin State	1.60	10	New
Phon In Kha	Sumprabum, Kachin State	0.90	10	New
Ti Del	HtanTaLan, Chin State	0.80	67	New
Thapyay Kha	Tanine, Kachin State	0.75	10	New

Source: MOEE[12]

In general, the development of SHP in Myanmar is hobbled by the lack of a targeted policy and legislation, despite the abundant SHP potential. Existing laws, such as the 2014 Myanmar Electricity Law, provide neither a regulatory framework nor incentives that apply to SHP specifically. The elaboration and adoption of these instruments is crucial for the future of SHP development in Myanmar.

RENEWABLE ENERGY POLICY

Myanmar is experiencing significant adverse impacts from climate change. Between 2019 and 2020, it was ranked as the world's second most affected country.[4] To provide a roadmap and to strategically address climate-related risks, the Government of Myanmar formulated and adopted the Myanmar Climate Change Policy (MCCP) and the related Myanmar Climate Change Strategy (MCCS) (2018–2030) in 2019.

The MCCP includes recommendations prioritizing and promoting RES and energy efficiency with the aim of meeting the growing energy needs of the country and ensuring energy security through low-carbon technologies.[6] The MCCS sets general goals for energy security and the sourcing of a significant share of total generation from RES. Overall, however, there is no comprehensive policy for RES development in Myanmar and specific targets for RES remain at the level of internal ministry reports not available to the public.[9] A comprehensive and binding set of RES policy initiatives and targets is still under development.

BARRIERS AND ENABLERS FOR SHP DEVELOPMENT

Myanmar has abundant water resources and high potential for SHP development. In view of the limited access to electricity still prevalent in rural areas, SHP should be one of the major RES serving rural communities. However, the development of the SHP sector in Myanmar is lagging.

Barriers to SHP development in the country include:
- Lack of legislation and regulations specifically targeting SHP;
- Limited financial resources and lack of green funding schemes in the banking system;
- Difficulty in developing community-based business schemes due to the low income levels in rural areas;
- Long and complicated procedures to acquire endorsement and approval for development from the authorities, including state and regional governments;
- Limited local technical knowledge, skills and operational experience in SHP;
- Insufficient technical data on topography, annual rainfall, distribution of water resources and potential SHP sites;
- Unstable political and economic situation in the country.

Enablers for SHP development in Myanmar include:
- Abundant water resources;
- SHP is particularly suitable to address significant unmet demand for electricity in rural areas;
- Government policies recommending development of SHP and RES in general.

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Philippines

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KEY FACTS

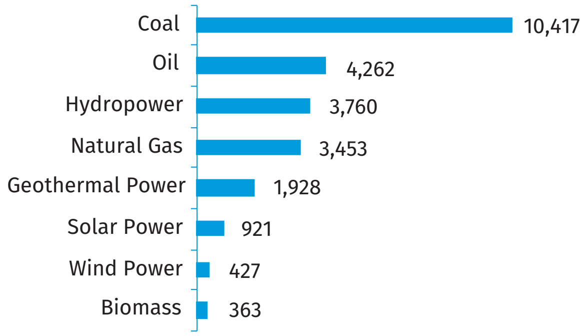
Population	109,581,085 (2020)[1]
Area	300,000 km[2]
Topography	The Philippines is an archipelagic country with more than 7,600 islands. It is divided into three major island groups: Luzon, Visayas and Mindanao. The highest point in the Philippines is Mount Apo with an elevation of 2,946 metres above mean sea level.[2] The larger islands (such as Luzon and Mindanao) are characterized by large volcanic peaks that emerge in the centre, with areas of low elevation around the shorelines.[3]
Climate	The climate of the Philippines is tropical and maritime. It is characterized by relatively high temperature, high humidity and abundant rainfall. The mean annual temperature is 26.6 °C.[4]
Climate Change	The observed temperature in the Philippines is warming at an average rate of 0.1 °C per decade. It is projected that the country-averaged mean temperature could increase by as much as 0.9–1.9 °C (assuming the moderate-emissions scenario, RCP4.5) or 1.2–2.3 °C (assuming the high-emissions scenario, RCP8.5) between 2036 and 2065. Warmer conditions or increase in mean temperature relative to the baseline climate are further expected by 2070–2099, ranging from 1.3–2.5 °C (RCP4.5) to 2.5–4.1 °C (RCP8.5).[4]
Rain Pattern	Rainfall distribution throughout the country varies from one region to another. The classification of climate per region is based on monthly rainfall received during the year using the Corona climate types (types I to IV). The mean annual rainfall of the Philippines varies from 965 mm to 4,064 mm annually.[5] The north-eastern monsoon (Amihan), characterized by cold winds, brings rains over the eastern side of the country from November to April. The south-western monsoon (Habagat), associated with heavy rain with warm moist winds, occurs from May to October.[6] The peak of the typhoon season is from July through October, when nearly 70 per cent of all typhoons develop.[7]
Hydrology	The Philippines is naturally endowed with major river basins, lakes, coastal and marine waters and groundwaters. There are 18 major river basins and 421 principal rivers defined by the National Water Resources Board (NWRB). The area occupied by the river basins is 108,923 km^2, which accounts for one third of the total land area. The largest river basin is Cagayan with a catchment area of 25,649 km^2. It is utilized for hydropower generation with several dams or powerplants built within its proximity. The second largest river basin is in Mindanao, covering an area of 23,169 km^2. There are 79 lakes that are mostly used for fish production. Laguna de Bay is the largest among the lakes with a total area of 900 km^2. It is also one of the five largest lakes in South-Eastern Asia.[8]

ELECTRICITY SECTOR OVERVIEW

In 2019, the Philippines had a total of 25,531 MW of installed capacity.[9] The major contributing electricity source was coal at 10,417 MW, or almost 40.8 per cent of the total installed capacity. Oil and natural gas contributed 4,262 MW or almost 17 per cent and 3,453 MW or almost 14 per cent, respectively. For the renewable energy sources, which accounted for a combined 7,399 MW, or 29 per cent of the total, hydropower contributed the highest at 3,760 MW or almost 15 per cent followed by geothermal power at 1,928 MW, or less than 8 per cent, solar power at 921 MW, or less than 4 per cent, wind power at 427 MW, or less than 2 per cent, and biomass at 363 MW, or 1 per cent (Figure 1).[9] From 2018, the installed capacity grew by approximately 7 per cent. A total of 1,675 MW of new capacity was added to the country's supply in 2019, including new coal-fired (1,559 MW), oil-based (8 MW), hydropower (31 MW), biomass (52 MW) and solar (25 MW) power plants.[9]

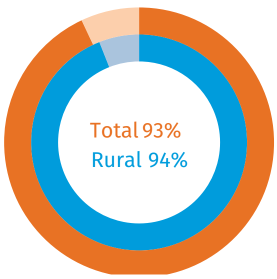
The power transmission in the Philippines is composed of three grids: the Luzon, Visayas and Mindanao grids. The total power peak demand in 2019 was 15,581 MW, which was 799 MW or 5 per cent higher than the 14,782 MW in 2018. The Luzon grid contributed 11,344 MW, or 73 per cent, of the total demand, while Visayas and Mindanao contributed a share of 14 per cent (2,224 MW) and 13 per cent (2,013 MW), respectively.[9] At the end of 2019, the electrification level reached 23.2 million households or 93 per cent of the total potential households.[10] From the World Bank Data, the access to electricity of urban and rural population in 2019 was 98 per cent and 94 per cent, respectively (Figure 2).[11]

Figure 1. **Installed Electricity Capacity by Source in the Philippines in 2019 (MW)**



Source: Department of Energy[9]

Figure 2. **Electrification Rate in the Philippines in 2019 (%)**

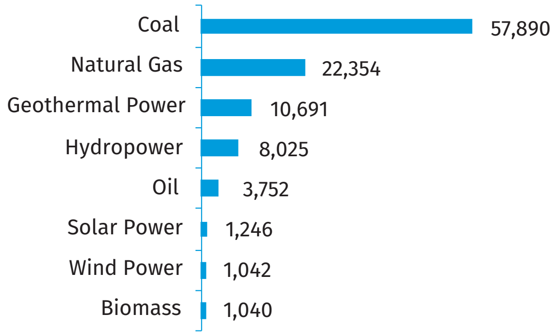


Source: Capongcol,[10] World Bank[11]

