RURAL AND RENEWABLE ENERGY SITUATION IN MYANMAR

1.1 Electricity access and development challenge

Energy supply and demand

Myanmar has abundant *energy resources*, particularly hydropower and natural gas. The hydropower potential is estimated to be more than 100,000 megawatts (MW) in terms of installed capacity. The total *primary energy production* was 22.5 million tons of oil equivalent (Mtoe) in 2013. Biomass made up about 46%, followed by gas (43%) and others (11%) consisting of hydropower, oil, and coal (ADB, 2016).

The *total primary energy supply (TPES)* is lower than the total primary energy production. Most of the produced gas is intended for export, which accounted for 79% in 2012, while the remaining 21% is utilized for domestic use. In 2015, the TPES was 20.1 Mtoe with a biomass share of 50% 10.0 Mtoe), followed by 17% (3.4 Mtoe) for hydro, 12% (2.4 mtoe) for gas, and 2% for coal (0.33 Mtoe). Myanmar has been reconnected with the world economy since its major reforms in 2011. Thus, domestic energy demand and supply have been increasing. For example, TPES increased from 11.8 MToe in 2000 to 20.1%, a 35% increase.

The power subsector[1]

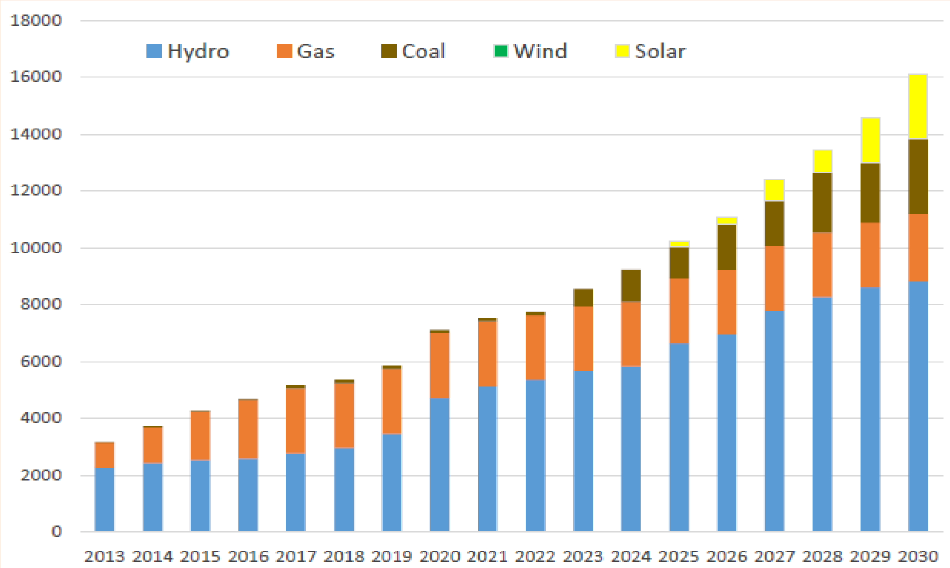
Total *electricity consumption* was 11,252 gigawatt-hours (GWh) in 2015, of which Yangon accounted for 44%. Electricity consumption has grown by 9.8% per year during 2000–2012. The peak load reached 2,500 MW in February 2016.The total *installed capacity* at mid-2016 is 4,764 MW, with 2,820 MW (59%) from hydropower, 1,824 MW (38%) from gas, and 120 MW (2.5%) from coal. Thus, Myanmar relies heavily on hydropower for its electricity generation (making up 72% of power production in 2014), yet the country has abundant hydropower resources that remain undeveloped. The country possesses over 46 GW of potential installed capacity from 92 possible hydropower projects. The Ministry of Energy and Electricity (MoEE) owns about 75% of total installed capacity and the rest owned by the private sector. The available capacity is approximately 50% of the installed capacity. Aging power plants and poor electricity transmission infrastructure cause severe power shortages, especially during the dry season when hydropower is in low supply. Of the hydropower capacity, 520 MW is reserved for export to China.

Installed capacity is expected to be expanded with new power projects adding about 11,000 MW over 2016-2030. By 2030, about 6,300 MW from 38 new hydropower plants will be added, and a first 500 MW coal plant will be added in 2023 (Soe Soe Ohn, 2016). The government tries to attract investment in hydroelectric, natural gas, and coal-fired electric capacity, to improve grid reliability, and to promote demand management. However, hydropower and coal-fired power plants are facing delays from local opposition, and gas-fired generation is dependent on the country's future domestic gas production and potential natural gas developments (EIA, 2016). Increased attention is therefore given to solar energy, which will become more competitive as the trend of decreasing prices for solar panels will continue, and over 2500 MW of solar energy will be added (see Exhibit 17).

[1] Data taken from various sources, ADB (2016, Doberman (2016), Soe Soe Ohn (2016, 2018), World Bank (2017)

* The Annex E is based on technical baseline reporting prepared by the PPG Team leader, J. Van den Akker, with contributions from the PPG members M.Nwa Soe, Th..Phyu Htoon, Kh.May.Khyi and M.Thin Aung, with S. Gubbi responsible for drafting Annex F

Exhibit 1 Least-cost power expansion plan



Natural resources	2015 (4271MW)	2030 (16112MW)
Hydro electricity	48%	55 %
Natural Gas	44%	15%
Coal	2%	16 %
Renewable Energy	6%	14 %

Plant Type	Installed Capacity in 2030	
	MW	%
Gas	2374	15%
Coal	2620	16%
Hydro	8818	55%
Renewables	2300	14%
Total	16112	

The country's transmission system comprises a network of 230-kilovolt (kV), 132-kV, and 66-kV transmission lines and substations. Most of these lines lead from the northern part of the country, where most hydropower plants are, to the southern load centres, particularly the Yangon area. A 454 km long 500 kV transmission line is under implementation from north to south through bilateral assistance. Technical and nontechnical losses of the combined transmission and distribution system were as high as 30% in 2003 and fell to 20% in 2013.

Institutional framework for the energy and electricity sectors

In April 2016, the government restructured its organization and reduced the number of ministries from 36 to 21, leading to a merger of a number of ministries. Ministries related to the energy sector are:

- *Ministry of Energy and Electricity MoEE* is the overall focal point for energy policy, coordination, and international cooperation and also the oil and gas sector, and is responsible for developing, operating, and maintaining all large hydropower and coal-fired thermal plants; for developing and maintaining the transmission and distribution systems throughout the country, and for operating gas-fired thermal plants and mini hydropower plants
- *Ministry of Environmental Conservation and Forestry* is responsible for forestry issues and policy (and regulates the use of biomass from forest resources for energy purposes). Its *Environmental Conservation Department (ECD)* is responsible for implementing environmental policy, strategy, framework, planning and action plan, including climate change issues. It has formulated the National Environmental Policy and Strategic Framework & Master Plan.
- *Ministry of Industry*, which has responsibility for energy efficiency and implementation of Energy Efficiency and Conservation policy and development plan
- *Ministry of Agriculture, Livestock and Irrigation* takes the lead in the development of biofuels, micro-hydropower (with an installed capacity of up to 10 MW), bioenergy from agricultural residues, for off-grid electrification (solar Home system, mini-grid system, etc)
- *Ministry of Border Affairs,* for off-grid electrification in border areas.
- *Ministry of Education* is responsible for the research and development of renewable energy technologies (RET) and the promotion of renewable energy, and also conduct formulation of RE policy and a specialised centre organises training courses on RE.

The Myanmar government created a *National Energy Management Committee* and National Energy Development Committee (NEMC/NEDC) in 2013 to facilitate cooperation and communication among energy-related ministries and organisations. However, the committees were disbanded in the ministerial restructuring that accompanied Myanmar's transition to a new government in 2016.

On the ground, various state-economic enterprises carry out most of the work in the power sector. About 57% of the power is generated by the state company EPGE (hydropower, gas, oil, coal) and independent power producers (IPPs). The Power Transmission and Systems Control Department develops the national transmission networks and substations. EPGE is also the single buyer having the authority to purchase electricity from different energy generators through individual power purchase agreements (PPAs) and sell it to state-owned distributors. IPPs in electricity generation are becoming more common, but foreign investment still requires links with either a local company or directly with the government. The Electricity Supply Enterprise (ESE) supplies power to the bulk of the country. Electricity distribution in Yangon falls under the auspice of the Yangon Electricity Supply Corporation (YESC) and in Mandalay under the Mandalay Electricity Service Corporation.

Relevant policy, legislation and regulation

The government has prepared a set of reform programs aiming to transform the country. The framework for these reforms was laid down in the *2011–2031 National Comprehensive Development Plan.* To ensure the development of the energy and electricity sectors, the NEMC prepared the *National Energy Policy* paper which was approved in Jan 2015[2]. The *Energy Master Plan* was elaborated by IES, MMIC with support from the Asian Development Bank and published in Dec 2015. Government plans as set out in the National Energy Policy paper include sector restructuring, investment planning, pricing, and fuel subsidy review, renewable energy and energy efficiency development, promotion of private sector, increased international trade, and a National Electrification Programme (NEP) with the aims at achieving 100% electrification by 2030.

The new *Electricity Law* was passed in 2014 allowing private sector participation. The associated Rules and Regulations, which are to be finalized, will address details on the implementation of the law and establishment of the Energy Regulatory Commission and its duties and mandate. The *National Electricity Master Plan* was elaborated with Japanese support by NEWJEC, Kansai Electric Power (2014). The ADB-supported the development of a *Renewable Energy Policy* in 2014, but this has remained in draft form. The Policy's goal is to achieve a 27% share of renewable energy in the total installed capacity of primary energy by 2030.

Under the new law states and regions can issue permits for small (< 10MW) power plants and for medium-sized power plants (30 MW) not connected to the grid. The new law will effectively encourage state-level government stakeholders to take a lead in promoting off-grid power infrastructure projects. Low-head hydropower technologies and cascades of smaller-scale (<10MW) dams have fewer environmental and social impacts, and are therefore likely to generate less public opposition, particularly when the electricity generated benefits local communities.

Renewable energy

Myanmar has rich hydropower potential that drains the four main basins of the Ayeyarwady, Chindwin, Thanlwin, and Sittaung rivers. It is estimated that there is more than 100,000 MW of installed capacity potential. Myanmar has identified about 300 **large hydropower** potential projects with a total installed capacity of 46,330 MW[3], while the current installed capacity of hydropower plants is about 3,200 MW. A total of 32 **mini hydropower** (with a total capacity of about 34 MW) projects have been implemented with installed capacity ranging from 50 kW to 5,000 kW to reach remote border areas in Kachin and Shan Stat. There is the potential for many more small- and medium-sized hydropower projects, each of which has a capacity of less than 10 MW, for a total potential installed capacity of approximately 250 MW (ADB, 2015). With the new Electricity Law (2014, the regional governments are permitted to approve small-scale hydro plants that power mini-grids in villages that are not connected to the grid (see next Section).

Myanmar has a strong solar radiation level. Myanmar's maximum **solar power potential** is estimated at about 40,000 GWh per year. **Solar energy** has been introduced in some rural areas in the last decade through photovoltaic cells for charging batteries and pumping water for irrigation. The MoEE is conducting a preliminary investigation to construct solar power

[2] NEMC's Order No.(1/2015)

[3] Of which 46.100 MW in 92 projects > 10 MW and 230 MW in 200 projects < 10 MW. Tint Lwin OO (2017)

plants of a total of 1,460 MW with foreign direct investment in Minbu, Magway Region, Myingyan, and Mandalay Region[4]. Solar PV is increasingly used to power off-grid villages in small mini-grid systems (see next Section), the Department of Rural Development (DRD) reported about 200 by 2017. Several households in a village already have a solar home system installed, either from the DRD programme (described in the next Section) or self-purchased.

Most of Myanmar is considered unattractive as average **wind** speeds are below 4 meters/second, except for coastline and mountain ranges[5]. Site-specific wind data is limited to a few; therefore, an in-depth assessment is needed. Foreign investment proposal of about 6,540 MW have been received, but are still in concept stage and none have started any activities. Regarding **biomass**, about 53% of the total land area is covered with forest and has a potential annual sustainable yield of wood fuel 19.1 million cubic ton. Large amounts of waste are generated in the big cities, such as Yangon or Mandalay, with organic materials that could be used generate energy by bio-methanation[6]. Agricultural residues and by-products (such as rice straw and husks, sesame stalks, palm leaves and animal waste) can be used to generate biogas[7]. Five biofuel plants were constructed by various agencies between 2003 and 2010 (with a total annual production of 19.5 million gallons) but have ceased operations, hampered by financial, legal and other issues. A large number of gasifiers are in operation using rice residues as feedstock.

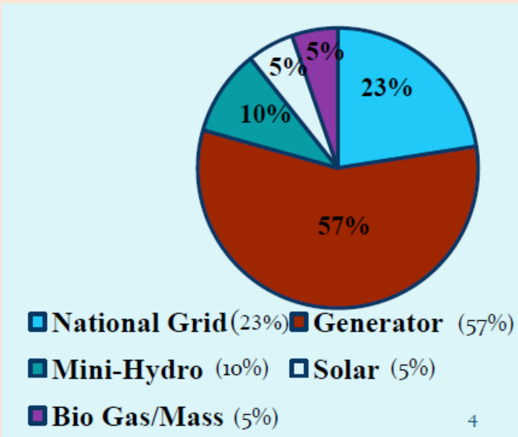
Electrification

Electrification rate

The country's average electrification ratio has grown from about 16% in 2006 to 26% in 2011 to 34% in 2015 and 57% in 2018[8]. Yangon City has the highest electrification ratio of approximately 78%. In comparison, the country's rural electrification rate, at 16% in 2015-16, remains among the lowest in the world. According to World Bank ESMAP estimates, over 7.2 million households in Myanmar were off-grid as of 2015.

Out of a total of 63,899 villages in Myanmar, 20,807 villages were considered electrified as of August 2016 (villages with at least 70% of electrified households are considered 'electrified), leaving over 43,092 villages unelectrified. Regions in the Central Dry Zone and Ayeyarwady delta region are better electrified than states in border areas; in Kayin and Tanintharyi states, electrification remains under 10%. There, most rural villages cannot tap into a steady stream of electricity, such as the grid. The NGO Spectrum SDKN has analysed the status of rural electrification, based on the 2014 Census, of which the results presented below.

Exhibit 2 **Current situation of rural electrification**



However, alternatives such as diesel generators are quite common in some area, despite their high costs (see Exhibit 18. Use of private generators for lighting is very high in Tanintharyi Region and parts of Mon State (see Exhibit 19). This might be because these areas are far from the national grid and have relatively high household income levels (due to remittances from migrants worming in Thailand). The use of small solar devices is also growing. Use of solar photovoltaic (PV) systems for lighting is highest in Shan State, Kayah State, and Kachin State (see Exhibit 19).

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4 Of which three projects (470 MW) had reached the stage of PPA (power purchase agreement). Solar power in Myanmar has an estimated levelized cost of electricity between USD 0.16-0.19/kWh (2014 figures; ADB, 2015; Tint Lwin Oo, 2017.

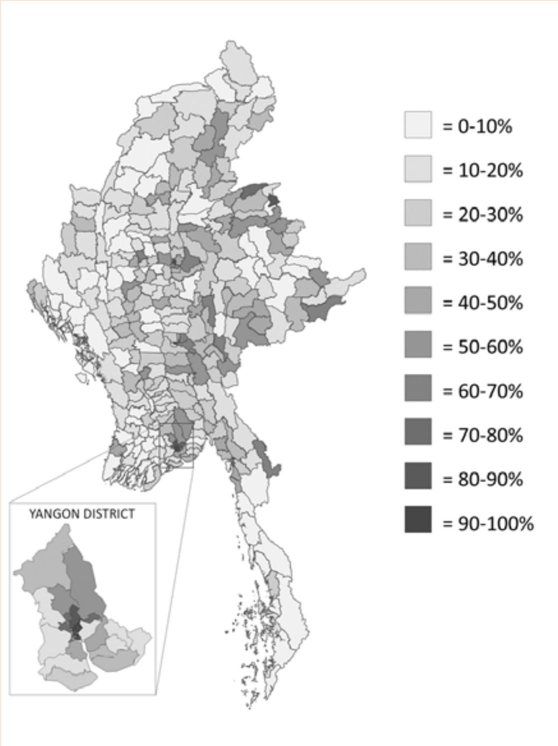
5 The theoretical wind energy potential is an estimated 80,000 GWh/yr

6 A waste-to-energy plant was commissioned in 2017 at Shwepyithar Township, Yangon

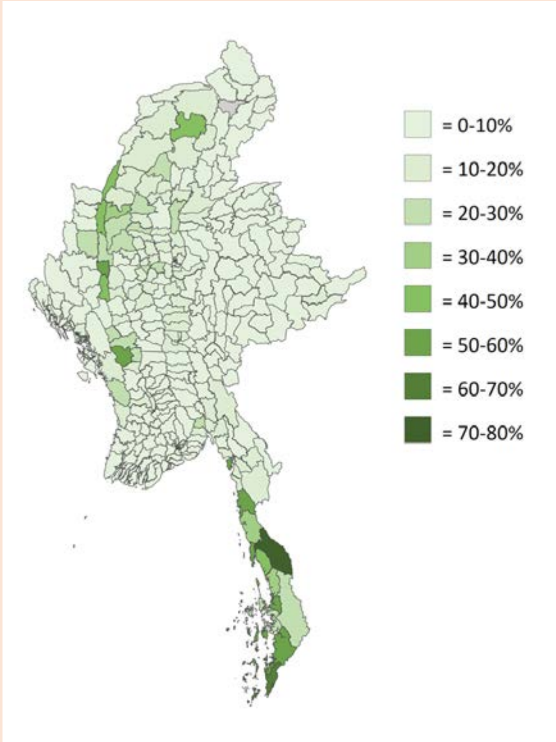
7 There are approximately 103 heads of livestock. Around 190 biodisgesters (5-25kW) have been installed. Source: ADB (2015) and Tint Lwin Oo (2017)

8 World Bank Indicators (2018)

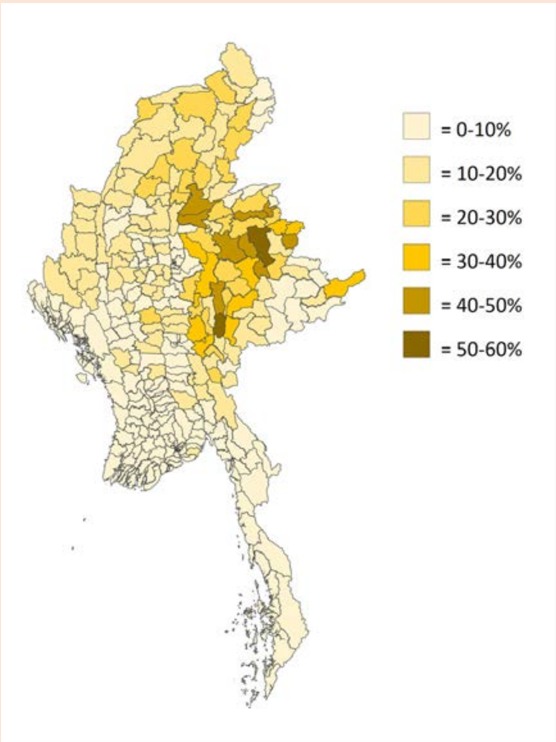
Exhibit 3 Township-level maps of access to energy technologies



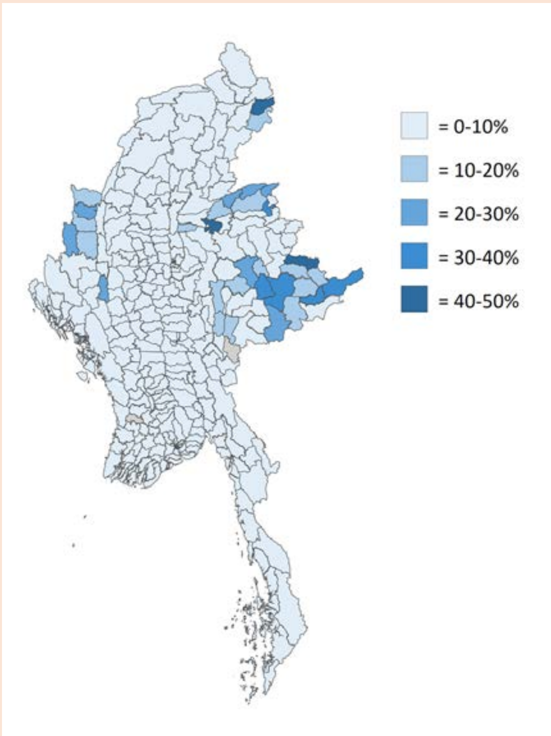
a) On-grid electricity



b) Diesel generatot



c) Solar PV



d) Mini-micro hydropower

Source: Spectrum – SDKN (2017)

In some rural townships in Shan State, over 50% of households use solar PV for lighting. One reason is that many solar PV panels cross the border from nearby China (KWR-ERIA, 2015). In some rural areas, the use of solar PV has already overtaken the use of generators. The use of private small hydro systems for lighting was highest in Shan State, Kachin State, and Chin State, with nearly 50% of households using small hydro mini-grids or lighting in mountainous townships in Shan State and Kachin State. Gasification, powered by rice husks and other agricultural by-products, are seen as an attractive energy source in the Ayeyarwaddy Delta. It is reported there are presently 1,000 or more gasification facilities in Myanmar (KWR-ERIA, 2015).

The use of batteries is concentrated in the central dry zone and reached over 20% in rural parts of Ayeyawady Region, Magway Region, Mandalay Region, Sagaing Region, Bago Region and Yangon. This might be because the flat terrain in these areas makes distribution of batteries more economic than in more hilly parts of the country. Households that rely on batteries may be well suited for transitions to solar PV systems, since they are likely to already own low-voltage appliances and be familiar with the basic concepts of battery charging and energy management.

On average, 26% of households in rural areas and 7% of households in urban areas relied on candles for lighting in 2014. The highest usage rates were in rural townships in Rakhine State, Kayin State, Naypyitaw, Kachin State and Mon State. Candles are an expensive and often dangerous source of lighting. Switching from candles to solar PV or mini-grid systems can provide a safer, higher quality and in many cases cheaper source of lighting

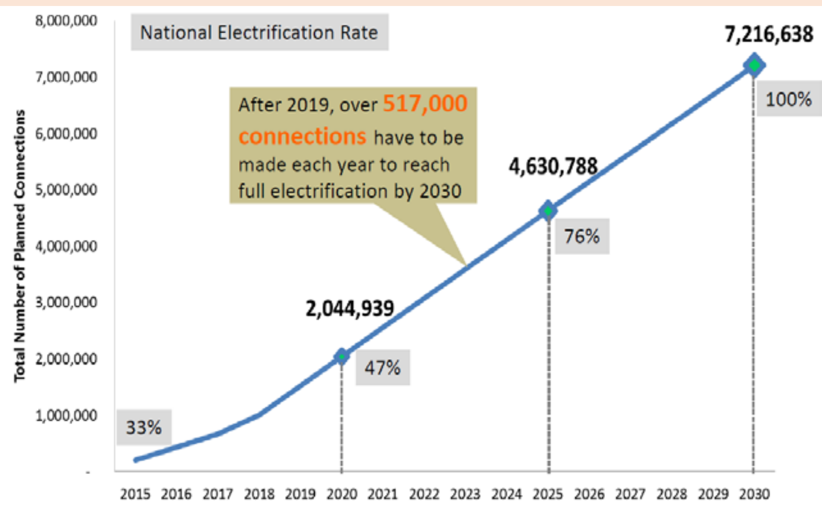
Off-grid suppliers are providing household and village electricity supplies (diesel and renewables) for rural customers through retail and tenders with the government, international organizations, and NGOs. Some of these local companies and social enterprises have a long-standing presence in Myanmar, while others are relatively new and came into existence primarily to implement government tender programs. Commercially oriented off-grid service providers face risks as there are no clear standards for setting retail tariffs nor clear options for interconnection upgrades to the utility network as the grid continues to extend into new service areas. Market data and consumer information (e.g., ability and willingness to pay for electricity) were not readily available, until recently (see section E.3).

National Electrification Plan (NEP)

At present, approximately 190,000 additional households gain access to electricity every year. At this rate, it would take almost 40 years to achieve full electrification. In 2014, the Burmese Government released its National Electrification Plan, with the ambitious goal of *providing electricity access to all households by the year 2030*. The plan aims to expand the national grid, under the MoEE, and develop off-grid electrification for remote communities by means of mini-grid and renewable energy (RE) technologies, under the MoALi.

Such a pace of electrification will be challenging given the geographical, financial and institutional constraints. Approximately 7.2 million household connections will be required in the next 16 years to fulfill the vision of universal electrification by 2030 (see Exhibit 20). This means that the number of household connections needs to increase from the current 189,000 a year, to an average of 450,000 a year over the next 16 years—a more than two-fold rise. This also implies a newly added power demand of 2,636 MW.

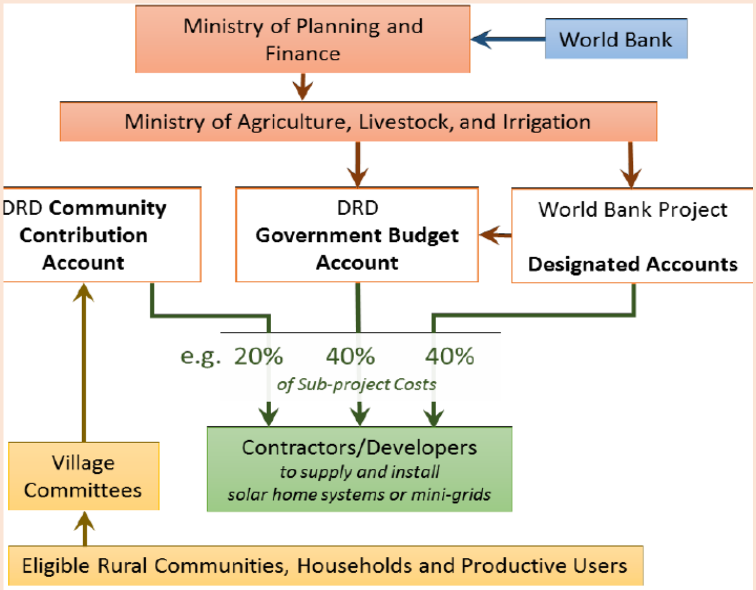
Exhibit 4 Rural electrification target in Myanmar



The total cost of the grid expansion, including investments into generation, transmission and distribution, is around USD 6-10 billion over the next decade and a half (about USD 800-1600 per connection)[9].

Financing these investments requires a financially viable power sector. It is currently not viable: the costs of production and transmission are about MMK 109 (USD 0.078) per kWh. However, the average tariff in Myanmar is only about USD 0.03 per kWh[10]. For each unit of electricity sold to residential consumers, the government is making a loss, which is about MMK 59-74 per kWh (Doberman, 2016).