The electricity gross generation of 106,040 GWh in 2019 grew by 6 per cent from 99,765 GWh in 2018.[12] Coal dominated the power mix at 57,890 GWh, increasing its share from 52 per cent in 2018 to almost 55 per cent in 2019. Natural gas contributed 21 per cent (22,354 GWh), while oil-based plants contributed less than 4 per cent (3,752 GWh).[9] Fossil fuels dominated the mix, and renewable energy technologies decreased their total generation share to less than 21 per cent (22,044 GWh) due to continuous drop in generation from hydropower and limited penetration of other technologies into the mix. Geothermal power contributed 10 per cent (10,691 GWh), followed by hydropower at 8 per cent (8,025 GWh), solar power at 1 per cent (1,246 GWh), wind power at 1 per cent (1,042 GWh) and biomass at 1 per cent (1,040 GWh) (Figure 3).[12]

The Philippines is highly dependent on fossil fuels, which accounted for 67 per cent of total primary energy supply (TPES) in 2019.[13] Oil maintained its position as the country's major energy source with close to one third at 32 per cent of the TPES (31 per cent net imported oil and 1 per cent indigenous oil), while coal contributed 29 per cent.[13] The increase in coal-based generation was attributed to new coal-fired power plants across the country. The Government declared a moratorium on new coal power plants in 2020. Additionally, to boost private investment in renewable energy, the Government opened up the sector to full foreign ownership in geothermal power and hydropower, which included 17 potential hydropower projects (mostly small-scale) with a combined capacity of 80 MW.[14] The 17 Pre-Determined Areas (PDA) for hydropower were offered in the 3rd Open and Competitive Selection Process for Geothermal and Hydropower Resources. As of May 2021, no applications had been received for 9 PDAs, while applications for 8 small hydropower (SHP) PDAs were disqualified. The Open and Competitive Selection Process was declared a failure and the PDAs are now open for direct applications.[15]

Figure 3. **Annual Electricity Generation by Source in the Philippines in 2019 (GWh)**



Source: HOEMD, REMB & DOE[12]

Amidst the ongoing economic crisis and the high cost of household utilities, the Philippines has the second highest electricity cost in South-Eastern Asia. Unlike other neighbouring countries, such as Thailand, Indonesia and Malaysia, electricity rates in the Philippines are not subsidized by the Government.[16] In 2020, the overall average retail rate of electricity decreased by 10 per cent to 7.96 PHP/kWh (0.15 USD/kWh) from an 8.87 PHP/kWh (0.17 USD/kWh) average rate in 2019.[17]

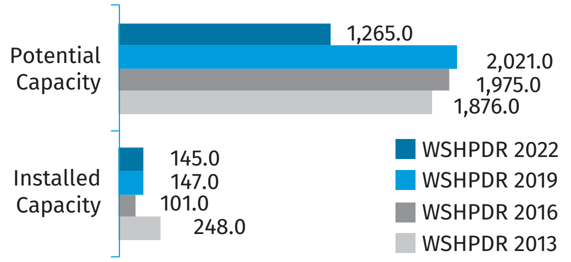
SMALL HYDROPOWER SECTOR OVERVIEW

In the Philippines, SHP is often a preferable choice to large hydropower due to the latter's negative environmental impacts, and SHP is considered one of the most cost-effective energy sources for rural electrification. SHP plants are economically more competitive and more sustainable than small-scale fossil fuel plants.[18] The country ranked 13th in the Eastern Asia and Pacific region for water resource availability.[14]

The term mini-hydropower is used in the Philippines for hydropower plants with 101 kW to 10 MW of installed capacity, while micro-hydropower defines plants with 1–100 kW capacity.[19] For this chapter, the term SHP will be used for hydropower plants of up to 10 MW. The Republic Act No. 7156, or the Mini-Hydro Law, was enacted to grant incentives to SHP developers.[20] The Law includes special privilege tax rates, tax and duty-free importation of machinery, equipment and materials.

As of December 2020, the Philippines had a total of 145 MW of installed SHP capacity and potential capacity of approximately 1,265 MW.[21] Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, both installed and potential capacities decreased mainly due to terminated projects being removed from the list of active hydropower service contracts (Figure 4).

Figure 4. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in the Philippines (MW)**



Source: DOE,[21] *WSHPDR 2013*,[22] *WSHPDR 2016*,[23] *WSHPDR 2019*[24]

Table 1 shows the most recently commissioned operational SHP plants, while Table 2 shows the ongoing SHP projects as of 2021.

Table 1. **List of Selected Operational Small Hydropower Plants in the Philippines**

Name	*Location*	*Capacity (MW)*	*Plant type*	*Operator*	*Launch year*
Calibato	San Pablo, Laguna	0.3	Run-of-river	PHILPODECO	2020
Asiga	Santiago, Agusan del Norte	8.0	Run-of-river	Asiga Green Energy Corporation	2019
Catuiran	Naujan, Oriental Mindoro	8.0	Run-of-river	Catuiran Hydropower Corporation	2019
Majayjay	Majayjay, Laguna	2.2	Run-of-river	Majayjay Hydropower Company, Inc.	2019
Loboc 2	Loboc, Bohol	1.2	Run-of-river	Sta. Clara Power Corporation	2019
New Bataan	New Bataan, Compostela Valley	3.2	Run-of-river	Euro Hydro Power (Asia) Holdings, Inc.	2018
Palakpakin	San Pablo, Laguna	1.5	Run-of-river	PHILPODECO	2018
Balugbog	Nagcarlan, Laguna	1.1	Run-of-river	PHILPODECO	2018
Maris Main Canal 1	Ramon, Isabela	8.5	Run-of-river	SN Aboitiz Power – Magat, Inc.	2017
Villasiga	Bugasong, Antique	8.0	Run-of-river	Sunwest Water & Electric Company, Inc. 2	2016
PRISMC	Rizal, Nueva Ecija	1.0	Run-of-river	PNOC – Renewables Corporation	2016
Bulanao	Tabuk, Kalinga	1.0	Run-of-river	DPJ Engineers and Consultants	2016
Amlan	Dumaguete, Negros Oriental	0.8	Run-of-river	Amlan Hydroelectric Power Corporation	2016
Linao – Cawayan (Upper Cascade)	San Teodoro, Oriental Mindoro	3.0	Run-of-river	Oriental Mindoro Electric Cooperative, Inc.	2015
Likud	Asipulo, Ifugao	0.8	Run-of-river	Provincial Government of Ifugao	2015
Tudaya 2	Sta. Cruz, Davao del Sur	8.1	Run-of-river	HEDCOR Tudaya, Inc.	2014
Tudaya 1	Sta. Cruz, Davao del Sur	6.6	Run-of-river	HEDCOR Sibulan, Inc.	2014
Cabulig	Claveria, Misamis Oriental	8.0	Run-of-river	Mindanao Energy Systems, Inc.	, 2012
Irisan 1	Tuba, Benguet	3.8	Run-of-river	HEDCOR, Inc.	2012

Source: HOEMD, REMB & DOE[25]

A total of 17 potential (mostly small-scale) hydropower projects was offered to qualified renewable energy developers in 2021. The 3rd Open and Competitive Selection Process (OCSP3) was started to further accelerate the development of renewable energy in the country. Although initial uptake by developers was slow, these projects have sufficient available technical data to serve as initial reference for those who are interested in acquiring the rights to develop the hydropower resources.[26]

Several hydropower plants in operation in the country were registered under the Republic Act 9513 through Hydropower Service Contracts. The continued effort of the Government to provide electricity to marginalized areas has resulted in a number of new projects, one of which is the Likud mini-hydropower plant in Ifugao providing up to 820 kW of electricity to the grid. The electricity generated by the plant was intended for the purpose of rehabilitation of the rice terraces in Banaue. Another project is the 40 kW off-grid hydropower plant in the Municipality of Brooke's Point in Palawan. It supplies electricity to the Sitio Tagpinasao Elementary School, 25 households in the upland areas, with plans to increase service to up to 150 households.[27]

Table 2. **List of Selected Planned Small Hydropower Projects in the Philippines**

Name	*Location*	*Capacity (MW)*	*Plant type*	*Developer*	*Planned launch year*
Alamada	Alamada, North Cotabato	3	Run-of-river	Euro Hydro Power (Asia) Holdings, Inc.	Q3 2021
Sipangpang	Cantilan, Surigao del Sur	1.8	Run-of-river	Paragon Pegasus Solutions, Inc.	Q3 2021
Tubig	Taft, Eastern Samar and Hilabangan, Samar	16	Run-of-river	Taft Hydroenergy Corporation	Q3 2021
Matuno	Bambang, Nueva Vizcaya	8.661	Run-of-river	Matuno River Development Corporation	Q3 2021
Labayat River (Upper Cascade)	Mauban, Quezon	1.4	Run-of-river	Labayat 1 Hydropower Corporation	Q3 2021

Source: HOEMD, REMB & DOE[25]

RENEWABLE ENERGY POLICY

Renewable energy is abundant and ideal for meeting the energy needs in the Philippines. This is because it is more suitable to provide small islands with decentralized renewable electricity than with centralized fossil fuel-based generation, which would need substantial grid investments. The competitive advantage of decentralized, carbon-free and flexible renewable energy compared with centralized and polluting coal is clear under the national circumstances of the Philippines and would improve energy access in remote areas and isolated islands.[28]

The Republic Act 9513 of 2008, or the Renewable Energy (RE) Act, was passed and was the first of its kind in South-Eastern Asia. The renewable energy law focuses on accessible, affordable and environmentally sustainable energy sources, or the so-called BiGSHOW, which stands for biomass, geothermal power, solar power, hydropower, ocean and wind power.[29] It encourages consumers and businesses to choose renewable energy resources through different fiscal and non-fiscal incentives. It has designed the following five major policy mechanisms to create a more renewable energy-friendly environment: feed-in tariff (FIT) system, net-metering system, renewable portfolio standards (RPS), Green Energy Option Programme (GEOP) and renewable energy market (REM).

The Renewable Energy Act of 2008 implementing rules and regulations mandated the Energy Regulatory Commission (ERC) to formulate and promulgate the FIT system rules. A resolution adopting the FIT rules was enacted in 2010. This policy aims to offer guaranteed payments on a fixed rate per kWh to emerging renewable energy resources, excluding any generation for its own use. The FIT ranges from USD 0.1936/kWh to USD 0.1174/kWh. As of 2020, the FIT rates approved by ERC were as follows: hydropower at 5.87 PHP/kWh (0.11 USD/kWh), wind power at 7.40 PHP/kWh (0.14 USD/kWh), solar power at 8.69 PHP/kWh (0.16 USD/kWh) and biomass at 6.60 PHP/kWh (0.12 USD/kWh). A resolution was approved to have in 2018–2019 a FIT of 5.87 PHP/kWh (0.11 USD/kWh) for run-of-river hydropower and 6.19 PHP/kWh (0.12 USD/kWh) for biomass.

The Development for the Renewable Energy Applications Mainstreaming and Market Sustainability (DREAMS) project initially started from August 2020 up to May 2021 and later was extended until January 2023. The project aims to reduce greenhouse gas emissions through the promotion and facilitation of the commercialization of renewable energy markets through the removal of barriers to increase investments in renewable energy-based power generation projects. The DREAMS Project is assisting the Renewable Energy Management Bureau (REMB) in the preparation of the National Renewable Energy Programme (NREP) 2020–2040. The NREP 2011–2030 defined the renewable energy targets and strategies to achieve overall 35 per cent of renewable sources in the energy mix. New targets were created under the NREP 2020–2040 with approximately 34,000 MW of renewable energy capacity set to be developed by 2040. As of 2019, the share of renewable energy in the total primary energy mix was 33 per cent. Net imported oil maintained its position as the country's major energy source, which was close to one third, followed by coal. With reduction of net importation by 1 per cent from 2018, energy self-sufficiency in 2019 improved to 51 per cent.[13]

The Philippines committed, through its Nationally Determined Contribution (NDC), to reduce greenhouse gas emissions by 30 per cent below the business-as-usual (BAU) levels by 2040. The 2017–2040 Philippine Energy Plan (PEP) also highlights the promotion of a low-carbon future as one of its energy sector strategic directions. To achieve these goals, emissions from fossil fuel combustion need to decline rapidly.[30]

The Sustainable Energy Finance (SEF) Programme is both an investment and an advisory programme being implemented by the International Finance Corporation (IFC) in different regions around the world. The Philippines SEF Programme was launched in 2008, the first in the Association of Southeast Asian Nations (ASEAN) region. The programme works with private banks to encourage lending to energy efficiency and renewable energy projects. Support is provided through technical advisory services, which help build capacity to develop new business lines, as well as through the Risk Sharing Facility (RSF), where IFC covers 50 per cent of the loan losses in case of default. With RSF, client banks are more inclined to finance energy efficiency and renewable energy projects, which enhances their portfolio build-up. At present, the Philippines SEF Programme has three partner private banks: Bank of the Philippine Islands (BPI), Banco De Oro (BDO) and BPI Globe BanKO (BanKO), with BPI having access to the RSF. The Development Bank of the Philippines

(DBP) and the Philippine National Bank (PNB) also offer financing to renewable energy projects.

Furthermore, the Renewable Energy Asia Fund (REAF) II invests in SHP, wind power, geothermal power, solar power and biomass projects in Asian developing markets, with a primary focus on India, the Philippines and Indonesia. REAF makes equity investments in small-scale renewable energy projects including hydropower projects of between 5 MW and 100 MW.

For renewable energy or SHP investors, several recent enabling policies and laws have been enacted. First was Executive Order No. 30 creating the Energy Investment Coordinating Council in order to streamline the regulatory procedures affecting energy projects. Other laws include: Republic Act No. 11032 Ease of Doing Business Act of 2018, DC2019-10-0013 Omnibus Guidelines Governing the Award and Administration of Renewable Energy and the Registration of Renewable Energy Developers, and Republic Act No. 11234 Energy Virtual One-Stop Shop (EVOSS) Act with its Department Circular No. DC2019-05-0007 (Implementing Rules and Regulations).

COST OF SMALL HYDROPOWER DEVELOPMENT

According to the Energy Generation Technology Assumptions for the Philippines Competitive Renewable Energy Zones (CREZ) Process, capital cost of putting up an SHP plant with capacity of less than 50 MW is 143,218,927 PHP/MW (2,830,000 USD/MW). The fixed operations and maintenance cost is 4,299,048 PHP/MW/year (84,949 USD/MW/year), while the grid connection cost (substation tie-in, 69 kV, steel tower, single circuit line) is 77,834 PHP/km/MW (1,538 USD/km/MW).[31]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

The Philippines is one of the most vulnerable countries to climate change, due to its high exposure to natural hazards, dependence on climate-sensitive natural resources and vast coastlines.[32] On average, 20 tropical cyclones enter the Philippines region every year and approximately 8–9 of them directly cross the country.[7] These numbers are the highest in the world and are expected to increase in frequency and severity due to climate change.[33] Other effects of the climate crisis on SHP development include extended periods of well below average rainfall triggered by El Niño events, leading to reduced hydropower generation. Changes in precipitation patterns and surface water discharges may adversely impact run-of-river hydropower plants.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The establishment of SHP in the Philippines is hampered by the following:

- There is social prejudice against building large dams thereby generalizing the same situation towards all hydropower technologies, which is due to the lack of understanding of renewable energy;
- There is a food or power (food versus fuel) dilemma for most hydropower resources;
- Hydropeaking is a challenge. Hydropeaking refers to changes in river flow due to the storage of water for hydropower use and disconnected water bodies formed by the construction of hydropower dams and run-of-river facilities built within the river system;
- Hydropower projects are mostly located in remote areas that have difficulty in road access, peace and order;
- Access to financing remains a massive problem, with only a few domestic banks currently supporting renewable energy projects in the country and recent years showing significant downturns in investments;
- Hydropower production is intermittent and is vulnerable to climate risks.[18,27,34]

Enablers of SHP include:

- Several enabling policies and laws have been enacted recently;
- A range of international funding opportunities is available;
- There is a vast source for hydropower in the Philippines, which remains untapped.[19,33]

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Thailand

Sangam Shrestha, Asian Institute of Technology; and Manish Shrestha, International Centre for Integrated Mountain Development

KEY FACTS

Population	69,799,978 (2020)[1]
Area	513,120 km[2]
Topography	Mountains cover most of northern Thailand and extend along the border with Myanmar down through the Kra Isthmus and the Malay Peninsula. The highest point is Doi Inthanon Mountain at 2,565 metres above sea level. The central area is characterized by lowlands dominated by the Chao Phraya River Basin.
Climate	The climate of Thailand can be classified into three seasons: hot season (March–May), rainy season (May–October) and cold season (November–February). The temperature ranges from 24 °C to 30 °C. A tropical monsoon, generally hot and humid, impacts the country most of the year.[2]
Climate Change	The average temperature is expected to increase by 2 °C by 2050 and approximately 4 °C by 2080.[3]
Rain Pattern	Average annual rainfall ranges from 1,020 mm in the north-east to 3,800 mm in the peninsula. Eighty per cent of the total annual rainfall occurs from May to October.[2]
Hydrology	Thailand is divided into 25 major river basins. Four major rivers that originate from the north are the Wang, Ping, Yom and Nan, which confluence to become the Chao Phraya River. Water from such rivers as the Chi, Mun and Songkhram drains to the Mekong River.[4]

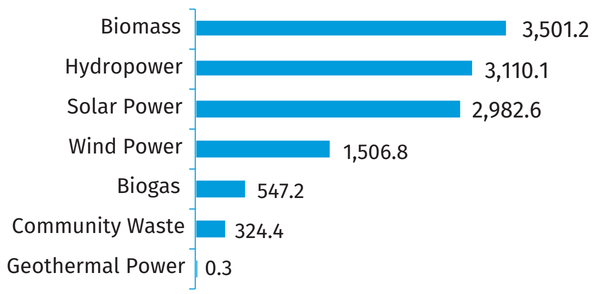
ELECTRICITY SECTOR OVERVIEW

The state enterprise Electricity Generation Authority of Thailand (EGAT) under the Ministry of Energy is the main authority responsible for the production and transmission of electric power throughout the country. As of November 2020, the total electricity generating capacity of Thailand was 39,760 MW, of which almost 40 per cent was from EGAT's power plants, whereas the remaining 60 per cent was from other domestic power plants including independent power producers (IPPs) and small power producers. An additional 5,721 MW was imported from neighbouring countries.[5] The total installed capacity of EGAT's power plants was 16,034 MW, including 8,262 MW from combined-cycle plants, 3,687 MW from thermal power plants, 3,055 MW from renewable energy plants, 30 MW from diesel-fired plants and 1,000 MW from other sources.[5]

As of September 2020, the total installed capacity of renewable energy was 11,972.6 MW, including 3,501.2 MW from biomass, 3,110.1 MW from hydropower, 2,982.6 from solar power, 1,506.8 MW from wind power, 547.2 MW from biogas, 324.4 MW from community waste and 0.3 MW from geothermal power (Figure 1).[6]

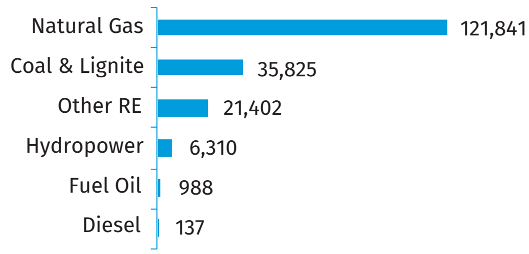
The major source of electricity generation in Thailand is natural gas followed by lignite. In 2019, Thailand generated 186,503 GWh of electricity and an additional 25,547 GWh was imported. Renewable energy sources, including hydropower, contributed 15 per cent of the total power produced in the country (Figure 2).[7]

Figure 1. **Installed Renewable Energy Capacity by Source in Thailand in 2020 (MW)**



Source: DEDE[6]

Figure 2. **Annual Electricity Generation by Source in Thailand in 2019 (GWh)**



Source: MoE[7]

EGAT has a total transformer capacity of 124,144 MVA with a total transmission length of 36,883 circuit-kilometres.[5] The electrification rate in the country is 100 per cent.[8]

EGAT has the sole right to buy electricity from private power producers and neighbouring countries. It sells wholesale electricity energy to two distributors: Metropolitan Electricity Authority (MEA), which supplies electricity to Bangkok, Nonthaburi and Samut Prakan, and Provincial Electricity Authority (PEA), which supplies electricity to the rest of the country.[9]

With the expansion of the economy and population growth, the electricity demand in Thailand has been going up every year. With the long-term economic growth projection of 3.8 per cent, net electricity demand is projected to increase by 3.13 per cent annually from 2018 to 2037.[10] It is forecasted that the peak energy demand in the year 2037 will be at 53,997 MW.[10] The Government plans to increase the total installed capacity to 77,211 MW by 2037, with a total of 56,431 MW of new capacity to be added and 25,310 MW of capacity to be retired during 2015–2037.[11] Further, it is planned that by 2037, approximately 37 per cent of the total power will be generated from renewable energy sources including hydropower.[12]

The Energy Regulatory Commission (ERC) is responsible for adjusting tariffs, which are uniform across the country in both the MEA and PEA distribution territories.[9] The electricity tariffs valid from November 2015 are shown in Table 1. The electricity tariff rate comprises two parts: a) a base tariff, which reflects the construction costs of power plants, the transmission and distribution costs, fuel and operation and maintenance costs; and b) automatic tariff adjustment (Ft) to compensate for inflation and exchange rate fluctuations at international fuel and power markets. Ft is adjusted every four months. In addition, a value-added tax (VAT) of 7 per cent is added to the base tariff and Ft.[9,13] The electricity tariff rate varies for different sectors based on an increasing block rate method. The tariff also varies according to the voltage level and time of consumption (peak and off-peak hours).[13]

Table 1. **Residential Electricity Tariff Rates in Thailand**

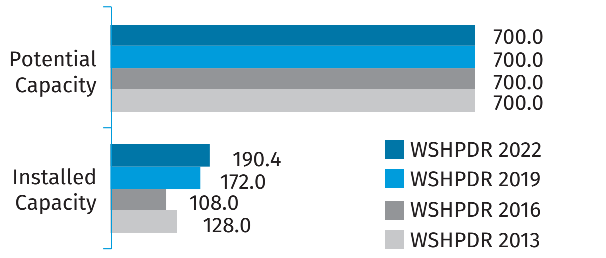
Normal tariff with consumption not exceeding 150 kWh/month	
Energy charge	*Rate per kWh*
First 15 kWh (1st – 15th)	THB 2.35 (USD 0.08)
Next 10 kWh (16th – 25th)	THB 2.99 (USD 0.10)
Next 10 kWh (26th – 35th)	THB 3.24 (USD 0.11)
Next 65 kWh (36th – 100th)	THB 3.62 (USD 0.12)
Next 50 kWh (101st – 150th)	THB 3.72 (USD 0.12)
Next 250 kWh (151st – 400th)	THB 4.22 (USD 0.14)
Over 400 kWh (up from 401st)	THB 4.42 (USD 0.15)
Service charge per month	TBH 8.19 (USD 0.27)

Source: MEA[13]

SMALL HYDROPOWER SECTOR OVERVIEW

Based on installed capacity, hydropower in Thailand can be classified as micro-hydropower (less than 200 kW), small/mini (200–6,000 kW), medium (6,000–20,000 kW) and large (above 20,000 kW).[14] The installed capacity of small hydropower (SHP) up to 6 MW in the country as of 2020 was 190.39 MW, indicating an 11 per cent increase compared with the *World Small Hydropower Development Report (WSHPDR) 2019* (Figure 3).[6] The development of SHP in the country is fostered through the national Alternative Energy Development Plan (AEDP2018), which set the goal of increasing the installed capacity of SHP to 376 MW by 2037.[15] The potential capacity of SHP is estimated at 700 MW.[16]

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Thailand (MW)**



Source: DEDE,[6] MoE,[16] *WSHPDR 2013*,[17] *WSHPDR 2016*,[18] *WSHPDR 2019*[19]

Note: Data for SHP up to 6 MW.