Exhibit 5 Responsibilities of stakeholders in the off-grid NEP



Source: ESMAP-WB, Wang (2016)

Amending tariff policy will be key for closing the funding gap which was USD 300 million (MMK 406.52 billion) in electricity subsidies over the fiscal year 2017-18 and will lose close to USD 500 million in 2018-19. The traditional argument for subsiding power consumption is that electricity is a prerequisite for almost all other aspects of development and that the poor can afford it. However, one counterargument is that the future access of the millions of unserved will depend on the funds available in the power sector to extend the generation and transmission and distribution capacity. Second, subvention is less fair than it seems. For example, a poor customer using 50 kWh per month receives a MMK 3500 subsidy, while one using 500 kWh gets MMK 30,000 worth of free electricity.

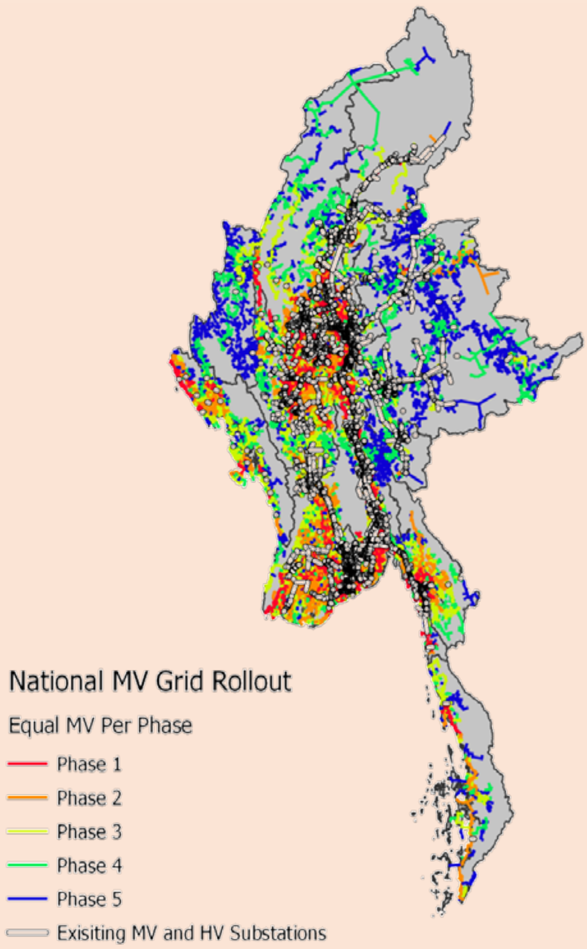
Grid electricity will not solve all problems. A prominent feature of the NEP is that the grid is planned on a spatial least-cost basis It is a technically efficient solution for many areas, but not for all. Areas closer to existing lines and in flatter terrain are to receive the grid sooner. Mountainous and remote regions can expect the grid to arrive much nearer to 2030, if at all. The process of expansion and connection also takes many years (once the grid reaches a township, it can take anywhere between one to four years for households to complete their connections). This will leave certain areas dependent on high-cost diesel and other sources that can cost up to MMK 500 per kWh, or which provide power only a few hours a day. At the same time some of their neighbours and nearby areas, which are connected, will receive 24-hour power at the MMK 35 per kWh residential or MMK 75 per kWh industrial tariff rates. This is bound to exacerbate social tensions and promote a sense of inequity (KWR-ERIA, 2015).

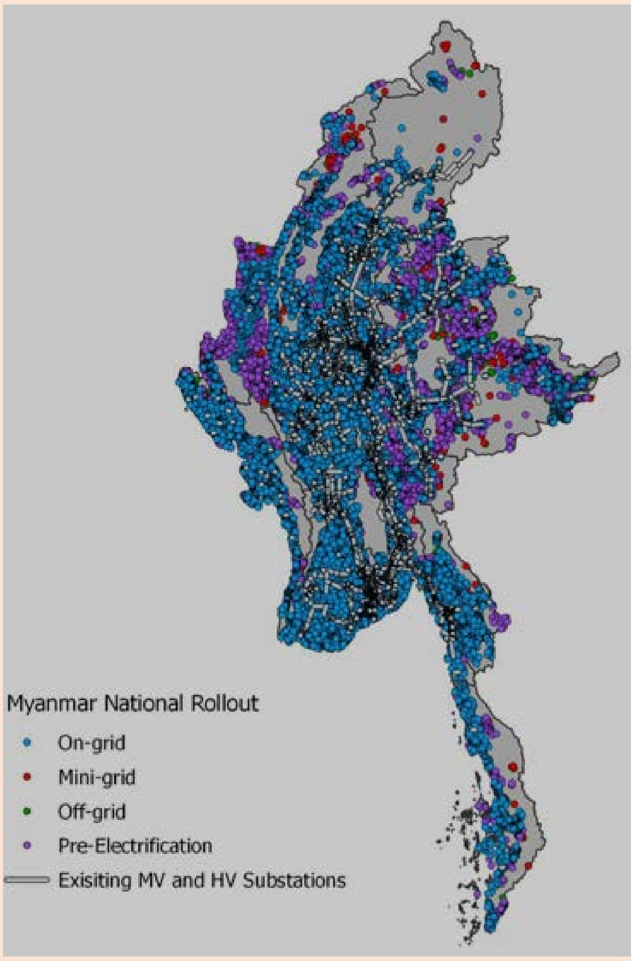
There exist immediate opportunities for electrifying villages without relying on or waiting for the grid. A priority, instead of waiting, is to help develop local grids in these regions (using solar panels, micro-hydropower turbines, and traditional biomass and/or in hybrid configuration with diesel generators) must be examined (and which could later be connected to the main line when it arrives). About 1.3 million of the 7.2 million households to be electrified are recommended for this '**pre-grid electrification**' (in particular areas covered by Phases 4 and 5). These are the purple dots in the figure on the right in Exhibit 22, especially in Shan, Chin, Kayah and Kachin States. Two promising technologies to achieve this are solar power and micro/mini-hydropower. Currently, largely as a result of charitable or non-governmental efforts, there has been an emergence of small solar devices used for basic lighting and charging of mobile phones. Another technology being used are (privately owned) diesel generators, with individuals in a village paying a fee to access its electricity.

[9] Own estimate, based on MoEE information (website) and Doberman (2016)

[10] Residential prices in Myanmar are K35 per kilowatt-hour for the first 100 units, K40/kWh for the next 100 units, and K50/kWh for all units after that. Prices for commercial and industrial customers are much higher, ranging from K75-K150/kWh, but the financial viability of supplying subsidized power to millions of people cannot entirely paid for by a few thousand businesses. Source: Doberman (2016), *Myanmar Times* (24 July 2018)

Exhibit 6 National grid roll-out plan





The NEP's electrification targets will be achieved in 5 phases, starting with low-cost and then moving to high-cost connections:

- Dense areas require shorter distribution lines and lower cost per connection and will be connected first. Remote communities require longer lines and higher cost and will be connected later (phases 1 to 3);
- Remote villages (mainly in Chin, Shan, Kachin and Kayah States) have the highest cost per connection, thus to be connected in the final phases (phases 4 and 5; see Exhibit 22) and will be served by off-grid solutions.

Phase 1 will run from 2016-2021, of which the grid extension (implemented by MoEE) is supported by the World Bank with USD 310 million and government contribution of MMK 51.5 billion. The aim is to electrify 6240 villages (750,000 households; population of about 2.6 million) by extending 5130 miles of 11-33 kV lines (Soe Soe Ohn, 2016b; MoEE website 2018)[11].

[11] Plus 11,600 grid-connected community buildings and on-grid public lighting (132,000 lights). Source: WB *Project Appraisal Document for the 'National Electrification Project'* (2015).

1.2 Status and plans in off-grid electrification

National Electrification Plan (NEP)

MoALI will implement the off-grid component of the NEP. The first Phase (2016-2021) will be supported by World Bank-IDA with USD 90 million (of which USD 10 million for technical assistance, USD 7 million for mini-grids, USD 53 million for solar home systems, and USD for community/public institutions), in addition to the Government's budget of about USD 75 million[12]. The off-grid component aims at providing electricity to about 650,000 households (see Exhibit 24).

The off-grid electrification programme consists of three components:

- Solar home systems (8575 villages)
- Mini-grid systems (344 villages), powered by solar, hydro, biomass or biogas)
- Community buildings (in 5548 villages)[13]

Village electrification committees

The NEP relies on a **self-reliant electrification approach**. The government will provide the grid to the township level. Villages within the township must then organise and collectively finance the final stage of connection. They must also organize the villages mini-grids and apply in Calls for Proposals (see further). **Village Electrification Committees (VECs)** are formed by community members. This body then works with local township electricity officials to devise a connection or mini-grid electrification plan, and crucially, to raise the funds from collective household savings. However, financial support for their functioning is very limited. Also, VECs receive with little guidance or technical support, and may not have the expertise to formulate rural energy proposals. This may explain why in the DRD-NEP Call for Proposals, most projects presented are drafted by project developers (o contractors on behalf of VECs) rather than the VECs themselves.

Solar home system program

The DRD's off-grid program was being implemented under the government's own budget, and with some support from a few donors, for several years prior to the approval of the World Bank-supported NEP. The DRD off-grid electrification program had electrified 416,727 households spread across 4,840 villages in Myanmar between 2012 and 2016, out of which

Exhibit 7 Configurations of SHS offered under the off-grid NEP

SHS Configuration	Capacity and service level	Total cost	Subsidy amount	Contribution from the HH
Small	3 LED lights (3 hours per day each) 1 TV (1.2 hours per day) 1 phone charging outlet (~2.5 hours per day)	MMK 300,000 (~US$ 220)	MMK 270,000 (US$ 198) – 90% subsidy	MMK 30,000 (US$ 22)
Medium	4 LED lights (3.5 hours per day each) 1 TV (1.8 hours per day) 1 phone charging outlet (~2.5 hours per day)	MMK 380,000 (~US$ 280)	MMK 330,000 (US$ 243) – 87% subsidy	MMK 50,000 (US$ 37)
Large	5 LED lights (4 hours per day each) 1 15 W DC TV (3 hours per day) 1 phone charging outlet (~2.5 hours per day)	MMK 420,000 (~US$ 310)	MMK 340,000 (US$ 250) – 81% subsidy	MMK 80,000 (US$ 60)

Source: ESMAP-WB (2016). Systems include battery (12 V 40 Ah, controller and 8 m of cabling

[12] Other donors contribute as well, KfW, EUR 9 million (2016-19), GIZ (2016-2018, for TA), Italy (EUR 30 million, 2018-21, for Chin State), ADB (USD 2 million, 20150-17) and JICA (JPY 994 million, 2014-17). Source: Soe Soe Ohn (2016a). In parallel to WB's NEP activities, the International Finance Corporation of the WB Group has setup a Lighting Myanmar program. The Lighting Myanmar program is planned to provide technical assistance and advisory services focused on quality assurance, developing knowledge products aimed at building market and consumer knowledge, and supporting Microfinance Institutions and private sector build technical capabilities and distribution channels for solar home systems in rural and off-grid areas of Myanmar.

[13] The WB *Project Appraisal Document for the 'National Electrification Project'* (2015) mentions 11,400 community buildings connected by mini-grid/off-grid options and 19,000 lights off-grid/mini-grid public lighting. These receive 100% grant funding (since then lowered to 80%).

365,102 households were electrified with solar home systems (prior to the beginning of World Bank-DRD NEP program) with the remainder by micro-hydro, biomass and grid extension.

The implementation model of the **SHS component of the WB-DRD National Electrification Plan (NEP)** involves procuring solar home systems from private companies (contractors) through international competitive bidding, with these contractors also responsible for installation and after-sales service. The technical specifications and quality standards of SHS are defined by World Bank and IFC Lighting Myanmar programs, and the contractors are responsible for ensuring that the SHS they install meet these standards and specifications. World Bank engaged a dedicated team for monitoring and verification of SHS installed by contractors.

Exhibit 8 **Yearly plan for off-grid electrification, Phase 1 (2016-2021)**

Sr.	Fiscal Year	SHS		Mini-Grid		Total		Estimated Cost (Million $)	Remark
		Village	HH	Village	HH	Village	HH		
1	2016-2017	2708	141465	10	1081	2718	142546	34.910	Complete
2	2017-2018	1367	87958	34	5184	1401	93142	24.954	On Going
3	2018-2019	1500	133275	100	11050	1600	144325	50.508	Plan
4	2019-2020	1500	122950	100	9095	1600	132045	46.355	Plan
5	2020-2021	1500	128550	100	7380	1600	135930	46.394	Plan
	Total	8575	614198	344	33790	**8919**	**647988**	203.121	

The first contracts for SHS were organised in 12 lots for bidding at a value of appx USD 30 million was signed in 2016 for delivery and one-year maintenance of some 136,000 SHS and 14,000 public facilities, and installation started in January 2017. In 2016-17 the off-grid solar programme has installed 160,660 SHS with a total installed capacity of 8.9 MW[14] A new round of international competitive bidding (ICB) was initiated for the procurement of over 140,000 SHS under the World Bank NEP in 2017-18, in addition to a further 19,000 SHS that will be procured by DRD with financial support from the German development agency KfW, thereby expecting to reach electrification of 750,000 households across Myanmar by 2018 in the various government programmes over 2012-18. The Total target 2016-2021 is 615,000 SHS in 8575 villages and mini-grids connecting 648,000 HH in 8919 villages (see Exhibit 24). Total cost: USD 203 million with funds coming from the Government (USD 15 million) and from donors as well as public (community) contributions.

Subsidies before 2016 on SHS were a full 100%[15]. Under NEP, subsidies offered to off-grid households range between 81-90% depending on the SHS configuration opted by each household. The subsidy is to come down to 85% in year 1 and 80% on average in year 5.

<u>Mini-grid programme</u>

The most common mini-grid generation technology observed in Myanmar is diesel generators. The 2014 Myanmar census reports that about 178,000 households (of which 152,000 rural) used “private water mills” as the primary source of electricity[16], while 1,013,149 households used diesel generators (of which 836,000 rural)[17]. Solar mini-grids, either stand-alone or hybrid PV/diesel are much less common. The DRD reports some 150-200 villages by 2017; most have been heavily subsidized as pilot projects commissioned by nongovernmental organizations or DRD.

14 Kayin: 12,356, Chin: 13,865, Sagaing: 12,059, Tanintharyi: 20,928, Rakhine: 35,403, Shan: 32,767, and Ayeyarwaddy: 33,102. Source: DRD, Soe Soe Ohn (2016a). Wang (2016)

15 Configuration: 80 W solar module, 12 V 65 Ah battery, controller, inverter, two 3W bulb and one 10 W tube plus 8 m of cabling

16 Hydro-powered mini-grid or pico-hydropower. Source: *End of 2015-2016 FY 70% Rural Electrification Villages*. Source of household data: 2014 Myanmar Census.

17 In rural areas, national grid coverage is much lower, at only 15 percent. About 1 million households (9 percent) receive electricity from private diesel generators, 11% of households use solar home systems, and another 21% use batteries charged in local towns. more than 16,000 of the country’s 64,000 villages get their electricity from diesel generators, micro-hydropower, or biomass. DRD mini-grid developers may be a national or international firm that is a private entity or any combination in the form of a joint venture (JV). data (2015)

Exhibit 9 Proposed State-level regulations for off-grid electricity systems

Under the NEP, the national grid is expanding quickly in some areas; but plans and targets for specific townships and villages tend to change over time. This uncertainty, makes mini-grid developers reluctant to invest if they suspect the national grid is arriving in the near future. After the National Energy Management Committee was disbanded, coordination between MoEE and MoALI on grid and off-grid electrification has not always been optimal, adding to the uncertainty issue.

A regulatory framework for mini-grids would partly address the uncertainties developers and investors face about their investments. One component of the GIZ support to NEP is on supporting DRD in developing a regulatory framework for mini-grids (e.g. financial support mechanisms, ownership structures, tariff schemes, grid interconnection). Small-scale energy enterprises can be isolated mini-grids (providing generation, distribution and/or power sales), small power producers (SPP), small distributors (SDN) and small electricity retailers (SER). The first elements of such off-grid regulatory framework (draft) have been proposed:

- Exclusivity (optional: providing exclusive rights to carry out project preparation activities in a designated area, for up to 12-18 months)
- Permission (simplified procedures for small companies to engage in generation, distribution and retail of up to 100 kW; full permitting procedure for capacities up to 10 MW)
- Tariffs (allowing reasonable return on investment and adjustments for inflation and changing fuel prices)
- Guarantees in the event of national grid arrival
  - Right to receive financial compensation (transfer of all assets of the mini-grid or company)
  - Linking to the grid as SPP, SDN or SER and legal right to operate (with streamlined approval < 1 MW) under a standardized small power purchase agreement (SPPA) and standardized feed-in tariff, or in case of SER, standardized small power sales agreement (SPSA)
  - Commissioning (must happen no more than 3 yrs from SPPA or SPSA signing; on verification of connection compliant with technical standards, an Interconnection Facility Certificate is issued)

Myanmar has two major business models for mini-grids. Some mini-grids are operated by a group of farmers selected by a village's Village Electrification Committee (VEC). In this model, the leader of each 10-household block in the village collects the monthly tariff payments. Other mini-grids are owned and operated by private entrepreneurs. Studies found that tariffs charged by the diesel-powered mini-grid operators are about MMK 1000-2000/month (USD 0.9-1.82/month) for a single light bulb connection and MMK 2500-5000 (USD 2.27-4.55/month) for a connection with lighting and TV. Equivalent tariffs per kWh are about USD 0.37-1.00. Tariffs of hydropower mini-grids are typically lower than tariffs at about MMK 200–K 860 (USD 0.18–0.78) per kWh (World Bank, 2017). Biomass gasifiers are common in the delta region, powering mini-grids as well as rice mills, irrigation pumps, sawmills, and oil pressing. Tariffs for biomass gasifier mini-grids are about MMK 400/month.

The **mini-grid component of the WB-NEP** has been progressing and two rounds of Call for Proposals (CfP) have been organized, supported by World Bank funding. The original budget for mini-grids in NEP (USD 7 million) has now been increased to USD 24 million (with the total budget for off-grid, mini-grids plus SHS, remaining at USD 24 million). In the CfP, the DRD-NEP Project Management Office (PMO) invites project developers to engineer, procure, construct, and operate renewable energy mini-grids[18] (or renewable-plus-diesel hybrid mini-grids) less than 1MW in a public-private partnership arrangement. During this process, DRD will provide assistance by means of construction subsidy and capacity building. The World Bank support (NEP project) will end on 30 September 2021.

The first CfP in 2016 resulted in 26 proposals (of which 10-12 approved for feasibility and 8 have been commissioned). In the 2nd Call (2017), 82 proposals were received (with over 40 in evaluation and 16 signed and under construction by June 2018, of which 13 were solar mini-grids). Proposals are being vetted by the PMO with technical community mobilization support (via township offices) with assistance from GIZ. The PMO is identifying co-financing arrangement and improving communication and information-sharing to facilitate greater participation from the private sector for investment in hydro mini-grids.

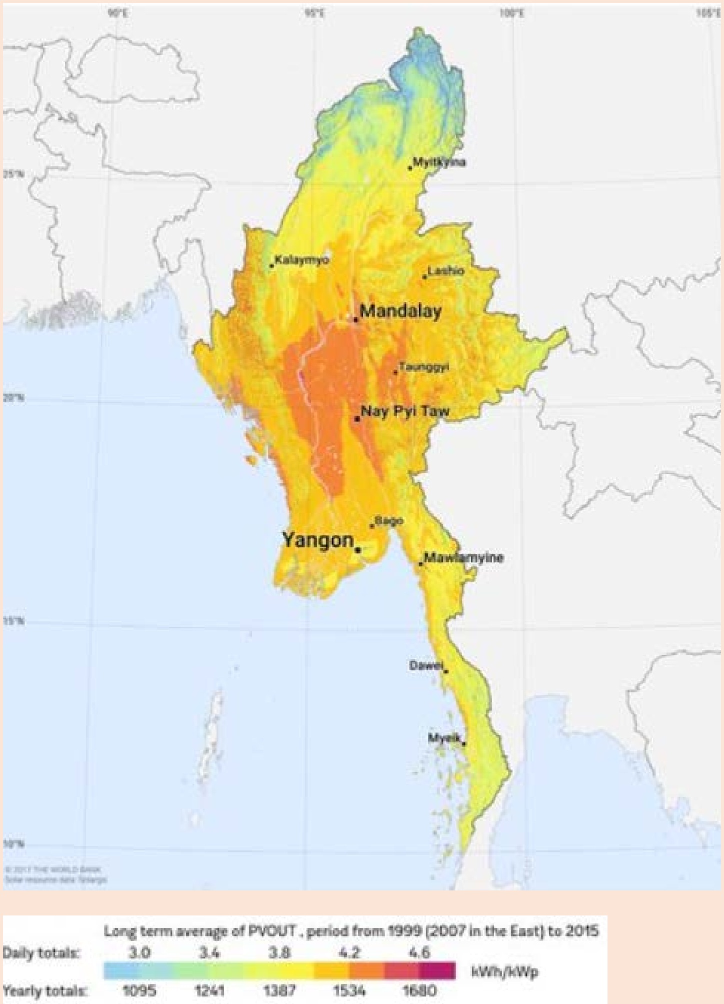
[18] Applicants may be the VEC (together with a developer) or a developer (together with a VEC). Prospective developers have two options by which to select a potential mini-grid site: a) Option 1: Developer-identified sites: Prospective developers may choose to identify and propose their own proprietary mini-grid sites, as long as the sites meet the minimum eligibility criteria described in forms NEP-8 and NEP-9, b) Option 2: DRD-identified sites: Prospective developers are encouraged to review a list of potential mini-grid sites which have been pre-screened by DRD to ensure that they meet the minimum eligibility criteria.

The **subsidy** for mini-grids was 80-20% in the first year and is expected to come down to 50-50% by year 5 (in 2021) of the DRD-NEP project. Currently, the subsidy is based on 60-40%, i.e. the government supports up to 60% of the eligible cost and equity share of the remaining balance is divided by the developer and the VEC, in which the community has to provide at least 20% of the cost (in cash and/or in-kind).

A third Call for Proposals is under preparation for 2018-19 aiming at 100 new mini-grid sites. Again, it will consist of DRD-identified sites, while proposals identified by developers can now (unlike the previous rounds) be presented on a rolling basis. This may attract proposals using technology other than solar (e.g. mini/micro hydro) that have longer lead times, and for this reason, could not be presented in the first two rounds.

Project developers will be entitled to operate the mini-grids for a specified number of years (e.g. 6 to 15 years, although the exact period of operation is to be determined as part of a comprehensive business model and agreed with DRD and the respective communities) and are expected to supply 24-hour, grid-quality electricity during this time. After the developer's period of operation, the mini-grid assets are to be transferred to the local Village Electrification Committee (VEC) for continued operation. For this reason, all mini-grids developed under the CfP shall be classified as Build, Operate, Transfer (BOT) or Build, Own, Operate, Transfer (BOOT). In addition to the capital grant support, DRD will provide capacity building and community mobilization assistance via DRD township offices. Mini-grid projects developed under the NEP must comply with the Environmental and Social Management Framework (ESMF) of the World Bank-Assisted National Electrification Project.

Exhibit 10 Photovoltaic potential map of Myanmar



Renewable energy resources for mini-grids

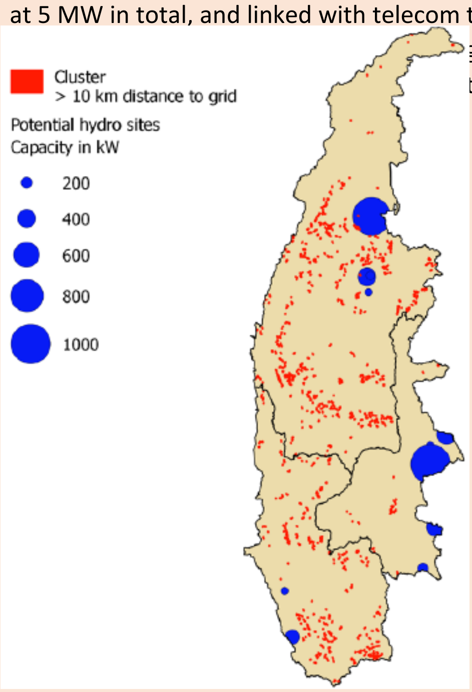
Solar home systems (SHS) seem best suited for relatively poor villages of about 100 households or less with minimal demand. In comparison, **mini-grids** can power larger residential loads can spur local economic growth through energizing larger productive use loads such as refrigeration, water pumping, saws, and agricultural processing such as rice mills or corn shelling. Grid extension and micro-grid development require organization and cohesiveness, while solar home systems can be installed on an individual basis. For villages that lack leadership or the ability to organize collective payment schemes, and for which demand is low, solar home units can be an ideal solution to household electrification needs. Even in larger settings where economic factors favour mini-grids over solar home units as a primary energy source, solar home units can play a valuable auxiliary role. That is because generators and gasifiers commonly used in villages and rural settings run for only two to three hours per night to provide power over the entire micro-grid. Therefore, any individual or commercial use during other times requires auxiliary provision through platforms such as solar home systems (KWR-ERIA, 2015)

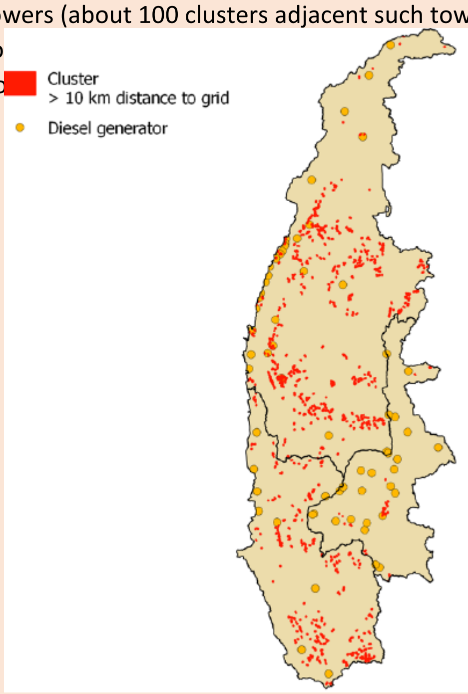
Geographic and climatic differences have a large impact on optimal off-grid electrification schemes given the need to build on regional strengths and concerns. Solar is considered optimal in areas such as the Central Dry Zone (see Exhibit 26).

Exhibit 11 On-grid and off-grid electricity planning using geospatial tools

The Asian Development Bank (ADB) has supported the project *TA 8657: Off-grid Renewable Energy Demonstration Project in Myanmar*, implemented by the the Department of Rural Development (DRD) of the Ministry of Agriculture, Livestock and (MoALI. The purpose of the TA was to support the Government of Myanmar in the scale-up off-grid solutions for renewable energy (RE) systems for providing energy access in Myanmar. One component has been geospatial least-cost energy access and investment plans for the regions selected under the project, i.e., the Magway, Mandalay, and Sagaing regions. The project team conducted extensive research and rigorous data analysis to produce a geospatial and investment plan for off-grid RE in these regions, and an online geospatial web-mapping tool that provides support to project developers in identifying opportunities for developing RE mini-grids. The tool (available at http://adb-myanmar.integration.org) maps the locations of unelectrified villages and provides information on available local resources (solar, hydro, biomass and wind) and nearby infrastructure. Users can select layers to display various datasets and interactively analyze the potential for off-grid electrification.