Table 2 shows a list of some existing SHP plants in Thailand.

Table 2. **List of Selected Operational Small Hydropower Plants in Thailand**

Name	*Location*	*Capacity (MW)*	*Plant Type*	*Launch year*
Kiew Kho Ma Dam	Wang River, Lampang Province	5.5	Reservoir	2018
Khlong Tron Dam	Nam Pat District, Uttaradit Province	2.5	Reservoir	2018
Khun Dan Prakan Chon Dam	Nakhon Nayok	10.0	Reservoir	2005
Pa Sak Jolasid Dam	Pasak River, Lopburi Province	6.7	Reservoir	1999
Mae Ngat Somboon Chon Dam	Mae Ngat River, Chaing Mai province	9.0	Reservoir	1986
Ban Khun Klang	Ban Khun Klang Villaage, Choom Thong District, Chiang Mai Province	0.2	N/A	1982
Ban Santi	Ban Santi 1 Village, Bannang Sata District, Yala Province	1.3	N/A	1981
Huai Kum Dam	Nam Phrom River, Chaiyaphum province	1.1	Reservoir	1980

Name	*Location*	*Capacity (MW)*	*Plant Type*	*Launch year*
Ban Yang	Ban Yang, Fang District, Chiang Mai Province	0.1	N/A	1972
Nam Pung Dam	Phung River, Sakon Nakhon Province	6.0	Reservoir	1965
Naresuan Dam	Nan River, Phitsanulok Province	8.0	Reservoir	N/A
Huai Kui Mang	N/A	0.1	N/A	N/A
Klong Chong Klam	N/A	0.02	N/A	N/A

Source: EGAT[20]

Note: SHP plants up to 10 MW.

The northern part of Thailand has most of the potential for developing SHP. An additional 256 sites in the northern part of Thailand have been identified for the development of small and medium hydropower plants.[14]

RENEWABLE ENERGY POLICY

The Ministry of Energy (MoE) of Thailand, developed five integration master plans: 1) Thailand Power Development Plan (PDP2018), 2) Energy Efficiency Development Plan (EEDP), 3) Alternative Energy Development Plan (AEDP2018), 4) Natural Gas Supply Plan and 5) Petroleum Management Plan.

Thailand Power Development Plan 2018–2037 targets an additional 56,431 MW of installed capacity by 2037, of which 53 per cent will be powered by natural gas, 20 per cent by renewable energy, 12 per cent by coal, 9 per cent will come from import and 6 per cent from energy saving.[12] The Energy Efficiency Development Plan seeks to reduce greenhouse gas (GHG) emissions according to the pledge submitted to the United Nations Framework Convention on Climate Change (UNFCCC) at COP21. In particular, it set the target to reduce final energy consumption by 20 per cent in 2030 compared to 2005.[21] The Alternative Energy Development Plan aims to increase the share of renewable energy in the total power demand to 33 per cent in 2037.[15] The Alternative Energy Development Plan promotes renewable energy schemes designed to strengthen the community, lessen the dependence on fossil fuels and address social problems such as municipal solid waste (MSW) and agricultural waste. The development strategies to reach this goal include:

- Promotion of power generation from MSW (900 MW), biomass and biogas (6,714 MW), to benefit both farmers and communities;
- Set up targets for provincial renewable energy development by zoning electricity demand and renewable energy potential;
- Development of power generation from solar and wind power if the investment costs can compete with power generation using liquefied natural gas (LNG);
- Provision of incentives by using competitive bidding and promotion of energy consumption reduction.

The government policy supports the participation of the private sector in electricity generation. Small and Very Small Power Purchase Agreements (2002), Strategic Plan for Renewable Energy Development (2004), Feed-in Premium for Renewable Power (2009), National Renewable Energies Development Plan 2008–2022 (2012), Alternative Energy Development Plan: AEDP (2018) and Thailand Power Development Plan 2018–2037 (PDP2018) are some of the policies supporting private investment in the energy sector.

To promote and support alternative energy, MoE provides feed-in tariffs (FITs) to very small power producers.[11] The FITs are provided for a 20-year term to all forms of renewable energy except for landfill, which is eligible for a period of 10 years. For some projects, FITs will provide financial certainty over a period twice as long as under the adder rate scheme. The rates are determined based on the type of renewable energy, installation location and installed capacity. The highest rates are provided to MSW and wind energy. For hydropower projects, the FIT rate is 4.9 THB/kWh (0.16 USD/kWh) for 20 years.[11] Projects located in Yala, Pattani, Narathiwat and four subdistricts of Songkla (Jana, Tepha, Sabayoi and Natawee) will receive 0.50 THB/kWh (0.02 USD/kWh) for the lifetime of the project.[16]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

Construction of SHP plants is restricted in protected areas. The relevant regulations include:

- Forest Act (1941);
- National Park Act (1955);
- National Reservation and Protection Act (1992);
- National Reserved Forest Act (1964);
- Cabinet Resolution of 15 May 1990 restricting the use of conservation areas by private agencies.

BARRIERS AND ENBLERS FOR SMALL HYDROPOWER DEVELOPMENT

The main obstacles to SHP development in Thailand are presented by the following factors:

- Most of the potential hydropower sites in the northern region of Thailand are located in protected forested areas;
- The existing policies undermine the growth of the SHP sector. If the policies were reformed with the provision of the right of ownership and selling of excess electricity, this would attract private investors and contribute to the development of SHP as well as the national grid.[22,23]

The key enabling factors for SHP development include:

- Political will and support for renewable energy development and SHP specifically;
- Availability of incentives for renewable energy producers.

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24.

Timor-Leste

Danila Podobed, International Centre on Small Hydro Power (ICSHP)

KEY FACTS

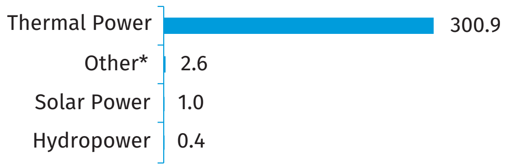
Population	1,280,743 (est. 2019)[1]
Area	14,954 km^2 [1]
Topography	The topography of Timor-Leste is primarily mountainous. The interior of the country is dominated by the Ramelau Range, with the country's highest point located at Mount Ramelau, 2,986 metres above sea level. In the north of the country the mountains extend almost directly to the coast, but in the south the elevation decreases and levels off, forming a coastal plain.[2,3]
Climate	Timor-Leste is divided into three climactic regions. The northern coast region is characterized by mean annual temperatures of over 24 °C, moderate rainfall and a dry season lasting five months. In the mountainous region, average annual temperatures are below 24 °C, rainfall is high and the dry season lasts four months. In the southern coast region, average annual temperatures are above 24 °C, rainfall is very high and the dry season lasts only three months.[3]
Climate Change	Observations indicate that average temperatures in Timor-Leste have been increasing by approximately 0.16 °C per decade since 1950. Climate change projections for Timor-Leste predict a rise in average annual temperatures of between 1.25 °C and 1.75 °C by 2050.[3]
Rain Pattern	Average annual precipitation in Timor-Leste ranges from less than 1,000 mm in lowland areas of the northern Coast to approximately 2,500 mm on the mountain slopes facing the South Coast, where rain falls for nine months out of the year.[3]
Hydrology	There are more than 100 rivers in Timor-Leste, but very few of these flow year-round. The longest river, the Northern Laclo, is 80 kilometres long. Lake Ira Lalaro is considered the largest lake in the country, with the lake's area fluctuating anywhere between 10 and 55 km^2.[2,3]

ELECTRICITY SECTOR OVERVIEW

The electricity sector of Timor-Leste is almost entirely dependent on thermal power. In 2021, the total installed electricity generating capacity in the country was approximately 304.9 MW, including 300.9 MW (99 per cent) provided by utility-scale thermal power plants, an estimated 1.0 MW provided by distributed solar power and nearly 0.4 MW provided by hydropower, in addition to 2.6 MW provided by a mix of solar power and diesel generators on Atauro Island (Figure 1).[4,5,6] There are four major thermal power plants in the country, although with the 27.5 MW Comoro power plant out of operation, the available thermal power capacity amounts to 273.4 MW (Table 1).[5] Solar power in the country is represented by a large number of small- and medium-sized installations with an estimated 1 MW total installed capacity, including a 300 kW solar power plant installed at the United Nations House in Dili.[6,7] Additionally, a number of generators powered by biogas have been installed across Timor-Leste, but accurate data on their cumulative installed capacity are not available.