In the three regions there are 14,822 villages. Of these, 1,807 villages (or 12%) are supplied by diesel. About 7,560 village are unelectrified. Of these, 2,926 villages (mainly in Magway and Sagaing), or 32%, are located further than 10 km from the distribution grid, and therefore should be a high priority for RE mini-grid investment, as the probability of electrification from grid extension in these areas is extremely low to non-existent (within the next 7 years). Villages were organized in clusters. This approach creates larger mini-grids, which can lower the unit cost of energy for consumers, for the same investment return. The geospatial exercise allowed for identification 508 village clusters (or 19%) clusters (each with a population of over 2500) and therefore have sufficient scale to be suitable for large scale RE off-grid mini-grid, at a total investment cost of USD 759 million, inclduing a) hydro mini-grids (investment of USD 60 million in 20 village clusters at 16 MW in total), b) biomass (at an estimated 100 locations with investment potential over USD 100 M for rice residues for gasifiers), c) biogas (investment of USD 170 million, using animal feedstock), d) wind energy (USD 73 million), and e) the remainder served by solar PV mini-grids (investment of USD 163 million), including as diesel replacement in hybrid systems (investment of USD 15 million in solar PV grids in 50 village clusters at 5 MW in total, and linked with telecom towers (about 100 clusters adjacent such towers (about USD 30 million in go N (with an associated t o



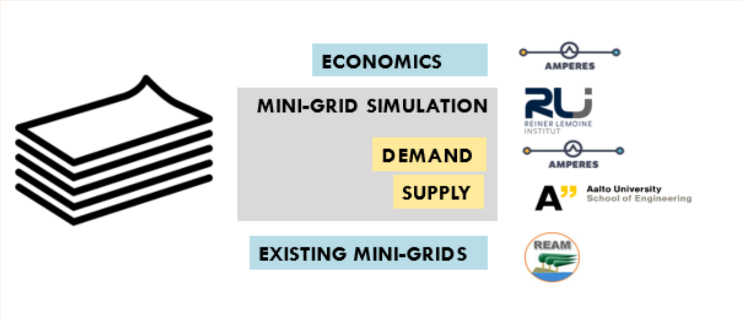


For the investment plan, in 28 suitable sites were selected. In the end, of these 12 projects (all solar PV mini-grids at 90 kW at an average distance of 16 km to the grid) were implemented, providing a basis level of electricity services to about 1,970-2,250 households at an investment cost of USD 730,000 (with a 80% ADB contribution).

Source: ADB (2017a) and ADB (2017b)

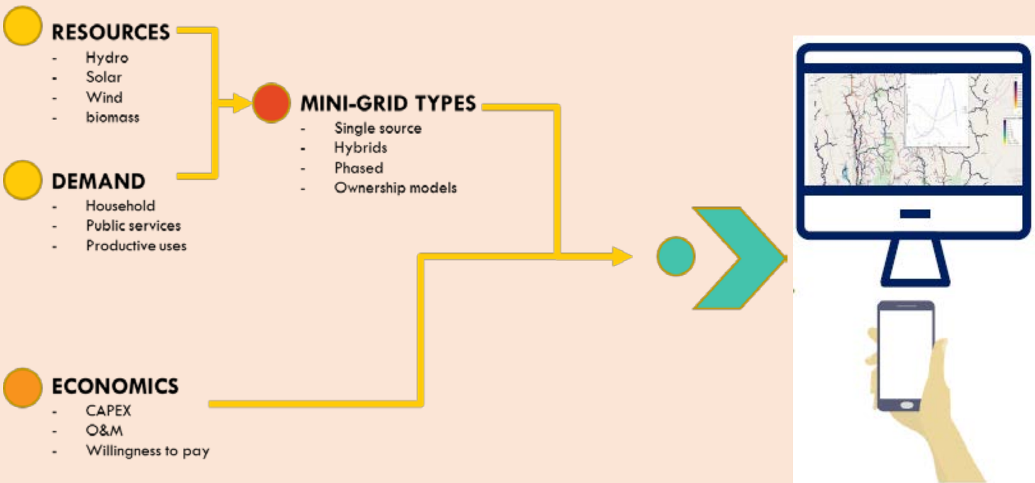
Exhibit 12 **Renewable energy resource assessments**

Aalto University (Finland), *Rainer Lemoine Institute* (RLI), Australian Mekong Partnership for Energy Resources and Energy Systems (*AMPERES*), and *REAM* work together in making estimates of the preliminary renewable energy resource potential of all villages in Myanmar.



The thesis *Myanmar's Renewable Energy Potential* (Said, 2018) mapping the country's renewable energy resources (biomass, wind, solar, hydro) at a high spatial and monthly temporal resolution as a first phase of the CORE-KIT application Community Renewable Energy - Knowledge Integration Tool). Its aim is to accurately provide a preliminary assessment of the potential energy for the purpose of identifying suitable locations for the implementation of decentralised, or off-grid, energy systems.

CORE-KIT will be an open-source web based interactive platform to map the renewable energy potential of every village within Myanmar. It will provide RE practitioners (private and CSOs) with sufficient information to understand where and how CORE mini/micro grids can be developed, to share data and information about their mini/micro grid pilots, and provide the necessary info (as indicatrioed in the figure below) to identify investment opportunities and preliminary feasibility study, with an ever increasing data base.



Outputs from global/regional hydrology models are readily available online, but they may not provide information at desired resolution**. Hydrostreamer** is a hydrology modelling package to downscale distributed runoff data products by spatial relationship between the areal unit in runoff data, and an explicitly represented river network. It has been used to model to Mekong river system and is now used to model river systems in Myanmar.

By integrating various resources assessments (solar, hydroshed and hydro-climate data) a more optimal mini-grid system design can be achieved. Currently, developers typically install a particular technology, or solar, or hydro, or biomass. However, over the year, there is 30-60% seasonal variation in solar and wind and 80-90% variation in micro hydro, which implies that in Myanmar **RE hybrid solutions (solar-hydro)** can often be optimal for a village. This type of integrated resource estimation with dynamic demand forecasting for villages allows extrapolating how demand will grow with access. This will improve understanding of how demand evolves of the pay-back period and should help improve the economics projections driving mini-grid decisions.

Source: Presentation *CORE-KIT,* HycEM Roundtable, 28 May 2018; info provided by Amperes; Said (2018)

Micro-hydro in the mountainous locations that possess adequate free-flowing water. However, hydro is site-specific. The installation of viable facilities requires the identification of an adequate energy source. This generally requires locating the generating facility close to the point of consumption, and this can be a challenge in rural environments. Otherwise, with lengthy transmission distances, one runs into the same costs with mini-hydro that can make grid extension an expensive and technically challenging.

Gasification, powered by rice husks and other agricultural by-products, are seen as an attractive energy source in the Ayeyarwaddy Delta. It is reported there are presently 1,000 or more gasification facilities in Myanmar (KWR-ERIA, 2015). The abundant rice paddy in the Delta makes rice husk gasifiers a preferred alternative or supplement to diesel generators in this region. Although economically viable, the environmental impact of rice husk gasifiers is questionable given the lack of enforceable standards and concerns over discharge. More environmentally friendly technology is feasible but will add up to 50% onto the cost of the equipment. In addition, gasification generally requires more maintenance and care than generators that are powered by diesel alone. This makes them difficult to operate in the village and at township level. Rice mills and factories using gasification equipment and may provide excess power to neighbouring villages, but this is not always feasible and/or may be seasonally constrained.

The attractiveness of hydro and biomass in mini-grid proposals is impinged by the need for identification and assessment of a viable (and available) energy source and creates a need for up-front engineering and feasibility studies. This can be costly and time intensive and makes it difficult to utilize in a rural electrification context. Hence, we see in the two rounds of Call for Proposals in the DRD-NEP, a dominance of solar PV mini-grid proposals. Small mini-hydro and gasification projects require a basic level of maintenance that places the resource beyond the reach of (and makes it less viable for) individual towns and villages and even small groups of towns and villages. This underscores the importance of greater local-level technical training and capacity building around operation and maintenance (O&M).

1.3 Opportunities and issues in off-grid electrification and options for scaling up

Opportunities for off-grid electrification

Generation technologies used in mini-grids span a range of maturities from fully mature (e.g. diesel generation, mini-hydropower) to technologies that are still maturing (biomass gasification). Many of the component technologies (solar panels, inverters, diesel generators) are mature and manufactured/deployed at large scales. For example, solar panels mass-produced and used in grid-connected solar farms are perfectly suitable for mini-grids. Mini-hydro generators have been in use for over a century even if their deployment has not reached the scales found with PV or diesel. Regarding solar PV, improvements have led to a radical price decrease of solar panels, while new electricity storage options (lithium-ion batteries, flow batteries) have led to an increase in the lifetime of batteries.

Recent technology mini-grid improvements include a variety of new billing solutions incorporate “pay as you go” (PAYG) metering using money transfers on cell phones or pre-paid cards. These technologies substantially reduce expenses with bill collection that has been a challenge with rural mini-grids. Remote monitoring using cell phone networks reduces O&M costs, repair costs, and downtime by allowing problems to be diagnosed and repaired early by technicians before they result in failure.

Mini-grids have favourable costs for remote communities with households that use relatively small amounts of electricity (e.g. 700 Wh per day). The comparison of cost per unit of energy (LCOE) of off-grid renewable energy compared to the average LRMC of grid extension (for new household connections), illustrates that hydro, biomass and solar mini-grids are viable options from an economic perspective. The two key factors in determining the viability of mini-grids, in particular, are (i) distance from the grid, and (ii) scale. One way for creating economies of scale for mini-grid applications is by providing mini-grid technology on a village-by-village basis, is to cluster these in groups of villages so that mini-grid developers and operators can provide services at lower unit cost of energy (LCOE, in Exhibit 29) for the same investment return (ADB, 2017; ESAMP-WB, 2017).

This implies even that rather than a being a temporary pre-electrification solution ***until*** *the grid arrives, as mentioned in the NEP, solar and mini-hydro mini-grids can play a substantial role* ***as an electrification solution*** for off-grid power supply and that can later be integrated in the national grid system.

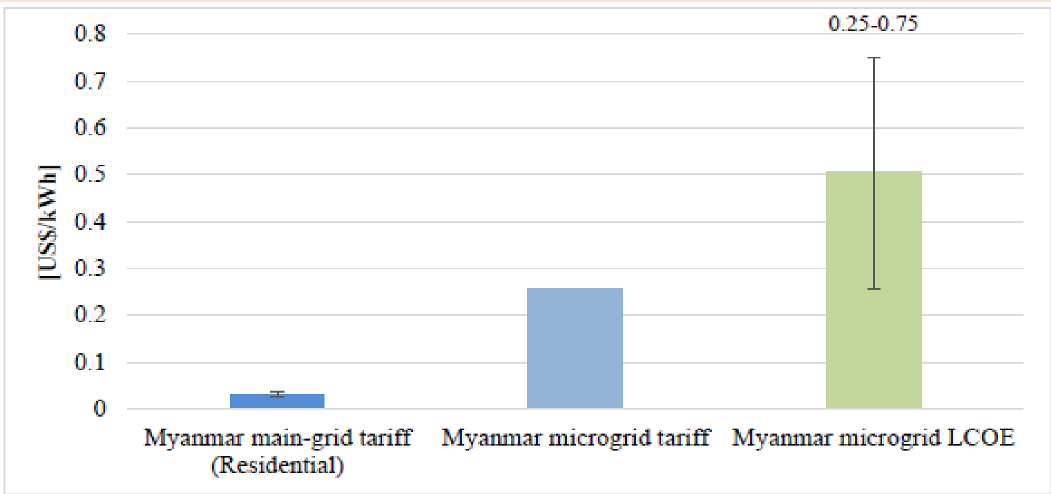
Costs of solar PV mini-grids

Exhibit 30 shows a comparison of residential tariffs on the main grid, one of the tariffs of the hybrid system microgrid, and the estimated LCOE of solar PV mini-grids. The LCOE values of microgrids powered by solar PVs and batteries in Myanmar are still high, but lower than those of diesel power sources depending on fuel price, and lower than (the real cost) of grid extension, depending on the distance to the grid.

If the LCOE of microgrids decreases to the level of the current subsidised microgrid tariff, the subsidy needs could be lowered, or even no longer be necessary. Achieving a reduction in mini-grid costs is possible by clustering villages and pooling multiple projects, and standardization of equipment and mini-grid design, and reductions in financing costs) and by using local technology.

The gap between tariffs of microgrids and the main grid is a different issue. The gap is so huge that improving it in the short term seems difficult. The main-grid tariff should be increased enough to cover power generation costs, operation and maintenance costs for existing transmission/distribution lines and power plants, and new development costs. The government plans to increase the main-grid tariff over time. For now, it means that people in urban areas can enjoy electricity from the grid at cheap prices including the subsidy and also can get diesel fuel cheaper. In contrast, people in rural areas have to pay more for diesel fuel and for electricity. So, it stands to that electricity for people in rural areas should be subsidised, hence the motivation for subsidies to CAPEX of microgrids under the '60/20/20' DRD-NEP scheme.

Exhibit 14 Comparison of tariffs and solar PV mini-grid LCOE values



Left: Myanmar mini-grid residential tariff (2016, ADB)
Middle: average Myanmar microgrid tariff in the systems subsidised as part of '6
Right: estimates of levelised cost of electricity (LCOE) of solar PV mini-grid system

Local experience with hydropower and biomass mini-grid systems

Another way to reduce the cost of mini-grids is by working closely together with those developers that are (local) social entrepreneurs with proven experience in mini-grid development, and renewable energy associations (such as REAM, HyCEM, Solar Group). Involvement of 'home-grown' developers allows easy troubleshooting and lower cost. By 2017, Myanmar had about 5000-6000 mini/micro hydropower units (below 1 MW) and some 500 units biomass gasifiers for village electrification, and about 10,000 biomass gasifiers powering small-scale rice mills (D. Vaghela, 2017).

Exhibit 13 Mini-grid systems installed in Myanmar

Type	Number of plants
Minihydro (0-1 MW)	5840
Minihydro (1-10 MW)	17
Larger hydropower	18
Biomass and biogas	727
Wind turbines	25
Solar	94
Diesel	11740
Steam / cogeneration / natural gas	14

Source: MEE Net, 2018, PowerPoint *Energy Politics and Conflict, Green Energy in Shan State*, by Kyi Pho

Considering that the vast majority of these mini-grids were built from scratch with no government support (and no formal technology training and no international funding) under conditions of acute materials shortages, these are impressive figures. Communities and local private companies in Myanmar have developed considerable experience with biomass and hydro-based mini-grids. Much of Myanmar's experience in mini-grid deployment and operations has been gained the hard way, through trial and error. It demonstrates the existence of social entrepreneurs who have a) engineering skills to locally manufacture cost-effective (hydropower) technology (system designer and technology manufacturer), b) entrepreneur skills to identify productive end-uses of electricity (enterprise development); c) commitment to forging local partnerships for financially viable projects with rural communities (financier), and d) community mobilizer, O&M trainer, and service provider.

The experience of grassroots (hydropower) mini-grid practitioners provides a strong foundation upon which the NEP Off-grid component and other donor efforts should be built, helping them adapt better (more cost-effective, efficient, more robust, safe) technologies and scale up deployment (ESMAP-WB, 2017). However, the experiences of local private sector remain invisible and side-lined. One of the reasons is that international development partners work solely with the national government at the start of their programs, and the baseline studies often do not include the work of the local private sector.

Exhibit 15 Case study, locally governed, self-financed mini-hydro

This case study presents the most recent project of a leading mini-hydro developer and manufacturer in Myanmar, U Sai Htun Hla. It is an example of the type of a commercially viable, cooperative-based, and self-financed off-grid RE initiative, the RURED project tries to promote. U Sai Htun Hla has developed over 150 hydropower projects (below 1 MW) using a cooperative-based model for implementation. Some have been partially or fully supported by government or private funds, while most have been fully paid for by the community, with upfront investments from U Sai Htun Hla.

The Mae Mauk Waterfall Mini-hydro Project provides power to about 1200 households and local enterprises. Since the project needed to be self-financed, the goal for 100% electrification is being done phase-wise, in parallel to the consumers' increasing demand and the project's revenue available to re-invest into the project. In 2013, the project generated 50kW for less than 100 households. In 2015 the project was upgraded to generate 80kW for more than 450 households. The final phase will be to generate 400kW for households and enterprises in a total of 16-20 villages. This will cost an estimated USD 441,000.

The project is managed by Lin Yuang Chi Mini-hydro Cooperative Utility. The cooperative has a total of 100 shares, of which 50 are owned by U Sai Htun Hla and 30 owned by community members. The gap of 20 shares was raised from the connection fees paid by consumers. The monthly average revenue has increased from USD 1470 at the start of the project to USD 2500 currently, resulting from the end-uses listed below. The tariff ranges from USD 0.09-0.14 for cooperative members, USD 0.18-0.29 for all other consumers, and USD 0.59/unit for temporary users. The connection fees range from USD 135-440 for residential consumers, depending on their distance from the powerhouse. Operation and maintenance cost are about USD 900 a month. The Cooperative has a physical office, within an initial staff of 6-persons for operation and maintenance: utility manager, powerhouse operator, linesmen, meter readers, cashier, and bookkeeper.Examples of energy demand are summarised in the table below:

External enterprises	Village enterprises	Social services	Household uses
Coffee plantations, fuel pumps, poultry farm, telecom tower, technical workshop	Brick making, cash crop farming, daily goods shops, fruit processing, workshops, lime baking, silkworm breeding, tailoring, truck rental, vehicle repair	Health clinics, monasteries, public centres, schools, streetlights	Carpentry tools, corn thrasher, electric rice cookers/pans, fans, grinders, cell phone charging, rice mills, refrigerators, televisions, water heaters, washing machines, water pumps

Livelihood benefits include a) increased fuel affordability (clients spend 60-70% less due to diesel savings), job creation (50 people durting installation, and 8 for operations), income generation and PUE (number of external and village enterprises doubled, including women-led businesses), access to health services (24/7 electricity allows vaccine storage and minor

1.4 Financing for off-grid energy

Financial sector

Myanmar's financial sector is relatively small by global and regional standards and has been historically dominated by government-owned financial institutions, although several semi-governmental, private sector banks and representative offices of a few foreign banks have become prominent in recent years as the government attempts to introduce reforms that have triggered rapid transformation and growth in the sector.

Myanmar's banking sector is small by global and regional standards. Total assets of the banking sector as of March 2017 was just about MMK 48,834 billion (about USD 30.4 billion), amounting to about 1% of the size of the country's GDP.[19] Nonetheless, this represents a significant, nearly 12 times growth in comparison with March 2010 when total assets were MMK 3,853 billion (USD 3.08 billion) and amounted to just 11% of the size of the country's GDP at that time.

Although SOBs (state-owned banks) dominated the banking sector in Myanmar for a long time, private banks have grown quickly in recent years, and they account for 55% of banking sector system assets as of March 2017, with SOBs accounting for just 36% and FBBs accounting for the remaining 9%. As of early 2018, Myanmar's financial system now comprises 4 state-owned banks (SOBs), 24 private banks (with no government ownership), 13 foreign bank branches (FBBs).[20] Apart from banks, insurance companies and 176 organizations with microfinance license (not including cooperatives) and a nascent capital market[21]. The three biggest private banks are KBZ Bank, CB Bank, and A-Bank that accounted for 58% of total private bank assets, 64% of loans and 66% of deposits in Myanmar as of March 2017.[22]

Myanmar's financial sector is regulated by three different regulatory bodies. Banks are under the supervision of Central Bank of Myanmar (CBM), cooperatives operating in the microfinance sector are under the control of the Ministry of Cooperatives and MFIs are supervised by Financial Regulatory Department (FRD) under the Ministry of Finance.

In Myanmar's banking sector, deposit and credit interest rates are largely controlled and capped by the Central Bank of Myanmar (CBM). Loan interest rates made by the banking sector is capped at 13% per annum including bank charges and deposit rates are capped at 8% per annum. Most loans are offered on an average tenor of 1 year and nearly all loans require collateral. Overdraft facilities, which are essentially short-term working capital loans that are rolled over every year, are the most common types of business loans offered by banks to private sector borrowers against collateral. Although the 5% spread between the deposit and lending rates is higher than in many countries in the region and across the world, banks have reported that their net interest margin is considerably less than 5%, considering regulatory requirements on loan-to-deposit ratios to be maintained at a maximum of 75%.[23] This controlled, low-interest rate regime, in combination with a high rate of inflation, has resulted in negative real interest rates, causing low yield from savings and deposits.

Another result of interest rate caps, together with CBM's traditional insistence on collateral requirements for all types of lending activities from banks, has been a difficult lending environment for SMEs seeking working capital, but lacking sufficient collateral. According to a World Bank survey of over 600 private sector firms between October 2016 and April 2017, access to finance was their key barrier to scaling up their business.[24]

JICA has a two-step loan programme to provide funding to SMEs in Myanmar since 2015 wherein JICA offers low-cost wholesale funds to the government-owned Myanmar Economic Bank (MEB), which in turn provides credit lines to selected private sector banks at 4% for on-lending to SMEs at 8.5%. The six banks selected for the 2016 disbursement of this JICA program were SMIDB, MAB, A-Bank, CB Bank, MCB and KBZ Bank. JICA is planning a second disbursement in 2018.[25]

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19 International Monetary Fund (IMF) Country Report No 18/91: Myanmar: Selected Issues, March 2018

20 International Monetary Fund (IMF) Country Report No 18/91: Myanmar: Selected Issues, March 2018

21 Myanmar Financial Services Monitor and FMR Research & Advisory (in association with British Chamber of Commerce Myanmar and Baker McKenzie): Myanmar Financial Services Report, 2018. There are 24 licensed private banks in Myanmar, according to CBM's definition, and another five are expected to start operations in 2018

22 Myanmar Financial Services Monitor and FMR Research & Advisory (in association with British Chamber of Commerce Myanmar and Baker McKenzie): Myanmar Financial Services Report, 2018

23 ibid

24 ibid

25 ibid

Micro-finance sector

Although microfinance has a long history in Myanmar, most of the currently operational MFIs in the country were incorporated after the introduction of Myanmar's Microfinance Business Law, introduced in 2011. According to recent estimates and reports from FRD and Myanmar Microfinance Association (MMFA), the microfinance sector in Myanmar has reached over 3 million borrowers with an outstanding loan portfolio of USD 436 million.[26]

Despite the growth in licensed MFIs after the 2011 Law, UNDP-PACT's Microfinance operation remained by far the largest microfinance operation. By 2013, it had 630,000 clients in over 6000 villages with a USD 150 million loan portfolio. In June 2014, UNDP ended the campaign and transferred its microfinance assets and fund to the PACT Global Microfinance Fund (PGMF), which today accounts for around one-third of the country's total microfinance loan portfolio.[27]

Myanmar Economic Bank (MEB), a large government-owned commercial bank is designated to be the provider of wholesale lending to local MFIs (mainly MFIs structured as local companies). Myanmar Microfinance Bank (MMB), a privately-held commercial bank part of the Cooperative Bank (CB Bank) Group, is also structured to act as a wholesale lending bank for local MFIs (mainly MFIs structured as local cooperative societies). Capital raising and borrowing restrictions exist for both domestic and foreign-owned MFIs in the country, and interest caps result in further restrictions on lending and deposit-taking activities of MFIs.

Access to finance for renewable energy developers

Renewable-energy systems are becoming more accessible to rural communities following the 2011 microfinance law and implemention framework, which enabled domestic and foreign investors to launch privately owned microfinance institutions (MFIs) for the first time in Myanmar. In the year following this legislation, 118 MFI licenses were issued, and overall microfinance outreach is estimated at 2.8 million micro-clients (as of 2013). Some MFIs in Myanmar, such as PACT Global Microfinance Fund, are starting to offer low-interest loan products to rural clients for purchasing solar lanterns and home lighting systems. These loans go up to approximately USD 200 and interest rates are capped annually around 24% (Ross, CSIS, 2015). Also, social enterprises have offered credit to rural customers purchasing solar lanterns and home lighting systems, with short-term loans ranging from one to four months.

Myanmar's financial environment presents a challenge for electrification projects. The country's banks are acknowledged as offering limited financial services that are inadequate for meeting the needs of individuals and businesses, and this has created significant barriers to local energy entrepreneurs. Today, most borrowers, including mini-grid developers, are limited to one-year loans at 13% interest rates, and they must use their homes or other immovable property as collateral[28]. Most mini-grid developers (both domestic and foreign-funded) invest their own capital as equity for developing mini-grids in the country. Most domestic mini-grid developers choose to participate in the DRD-World Bank mini-grid financing program that offers 60% CAPEX subsidy and an additional 20% to be financed by local communities (end-consumers), leaving these developers to finance only 20% of CAPEX from their own (equity) sources. Well-funded internationally-funded mini-grid developers, such as Yoma Micropower, use equity funding raised from their investors to provide almost 100% of CAPEX as equity financing.

However, the situation is slowly improving with financial reforms. For example, more business financing is anticipated now that several foreign banks received final licenses, opened branches, and launched the first foreign bank operations in Myanmar in decades. To promote mobile banking accessible in Myanmar, Telenor is partnering with Yoma Bank, one of Myanmar's largest private banks, for a mobile money service (pending further guidelines from the Central Bank of Myanmar). Such mobile money services would offer new opportunities for off-grid renewable energy suppliers to interface with rural customers.