Electricity generation in the country was estimated at 604 GWh in 2019, including approximately 602 GWh (nearly 100 per cent) provided by thermal power, 2 GWh provided by hydropower and 1 GWh provided by solar power (Figure 2).[6] Current electricity generation is sufficient to meet current and projected demand and no additional capacities will be necessary until approximately 2030. Demand is expected to rise with the completion and gradual expansion of the Tibar Bay Port and other projects after 2022.[4,5] Peak load increased from 73 MW in 2019 to 90 MW in 2021. Technical losses amounted to approximately 35 per cent as of 2021, with approximately 15 per cent losses across the transmission network and another 20 per cent in the distribution network.[5]

Figure 1. **Installed Electricity Capacity by Source in Timor-Leste in 2021 (MW)**



Source: Secretary of State for Environment,[4] ADB,[5] IRENA[6]

Note: *Referring to the mixed power system on Atauro Island, the composition of which is unclear from available data.

Table 1. **Utility-Scale Thermal Power Plants in Timor-Leste in 2021**

Name	*Capacity (MW)*
Betano	136.6
Hera	119.5
Comoro*	27.5
Inur Sakata (Ocussi-Ambeno)	17.3
Total	**300.9**

Source: ADB[5]

Note: *Out of operation as of 2021.

Figure 2. **Annual Electricity Generation by Source in Timor-Leste in 2020 (GWh)**

Source: IRENA[6]

Nationwide electricity access in Timor-Leste was 96 per cent in 2020 and over 94 per cent in rural areas, while access of households to the national grid was estimated at 80 per cent.[5,8] The transmission network consists of 603.4 circuit kilometres of 150 kV lines, while distribution is carried out over 2,500 circuit kilometres of 20 kV lines. The national electricity grid has consolidated over the past decade, replacing a series of mini-grids that in 2011 included 58 small-scale diesel generators supplying approximately 40 MW.[9] The generators themselves have also been replaced by large-scale thermal power plants and most are no longer in operation. As of 2021, the national grid serviced over 200,000 consumers.[5]

Generation, transmission and distribution of electricity in Timor-Leste is carried out by Electricidade de Timor-Leste (EDTL), a vertically integrated power utility company that had previously operated as a department in the Ministry of Public Works before being transformed into a state-owned enterprise in January 2021. The National Authority for Electricity (NAE), also established in 2021, acts as the state regulator of the electricity sector. The Finnish company Wärtsilä has been contracted to operate the country's diesel-powered plants in 2012 and again in 2017, while the China Nuclear Industry 22nd Construction Co. has been awarded the management contract for the transmission network in 2015.[5]

The cost of electricity generation for EDTL is predicated on the high cost of fossil fuel imports and was 0.42 USD/kWh in 2021. However, electricity tariffs are subsidized by the Government for all consumer categories and connection types.[5] Electricity tariffs, current as of 2021, are displayed in Table 2. Additionally, approximately 60 per cent of the generated electricity is not billed due to technical losses as well as unmetered and illegal connections. Prepaid electricity meters have been installed in Dili but much of the countryside still relies on unmetered connections.[5]

Table 2. **Electricity Tariffs in Timor-Leste as of 2021**

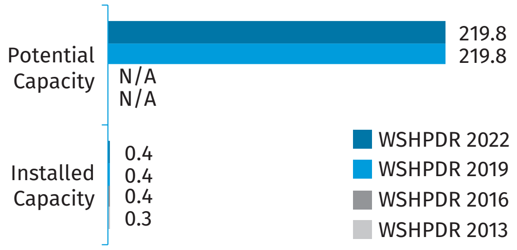
Category	*Monthly consumption*	*Price (USD/kWh)*
Residential (lifeline)	Up to 20 kWh	0.05
Residential	Over 20 kWh	0.12
Commercial	N/A	0.19
Industrial	N/A	0.24

Source: ADB[5]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of small hydropower (SHP) in Timor-Leste is 50 MW.[10] As of 2020, the installed SHP capacity in the country amounted to 0.35 MW, consisting of the 326 kW Gariuai (Gariwai) SHP plant, the 12–15 kW Loi-Huno SHP plant and the 15 kW Mausiga (Ainaro) SHP plant. However, all three plants were out of operation as of 2020 due to a variety of technical and environmental issues.[4,11] Potential for SHP up to 10 MW has been estimated at 219.8 MW in 2012.[12] Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, both installed and potential capacity of SHP up to 10 MW have remained the same, due to lack of SHP development as well as updated studies on SHP potential (Figure 3).[10]

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Timor-Leste (MW)**



Source: Secretary of State for Environment,[4] *WSHPDR 2019*,[10] Secretary of State for Energy Policy & Norwegian Water Resources and Energy Directorate,[12] *WSHPDR 2013*,[13] *WSHPDR 2016*[14]

A study of the country's hydropower potential was carried out between 2003 and 2006 by the Government of Timor-Leste in cooperation with the Norwegian Water Resources and Energy Directorate. The study identified 23 potential locations for SHP plants up to 10 MW with a total potential capacity of 219.8 MW and an estimated annual generation potential of 812.8 GWh. Of these, 15 sites with a total capacity of 187.6 MW and an estimated annual generation of 670.6 GWh were judged to be economically viable.[12] There are no official estimates of potential capacity for SHP up to 50 MW. However, a long-proposed hydropower project at Ira-lalaro Lake has been estimated as having a potential capacity ranging from 12 MW to 28 MW.[11,15] This suggests a total potential capacity, for SHP up to 50 MW, of at least 231.8–247.8 MW.

Overall, additional development and operation of SHP plants in Timor-Leste is complicated by the country's geological and environmental conditions. This includes a high mineral and sediment load of stream water interfering with turbines, as well as the porous nature of the bedrock that makes the impoundment of water necessary for the operation of reservoir-type plants difficult in certain locations.[4,15]

RENEWABLE ENERGY POLICY

Renewable energy development in Timor-Leste has been outlined in the Timor-Leste Strategic Development Plan 2011–2030, which was adopted in 2011 and targets a 50 per cent share of the country's energy needs to be sourced from renewable energy sources by 2030. The Plan estimates the country's total renewable energy potential from solar power, wind power, hydropower, biomass and solid waste to be 450 MW.[9]

Public consultations on a Draft Renewable Energy Law were carried out in 2016–2018 with the support of the United Nations Development Programme (UNDP). The Law is expected to target the creation of a financial mechanism for the promotion of renewable energy development and human capacity building in the sector.[5,10]

In 2017, Timor-Leste developed a National Climate Change Policy (NCCP), which promotes the gradual decarbonization of the electricity sector of the country through the promotion of renewable energy sources, particularly in rural areas. The Second National Communication of Timor-Leste under the United Nations Framework Convention on Climate Change (UNFCCC), published in 2020, projects a total annual electricity generation of 828.8 GWh by 2030. This is to include 128.2 GWh (15 per cent) provided by wind power, 89.7 GWh (11 per cent) provided by hydropower and 1.7 GWh (less than 1 per cent) to be provided by solar power. The remaining 609.1 GWh (73 per cent) are to be provided by thermal power, with generation from thermal power on a decreasing trend after 2028.[4]