As the financial sector evolves there may be increased opportunities to finance local entrepreneurs managing mini-grids for village electrification as well. However, in the meantime, demand for credit far outweighs supply. The limitations of

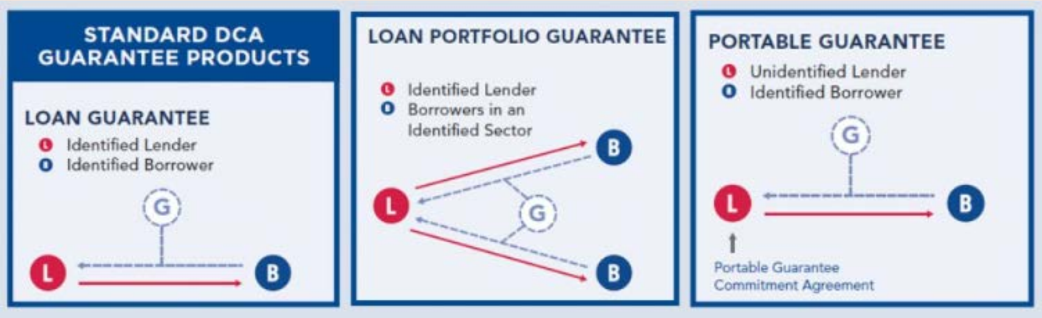
[26] ibid

[27] Myanmar Financial Services Monitor and FMR Research & Advisory (in association with British Chamber of Commerce Myanmar and Baker McKenzie): Myanmar Financial Services Report, 2018

[28] Ross (2015; CSIS)., based on REAM interviews with micro-hydropower developers, *Micro-Hydropower and Decentralized Renewable Energy for Myanmar Workshop*, November 26–27, 2014.

short-term loans currently available, combined with relatively high capital costs of quality renewable energy systems, mean many potential customers still cannot afford the high-quality energy solutions designed to improve their livelihoods and reduce energy poverty (Ross, CSIS, 2015). Banks in Myanmar have had very limited exposure to lending to renewable energy sector in the country (excluding large hydropower projects), considering the fact that renewable energy projects require long-term debt of typically 7-10-year tenors and most lending in Myanmar is for one-year overdraft loans. Given the fact

Exhibit 16 USAID DCA financial support products



that most domestic mini-grid developers in Myanmar are SMEs, availability of debt financing to these developers is even more restricted.

A-Bank (Ayeyarwaddy Farmers Bank) is furthest among Myanmar bank in considering to provide loans to RE entrepreneurs for rural energy initiatives. Developers would seek loans between USD 200,000 – 3 million with a payback period of 8-10 years at the max interest rate of 13%. REAM has facilitated discussions with DFCC Bank (Sri Lanka) to provide technical assistance on how to best appraise and service project-based loans.

USAID's Development Credit Authority (DCA) uses risk-sharing agreements to mobilize local private capital to fill this financing gap. The DCA partial credit guarantee is designed to:

- Reduce risks to generate additional lending to underserved markets and sectors
- Demonstrate the long-term commercial viability of lending in developing markets

Through DCA, more than 600 guarantees between financial institutions and USAID have made up to USD 5.5 billion in private financing available for more than 350,000 entrepreneurs around the world. More info can be found at www.USAID.gov/dca (see Exhibit 33).

USAID in Myanmar partnered with LOLC (Lanka Oryx Leasing Company) and four other micro-finance institutions (MFIs) in 2016 to issue a USD 10-million Development Credit Authority (DCA) loan portfolio guarantee to support loans to micro, small, and medium-size enterprises (MSMEs) in the agriculture sector. The guarantee has helped LOLC make larger loans and loans that were not supported by the group lending models. Using the guarantee, LOLC has been one of the first MFIs to make the maximum loan allowed by law to individual entrepreneurs, in addition to piloting new products in riskier areas. The state-owned Myanmar Insurance Enterprise introduced a Credit Guarantee Insurance (CGI) scheme for SMEs. The aim of the new insurance service has been to enable people who want loans from the banks but without collateral to have access to financial assets and lenders to reduce risks. The insurance would cover up to 60% of the loan (i.e. if debtors fail to pay, CGI reimburses 60% of the loan with the lender shouldering 40%). The premium for a loan without collateral is set at three kyats (per 100 kyat of the insured amount) for the first year, two kyats for the second year and one kyat for the third year and years thereafter. CGI is now used by businesses in both the industrial sector as well as the agricultural industry and the amount of CGI loans has been small; by Feb 2019 there had been 600 applicants (through CB Bank, SMIDB and Myanmar Economic Bank)[29].

[29] Source: Myanmar Times (12.02.19) and www.myanmargeneva.org (item 29.06.14)

1.5 Stakeholders in off-grid electrification

Stakeholder	Description
Government	
Ministry of Agriculture, Livestock, and Irrigation (MoALI)	MoALI's Department of Rural Development (DRD) takes the lead in the development of biofuels, micro-hydropower (with installed capacity of up to 10 MW), bioenergy from agricultural residues, for off-grid electrification (solar home system, mini-grid system, etc). MoALI-DRD implements the off-grid component of the National Electrification Plan (NEP).
Ministry of Energy and Electricity (MoEE)	MoEE is the overall focal point for energy policy, coordination and international cooperation and also the oil and gas sector, and is responsible for developing, operating, and maintaining all large hydropower and coal-fired thermal plants; for developing and maintaining the transmission and distribution systems throughout the country, and for operating gas-fired thermal plants and mini hydropower plants. MoEE implements the grid extension component of the NEP.
Ministry of Natural Resources and Environmental Conservation (MoNREC)	Regulates the use of biomass from forest resources for energy purposes and is responsible for climate change issues. It has formulated the National Environmental Policy and Strategic Framework & Master Plan, and is responsible for climate change and greenhouse gas emission monitoring, reporting, and verification (MRV) as part of National Communications and NDC. The GEF operational focal point is at its Environmental Conservation Department (ECD)
Ministry of Education	Responsible for the research and development (R&D) of renewable energy technologies (RET) in universities and RE-relevant education in universities and training institutes.
Development partners	
Asian Development Bank (ADB)	During 2015-2017, ADB implemented the *Off-Grid Renewable Energy Demonstration Project to support the scale-up of off-grid solutions for renewable energy (RE) in Myanmar* with a budget of about USD 2 million (of which about USD 500,000 for off-grid pilot projects in Magway, Mandalay and Sagaing regions.
Agence Française de Développement (AFD)	AFD is in identifying options to support rural energy project (RE mini-grids, biomass) with a soft loan of EUR 15-25 million
Department for International Development (DFID), UK	DFID is in discussion with DRD on supporting pilot testing mini-grids with solar hybrid power systems using the ABC model in Mandalay, Magway and Shan through Infracapital Myanmar. DFID also partners with IFC's Lighting Myanmar.
European Union (EU)	A market assessment study on rural electrification will also be launched soon to support EU's discussion with financing institutions. The EU plans to use its finance blending facility (ElectriFi, Asian Investment Facility) from 2019 onwards
Gesellschaft für Internationale Zusammenarbeit (GIZ) MFAT (New Zealand)	GIZ supports (with financing from German and New Zealand governments) Myanmar with the implementation of the off-grid component of NEP (Promotion of Rural Electrification, RELEC) from 2016-18 to be extended to 2020 to support DRD in a) developing a regulatory framework for mini-grids (at Union level and at state-level in Shan state), b) establish the pipeline of projects in various rounds of Call for Proposals (supported by World Bank), c) developing a gender mainstreaming strategy for mini-grid policy and implementation, and d) strengthen the competence of government, private sector, and community stakeholders. The budget is composed of EUR 4 million (German government, BMZ) and NZD 1.5 million (New Zealand, MFAT)
International Finance Corporation (IFC)	In cooperation with DFID, IFC's Lighting Myanmar project supporting manufacturers and distributors of high-quality solar to enter and scale in Myanmar, through market research, business development support, consumer education, and policy engagement, while also exploring support for appliance and productive use sectors. Separately, IFC has invested in Yoma MicroPower project developing solar power solutions for telecom towers, with attached mini-grids to electrify nearby communities. Implementation period: 2016-2020. The budget is about USD 4 million.
Italy (AICS)	During 2018-2021, Italy provides financing to NEP for the implementation of SHS, mini-grid, and public lighting systems in Chin villages, through a soft loan of EUR 30 million, and supervision support and M&E services (grant of EUR 1.95 million)
Japan International Cooperation	JICA focusses on supporting on-grid electrification during 2013-2021 through its "Regional Development Project for Poverty Reduction". There has been a small pilot project for micro-

Agency (JICA) and JICS	hydropower generation along irrigation channels in Mandalay (2016-208; about USD 150,000), while JICS has supported some 11 solar and hydro mini-grid projects in Chin and Shan States.
KfW (Germany)	KfW has been providing financing to support the government's NEP: a) off-grid: Grants for SHS and communal PV systems in Southern Shan State (as part of NEP's competitive bidding process; EUR 9 million) and b) on-grid: Mainly soft loan for rehabilitation and extension of the existing medium and low voltage distribution network and the establishment of respective household connections in Southern Shan State (around EUR 31 million)
World Bank (WB)	The WB has been supporting the National Electrification Project (NEP), in Myanmar since 2016 with two components: 1) on-grid extension with MoEE (USD 350 million budget) and off-grid electrification with MoALI-DRD (SHS and mini-grids, USD 90 million budget, of which USD 80 million capital support and USD 10 million TA). The program will run to September 2021. WB and DRD have implemented the SHS program through international competitive bidding. The first contract of USD 30 million has been signed and installation of 136,000 SHS was started in Jan 2017 with a second contract launched in 2017. The mini-grid program has been launched through Call for Proposals (CfP). WB and IFC have recently approved a new USD 3.5 million results-based financing for off-grid program WB participates in an energy sector coordination/working group that includes IFC, GIZ, KfW, and a number of other development agencies working in the energy sector in Myanmar.
USAID DCA	USAID's Development Credit Authority (DCA) uses risk-sharing agreements to mobilize local private capital to fill this financing gap. In Myanmar DCA has partnered with LOLC and other micro-finance institutions in 2016 to issue a USD 10 million loan portfolio guarantee to support loans to micro, small, and medium size enterprises in the agriculture sector.
NGOs	
PACT Smart Power Myanmar	PACT has been working since 1997 in Myanmar. The NGO supports community education with grassroots governance through Village Development Committees and financial sustainability through Village Development Funds. Pact Global Microfinance Fund (PGMF) is the leading microfinance institution in Myanmar. Pact has been implementing the Ahlin Yaung (AY) Renewable Energy Access Program built on Pact's multiple financing mechanisms in Myanmar: microfinance, women's micro-enterprise loans and Village Development Funds (VDF) as well as Pact's capacity building expertise. Using the data on VDF spending, Pact developed and is implementing a financing model for purchases and distribution of solar home systems in rural areas of Magway, Sagaing. Mandalay and Tanintharyi. To date, the fund has impacted the lives of over 185,000 beneficiaries by covering upfront costs of SHS for households and community lighting sources. With essentially 100% repayment, the fund also incentivizes community ownership by returning interest generated to the village for further development needs. In May 2018, Pact launched Smart Power Myanmar (SPM) with the support from The Rockefeller Foundation to accelerate access to energy access in rural Myanmar through decentralized energy solutions. By bringing together key players in the public and private sectors, Smart Power Myanmar aims to support the rollout of thousands of mini-grids and other rural electrification solutions that are in line with Myanmar's NEP and with a focus on customer-centred solutions, long-term socio-economic development and systemic change. In addition to the Rockefeller Foundation, the facility's founding members include The World Bank, USAID, and Yoma Strategic Holdings. Smart Power works with mini-grid developers under DRD-led mini-grid program on improving their business models through demand stimulation and productive use support, analytics of operational data and streamlining of services.
Renewable Energy Association of Myanmar (REAM) HyCEM Solar Group	Established as a nongovernmental organization (NGO) in 1999, REAM works with local inhabitants, professionals, technicians, micro or small enterprises and other like-minded organization to upgrade the awareness and living standard of people in remote areas of Myanmar through the promotion of Renewable Energy Technology (RET). Information, education, and communication are the three main services provided by REAM and also supports small development projects in Myanmar (mini-hydro, solar, biomass). REAM has facilitated the formation of association of hydro entrepreneurs (HyCEM, Association for Hydropower for Community Empowerment in Myanmar) and the Solar Group of UMFCCI (Union of Myanmar Federation of Chambers of Commerce and Industry)
World Wildlife Fund (WWF)	WWF's Energy Report (with REAM) shows that it is technically and economically feasible to achieve 100% renewable energy in Myanmar by 2050. The report mentions that not only this it possible, but

	renewable energy makes economic sense and prices are decreasing, especially photovoltaic (PV) (see website) WWF's energy program in Myanmar works with solar PV in Kayin State, in cooperation with civil society, private sector, KNU and plans to support 2-3 mini-grids (solar, hydro or diesel hybrids) as demonstration projects to educate State-level and national authorities. WWF is planning to develop similar activities in Thanintaryi where WWF is working with Myanmar Ecosolutions.
UN organisations	
United Nations Development Programme (UNDP)	The following ongoing or planned projects may have links with RE or PUE: • R2R Integrated Protected Area Land and Seascape Management in Tanintharyi (GEF: USD 5.25 million), 2017-2022 • Reducing Climate Vulnerability of Coastal Communities of Myanmar through an Ecosystem-based approach (Rakhine) (GEF: USD 7 million), 2019-2023 • Governance Resilience and Sustainability Project (GRSP), 2018-2022 GRSP is intended as an umbrella programme under which various UNDP-supported energy, environment, climate change, and disaster risk reduction activities in Myanmar can be linked and integrated (including the proposed UNDP/GEF Rural RE Project). The following Project outputs are targeted: • Output 1 – Resilience and sustainability policy frameworks are strengthened and implemented. • Output 2 – Increased promotion of small and large-scale green investments. • Output 4 – Local environment, climate change, and disaster risk issues are addressed through subnational implementation of innovative policies and action plans. wing project outputs are targeted:

1.6 Rural energy demand and PUE in the proposed Project Areas

Solar home systems can power standard residential loads such as lighting, cell phone charging, and entertainment electronics. In comparison, mini-grids can spur local economic growth through energizing larger productive use loads such as refrigeration, water pumping, saws, and agricultural processing such as rice mills or corn shelling. Thus, decentralized solutions such as micro-grids or mini-grids can play a major role in supporting a modern, reliable energy system. If it is powered by RE sources, new electrification at the village level is environmentally sustainable. It can also help to accelerate productivity and further development of the village. This Annex E.8 gives a description of the proposed geographical focus areas in Tanintharyi Region and Shan State. A recent study was carried out by PACT on productive uses and rural energy. The study has conclusions that are also of interest for electricity and PUE in the RURED project areas and, therefore, a brief summary is provided in Exhibit 34.