Little progress on installing new renewable energy capacities has been made so far, although solar power biomass applications used for both electricity generation and other purposes have been gradually expanding their presence, particularly in rural areas.[4] A memorandum of understanding was signed by the Government and private companies in 2018, targeting the addition of 28 MW in solar power capacity, while the Ministry of Public Works launched the installation of 3,000 solar panels in remote parts of the country in 2020–2021.[16]

EFFECTS OF C4LIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Total annual precipitation is expected to increase in Timor-Leste in the coming decades, up to 100–120 mm in coastal areas and 260–300 mm in the mountains. However, the impact of this shift on local water resources is poorly understood, with expected decreases to potable water quality as a result of extreme weather events such as floods. The impact on river systems is also expected to be negative and include degradation of watersheds, erosion and landslides.[3] Although hydropower plays a negligible role in the electricity sector of Timor-Leste at the current stage, these factors may be expected to complicate further development of SHP and other hydropower due to increased competition with other water use sectors and potential damage to infrastructure.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key obstacles to SHP development in Timor-Leste include the following:

- Significant available reserve capacities of thermal power coupled with moderate energy demand obviate the need for additional capacity in the near term;
- Extension of the national grid removing the need for local generating capacity in many remote communities;
- Geological and environmental conditions complicating the construction and operation of SHP plants;
- Climate impacts negatively affecting available water sources.

Enablers for SHP development in the country include:

- Significant remaining SHP potential assessed and inventoried in previous studies;
- Demand for stable electricity access by the approximately 20 per cent of households not yet connected to the national grid;
- High cost of electricity generated from thermal power;
- Projected future growth in electricity demand;
- Ambitious government projections for generation from hydropower to 2030;
- Existing non-operational SHP plants that require refurbishment.

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Viet Nam

Danila Podobed, International Centre on Small Hydro Power (ICSHP)

KEY FACTS

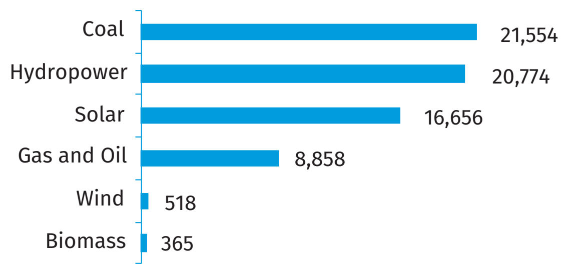
Population	97,338,583 (2020)[1]
Area	330,972 km^2[2]
Topography	Viet Nam has five topographical regions. The north of the country consists of the Northern Highlands and the Red River Delta, while the south includes the Annamite Range, the Coastal Lowlands and the Mekong River Delta. Mountains comprise approximately 80 per cent of the area of Viet Nam, with the country's highest point at Mount Fansipan (3,143 metres).[3]
Climate	Viet Nam has a tropical monsoon climate throughout much of the territory, with differences between north and south. The northern climate has four distinct seasons, while the southern climate is composed of a wet season lasting from May to November and a dry season lasting from December to April. Average monthly temperatures range from 10–16 °C in the winter to 25–30 °C in the summer.[4] Average temperatures vary greatly. For example, in Hanoi they can range from 17 °C in January to 29°C in June.[4]
Climate Change	Average annual temperatures in Viet Nam experienced a gradual increase between 1958 and 2014 of 0.62 °C, rising at approximately 0.10 °C per decade. According to climate change projections, average annual temperatures in the country are expected to rise by 1.3–1.7 °C by the mid-21st century under a moderate climate change scenario and by 1.8–2.3 °C under an extreme climate change scenario.[4]
Rain Pattern	Most rainfall in Viet Nam occurs during the monsoon season, with the north and south receiving heavy rains from May to October and the central parts of the country from September to January. Average annual precipitation is 1,763 mm in Hanoi, 2,867 mm in Hue and 1,910 mm in Ho Chi Minh City. The average air humidity is over 80 per cent.[5]
Hydrology	The two major rivers in Viet Nam are the Red River in the north and the Mekong River in the south, with a length of 510 kilometres and 220 kilometres respectively. The overall length of all of the country's rivers is 41,000 kilometres, with approximately 300 billion m^3 of water flow per year, in addition to 3,100 kilometres of canals.[5]

ELECTRICITY SECTOR OVERVIEW

The major sources of electricity generation in Viet Nam are coal, natural gas and hydropower, with solar power capacity undergoing a dramatic expansion in recent years but providing relatively little electricity. Total installed electricity capacity in Viet Nam was 68,725 MW in 2020, of which coal-fired power plants provided 21,554 MW (31 per cent), hydropower provided 20,774 MW (30 per cent), solar power provided 16,656 MW (24 per cent), gas- and oil-fired power plants provided 8,858 MW (13 per cent), wind power provided 518 MW (1 per cent) and biomass provided 365 MW (1 per cent) (Figure 1). An additional 572 MW were available from interconnections with China and Laos.[6]

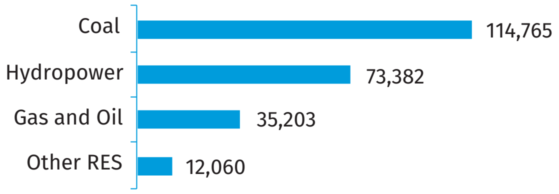
Total electricity generation in 2020 reached 235,410 GWh, with coal providing 114,765 GWh (49 per cent) of the total, hydropower providing 73,382 GWh (31 per cent), gas and oil providing 35,202 GWh (15 per cent) and non-hydropower renewable energy sources (RES) including solar power, wind power and biomass providing 12,060 GWh (5 per cent) (Figure 2). Electricity imports from China and Laos totalled 3,059 GWh.[6]

Figure 1. **Installed Electricity Capacity by Source in Viet Nam in 2020 (MW)**



Source: EVN[6]

Figure 2. **Annual Electricity Generation by Source in Viet Nam in 2020 (GWh)**



Source: EVN[6]

The energy mix of Viet Nam has been undergoing significant shifts over the last decade. Hydropower, once the mainstay of the electricity sector in the country, has seen its share of total installed capacity decrease from 46 per cent in 2014 to 43 per cent in 2016 and 36 per cent in 2019. The share of large hydropower plants is expected to decrease further to less than 18 per cent by 2030. Meanwhile, coal-fired power plants have expanded their share of installed capacity from 28 per cent in 2014 to 36 per cent in 2019, with the generation of electricity from coal nearly doubling between 2016 and 2020. At the same time, the share of coal as well as hydropower decreased between 2019 and 2020 due to a dramatic expansion of solar power capacity, from just 9 per cent of total installed capacity in 2019 to 24 per cent in 2020. This expansion was largely driven by rooftop solar power, which increased by a factor of 24 over the course of the year.[6,7,8,9]

The electricity sector development strategy of Viet Nam is outlined in the Power Development Plan (PDP). Under PDP 7 published in 2011 and revised in 2016, coal power was to continue expanding its share of both installed capacity and generation to reach 49 per cent and 55 per cent, respectively, by 2025.[9] However, the 2022 updates to the draft PDP 8, under continuous revision since 2021, have signalled a shift away from a major expansion of coal power in favour of RES in line with the commitments of Viet Nam towards decarbonization made at the 2021 United Nations Climate Change Conference (COP26).[10] Consequently, capacity targets for coal-fired thermal power have been revised downwards from 47,877 MW by 2025 and 55,477 MW by 2030 to 29,523 MW and 37,323 MW, respectively. At the same time, the targets for solar power and wind power have been increased by a factor of 3–4. Relative to PDP 7, hydropower targets have been revised slightly downwards.[11] Expansion of hydropower capacities in Viet Nam is difficult due to the saturation of the existing large hydropower potential, with no significant expansion of large hydropower planned after 2025. At the same time, substantial growth of the small hydropower (SHP) sector, along with that of other RES, is planned until at least 2045.[11,12]

The progress of Viet Nam in electrification has been outstanding, with 100 per cent of the population having access to electricity as of 2020. In 1997, this rate stood at 78 per cent.[13] In the 2000s, the Government increased its support for rural electrification efforts, especially in remote communities and villages. As a result, the use of off-grid systems, including SHP plants, increased across the country and in rural areas in particular.[14]

The state remains the main actor in the electricity sector, with the state-owned Electricity Corporation of Viet Nam (EVN) owning approximately 17 per cent of the country's total installed capacity and three subsidiary generation companies (GENCOs) owning 25 per cent. The remaining 57 per cent are owned by foreign build-operate-transfer (BOT) companies and domestic independent power producers (IPPs).[6,8]

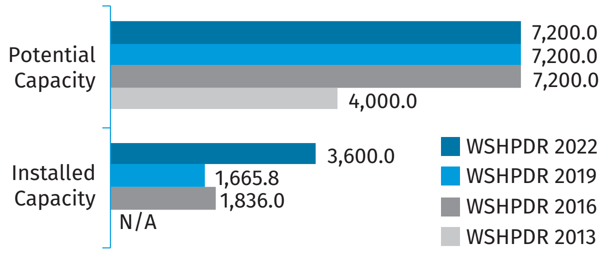
The country's electric system is operated at a high voltage of 110 kV, 220 kV and 500 kV and at a medium voltage of 6 kV to 35 kV, which is integrated into the 500 kV transmission network. The power transmission lines of 220 kV and 500 kV are managed by EVN's National Transmission Power Corporation (NTC), while the 6 kV, 35 kV and 110 kV lines are managed by regional power utilities.[6,15]

The Electricity Regulatory Authority of Viet Nam (ERAV) is responsible for monitoring and setting electricity tariffs in the country. In 2009, the Government embarked on tariff reforms aimed at establishing market-based retail tariffs with performance-based tariffs for transmission and distribution.[7] As of March 2019, the average retail electricity tariff in the country stood at 1,864.44 VND/kWh (0.083 USD/kWh), increasing from 1,568.70 VND/kWh (0.069 USD/kWh) in 2017. Electricity tariffs in Viet Nam are lower than average for the Association of Southeast Asian Nations (ASEAN) countries and globally, ranking 101 out of 147 countries in descending order.[7,16]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of SHP in Viet Nam is up to 30 MW (as per Decision of the Ministry of Industry No. 3454/QD-BCN dated 18 October 2005).[7] As of 2020, the installed capacity of SHP up to 30 MW was approximately 3,600 MW and SHP potential is estimated at 7,200 MW, indicating that 50 per cent of total potential has been developed so far.[8,11] Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, installed capacity has more than doubled due to ongoing SHP development, while estimated potential capacity has remained the same (Figure 3).[8]

Figure 3. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Viet Nam (MW)**



Source: *WSHPDR 2019*,[8] Burke & Nguyen,[11] *WSHPDR 2013*,[17] *WSHPDR 2016*[18]

The development of SHP plants in Viet Nam is mainly concentrated in the northern and central parts of the country.

The first plants were constructed and funded by the Government between 1960 and 1985. Between 1985 and 1990, the hydropower sector received investments from other parties, including ministries, industries, provinces, military units and cooperatives. In 2003, the electricity market was liberalized and the private sector started investing as well.[8]

Between 2011 and 2014, the number of SHP plants in the country increased dramatically, owing to a high inflow of private investments. However, lax oversight, lack of expertise and violation of agreements on the part of some developers have resulted in floods, dam breaches, deforestation and environmental degradation. As a consequence, the Government ultimately decided to strengthen its oversight on licensing new plants, especially small-scale ones. The Government also started cancelling planned SHP projects, including those already under construction. In October 2013, for example, 418 projects with a total capacity of 1,174 MW were removed from the country's hydropower development plan.[19,20,21]

In 2016, after a three-year review conducted in collaboration with the province legislative officials, the Ministry of Industry and Trade (MOIT) decided to remove 471 small and cascade hydropower plants from its PDP 7, including 8 large hydropower projects with a total installed capacity of 655 MW and 463 SHP projects with a total installed capacity of 1,404 MW. MOIT also rejected another 213 potential projects because of environmental and efficiency concerns.[22]

RENEWABLE ENERGY POLICY

The development of RES in Viet Nam has increased in recent years, accelerating after the COP26 summit in 2021 and the country's commitment to carbon neutrality by 2050. The increasing dependence of Viet Nam on fossil fuels imports due to rapid growth in energy demands has also contributed to calls for diversifying the country's energy mix away from fossil fuels.[23]

In 2015, the Government adopted the Renewable Energy Development Strategy 2016–2030 with outlook until 2050, (REDS) which came into force in 2016. The REDS set clear medium- and long-term goals, in particular for biomass, wind power and solar power technologies. The goals included an increase in the share of renewable energy in the installed capacity of large generation companies to 10 per cent by 2030 and 20 per cent by 2050, as well as a reduction of greenhouse gas emissions by 45 per cent by 2050.[24] REDS targets were expanded by the 2016 amendments to PDP 7, which set targets to 2030 of 5,990 MW in wind power capacity, 11,765 MW in solar power capacity, 3,444 MW in total capacity of biomass and other RES and a total hydropower capacity of 27,871 MW. All RES are to contribute roughly 38 per cent of total installed capacity by 2030.[11]

In 2020, the Government of Viet Nam passed Resolution No.55, which radically expanded the role renewable energy was to play in the country's planned energy development. The Resolution represented a clear direction away from the expansion of coal power outlined in PDP 7 and informed the sectoral targets set by the draft PDP 8.[12] While PDP 8 was still undergoing revisions as of mid-2022, expected targets would have RES accounting for approximately 50 per cent of total installed capacity in the country by 2030, with the share of coal reduced to less than 10 per cent by 2045 and plans for the construction of a nuclear power plant halted indefinitely.[10,11,12,23] Under the draft PDP 8, SHP was expected to increase to 5,000 MW by 2030 and to 5,900 MW by 2045.[11] These renewable energy targets will also be reflected in the National Energy Master Plan for the Period 2021–2030, Vision 2050, being drafted in parallel with PDP 8.[12]

The main instrument for the promotion of renewable energy in Viet Nam is the standardized Special Power Purchase Agreement for plants up to 30 MW and a standard tariff for small generators. Feed-in tariffs (FITs) had previously been available for solar power, wind power, biomass and solid waste.[8] As of 2021, FITs ranged between 0.085 USD/kWh and 0.098 USD/kWh for wind power, with proposed rates reduced to 0.068–0.082 USD/kWh for projects commissioned after 2023, while for solar power FITs ranged between 0.071 USD/kWh and 0.094 USD/kWh.[25] Since 2017, FITs for solar power and wind power have been continually revised downwards and there are indications that Viet Nam is planning to phase out FITs altogether and fully replace them with auction schemes, with the first auctions for solar power commencing in 2021.[12,25]

SHP development in Viet Nam has been incentivized with an avoided-cost tariff (ACT), defined as the difference between the cost of generation from SHP and the cost of generation of an equivalent amount of electricity from thermal power and subject to seasonal fluctuations.[7,26] The ACT for SHP was approximately 0.050 USD/kWh in 2020.[27]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

There are several barriers to the development of SHP in Viet Nam, including:

- Lack of a strong institutional and regulatory framework, leading to legal violations and environmental and social risks;
- Poor quality of construction and safety control, with subsequent low return of investment;
- Poor quality of management leading to concerns over efficiency;
- Repeated revisions to development plans leading to significant reductions in the number of planned SHP projects.

Enablers for SHP development in the country include the following:

- Considerable remaining undeveloped SHP capacity;
- Databases of potential sites available for investors;
- Considerable interest from the private sector in SHP development;

- National power development strategy is strongly supportive of large-scale expansion of all RES in general, including SHP.

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