Tanintharyi

- Area: 43,344.91 km^2
- Total population: 1,408,401 in total (female 707,782 - 50.25% , male – 700,619 - 49.75%)
- Rural: 76%, urban: 24%
- Percentage of female headed households: 28.9%
- Languages: Burmese (although each district has its own accent and dialect) and minority languages
- Ethnicity: Myanmar (majority), Rakhine, Mon, Shan, Karen, Salone, Malay (Bashu), Dawei/Tavoyan
- Administrative divisions: 3 Districts, 16 Townships/ Sub-townships, 83 Wards, 264 Village Tracts, 1,250 Villages
- Capital: Dawei
- Main economic activities: Fishing, Forestry, Mining, Agriculture

Socio-economic characteristics

The Tanintharyi Region is a coastal region (from the Gulf of Moattama to the mouth of the Pakchan River, about 1,200 km in length) in the Bay of Bengal and along the Andaman Sea. The Region includes the Myeik archipelago with over 800 islands. The Region is administratively divided in three Districts, Dawei, Myeik, and Kawthaung

Exhibit 17 Description of Dry Zone area

A recent study was carried by PACT Myanmar in the dry zone area of Myanmar. The dry zone covers only around 15% of the country but is home to nearly a third of its total population of 55 million. The rainfall is about less than 700 millimetres annually compared to 2000 -5000 millimetres in other parts of the country. Majority of the population in rural is doing farming, and one important energy use is for water pumping. However, geographic conditions across the villages are different, villages with some access to water have relatively higher and more stable agricultural productivity, higher income and a broader occupational mix. These characteristics significantly impact the nature and potential of energy use.

The villages in the dry zone can be categorized into four; A1, A2, B1, B2 based on quantity and types of uses of electricity in the surveyed of 50 villages across the four townships (Pauk, Salingyi, Mindon, Thazi):

- **Type A villages**: have a mix of cultivable wetland in addition to dry land. The wetland comes from accessible natural irrigation sources such as rivers, streams or stationary water bodies like lakes and ponds. Such villages have higher agricultural productivity and higher income (including rice paddy cultivation, which sells at a higher price compared to other crops). A stronger agricultural economy, in turn, drives a greater variety of occupation beyond farming.
- **Type B villages:** only have cultivatable dry land as they lack access to natural irrigation sources. In these villages, paddy cultivation is rare and overall agricultural productivity tends to be lower. Income of those villages is 10% to 20% below those in Type A villages. A weaker agricultural economy means that there are few occupations beyond farming.
- **Type 1 villages**: are well connected to the township centre (usually the largest urban area in a township), through the road with good condition throughout the year. They have a larger number of different commercial enterprises with good access to the market.
- **Type 2 villages**: lack of good road connections to the township centre, in cases where connectivity exists, they are connected only through a poor road, available only for the dry season. As a result, such villages tend to have few to no commercial enterprises.

Per capita energy demand is an important metric to understand current energy use. It gives the investors or developers a sense of the density of electricity demand independent of population size, making villages more comparable.

There are two types of demand of which *household demand* and *productive demand:*

- The **household demand** is typically from appliances and lighting exclusively within households, such demand has no direct impact on the production of goods or services and provides no source of income for the user. Therefore, it is insufficient to the developers to make it viable even it adds to the revenue of mini-grid business model. Such demand can vary or drop off as families change consumption patterns which shift in weather, shits in income or travel and migration.
- The **productive demand** is based on activities that generate income for the user through the production of goods or services or support community development needs and thereby add to the village economy. Such demand typically comes from machinery, lighting and other appliances used by commercial enterprises, from machinery used for farming and agricultural processing or from village large community institutions like religious centres, schools, and health centres. Such demand constitutes the bulk in a village and is critical to the viability of mini-grid business model. Such demand is often based on income-generating activities, it can make payments more reliable.

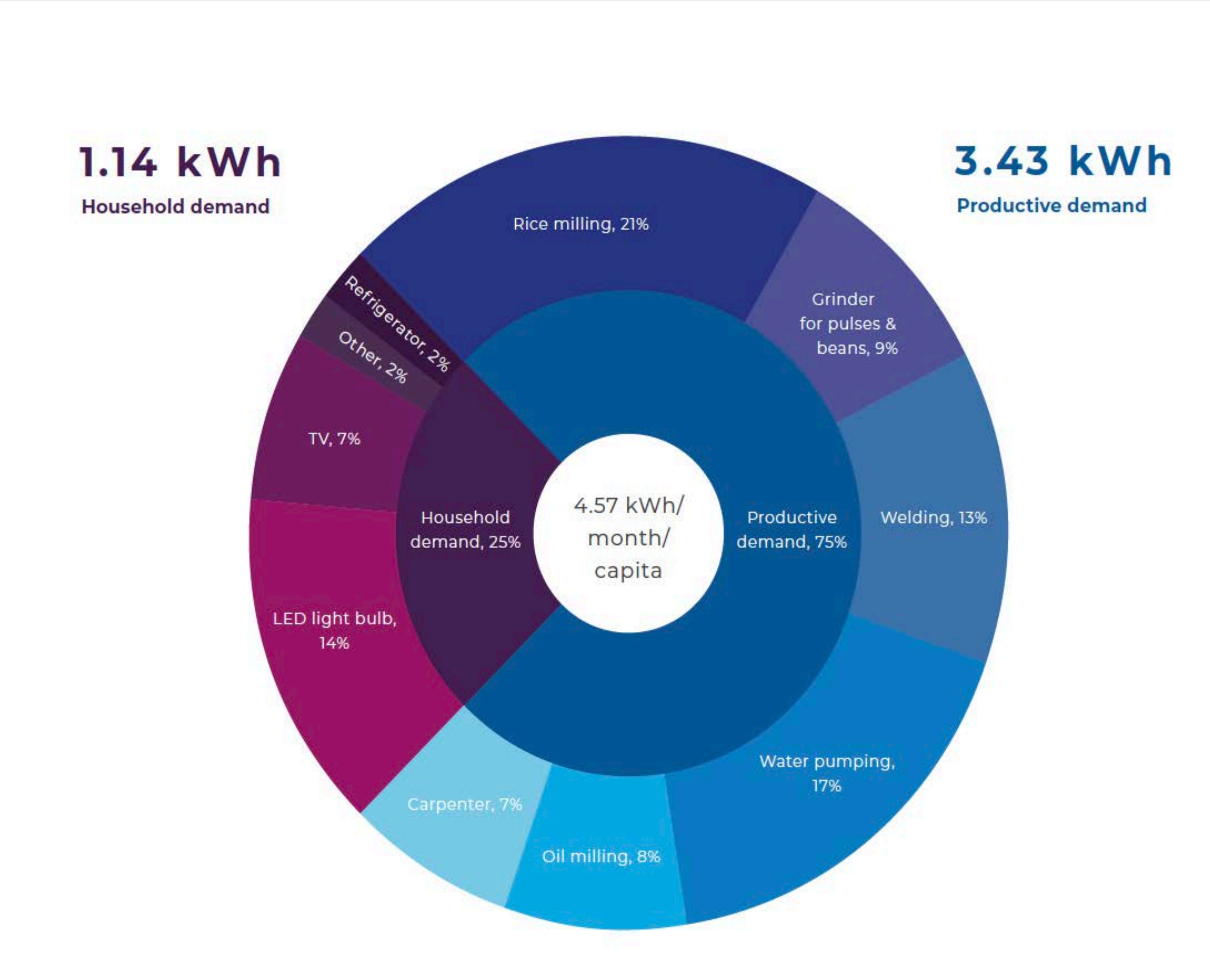
Electricity generated by solar or solar hybrid mini-grid should be consumed during the daytime. The consumption after daytime hours makes the use of batteries, which are expensive, and have a comparatively shorter lifespan with limited numbers of charged cycles before capacity has been reduced. As a result, productive demand tied to daytime commercial enterprises is a strong driver for mini-grid viability. Household consumption is more likely to occur at night for the relatively smaller loads (e.g. light bulbs, phone charging, TV).

The developers or investors need predictable usage pattern to ensure their revenue is stable. Therefore, seasonality also is important to consider. For example, agricultural demand for the processing of a particular crop is seasonal, and may be less supportive of the mini-grid business case. Other demands such as welding, carpentry or for service-oriented demand such as beauty salons and local shops provide much more predictable power demand.

Description of Dry Zone area (cont'd)

Telecom towers are also an important factor to consider for the anchor load since they run for 24 hours with a fixed capacity of around (2-4 kW). Another factor for ideal demand is extracting of the maximum value of each watt-hour of energy. For example, the perception of a barber of the value of each watt-hour used may be relatively high since he receives a large sum of money for about ten minutes service which in turn power consumption of usage of hair clipping is high. In contrast, for farmers who use high power to pump the water for irrigation, their income is indirectly depending upon the growing crops and therefore the perception of each watt-hour used for pumping water is lower.

The government, together with public and private sector developers are beginning to invest in the decentralized energy sector through both subsidies and direct private sector investment. However, it is needed to access quality information and data on energy demand for the developers, investors, policy-makers, and communities in order to make the appropriate evidence-based decision to grow the investment efficiently. It is hard for business modellers to plan for a potential future plan with very little knowledge about trends in energy use from micro-grids in rural Myanmar. This gap is one of the barriers for the productive uses tied to the commercial and agricultural use of machinery in villages.



Cumulative productive and consumptive load share and major use types across all non- grid connected (NGC) villages of 44 villages in dry zone. *Source:* Pact Myanmar (2018).

Livelihood activities

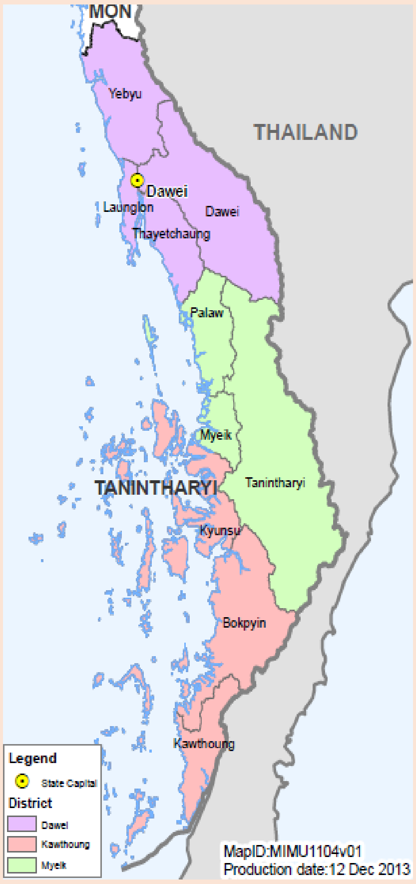
The population in Tanintharyi relies heavily on fishing (80% reported to be involved in some way). Various large companies are responsible for most seafood processing and exports from the region. Aquaculture has the potential to be a significant source of income and employment for people living in the Region. Small businesses, often family or women-owned, use basic technologies (without a freezing process) to produce dried fish, dried shrimps, fish paste, and fish sauce. Although local fishermen acknowledge selling finished products is more profitable than selling raw fish, the high cost of power is cited as a major impediment to food processing. Access to credit is another limiting factor for growth; artisanal fishermen are caught in a cycle of debt as they rely on wholesale buyers who finance their fishing operations by paying for the catch in advance, but if the yield falls short, the fishermen are prevented from selling at a better price to other buyers later in the year.

Regarding agriculture, cash crops such as rubber, oil palm and cashew are important in the lowland south of the Tanintharyi Region. As of 2013, approximately 360,000 acres of oil palm and 300,000 acres of rubber were planted in Tanintharyi, with oil palm plantations concentrated in the southern half of the region (i.e, Kawthoung District) and rubber in the northern half. Oil palm is a large-scale commercial activity, while rubber and cashew are grown at various levels, small up to large, by farmers. The rubber production has found itself into trouble due to the low price of rubber. Betelnut and banana intercropping is common in Tanintharyi. As seasonal crops, paddy rice, corn, sesame, chili pepper, peas and beans, and vegetables are grown. Small-scale livestock rearing is being done for home consumption.

Mining has also emerged as a significant industry, for example, Tanintharyi supplying up to 2/3 of Myanmar's tin and tungsten. Pearls cultured at Pearl Island creates much budget obtained from foreign countries at the Myanmar Gems Emporia. The current Dawei deep seaport and Special Economic Zone projects are part of the industrial development plan

Beautiful islands and beaches such as Maungmagan (near Dawei) and in the Myeik Archipelago render great opportunities for tourism.

Exhibit 18 Administrative divisions, Tanintharyi



Source map: UNICEF (2013)

Tanintharyi

- **Dawei**
  - Dawei
  - Launglon
  - Thayetchaung
  - Yebyu
- **Myeik**
  - Mweik
  - Tanintharyi
  - Kyunsu
  - Palaw
- **Kawthaung**
  - Kawthaung
  - Bokpyin

Region
District
Township

Livelihoods activities by rural women

- Coastal aquacultures, such as shrimp farming and crab farming
- Working at the fishing industry
- Making dried fish
- Agriculture (working as daily labourer or on their own farm)
- Making traditional snacks
- Running a small grocery at home

List of organizations working on livelihoods in Tanintharyi

- Advancing Life And Regenerating Motherland (ALARM), Boatpyin Township
- HELVETAS Myanmar, Dawei Tsp, Myeik Tsp
- Norwegian Refugee Council (NRC), Palaw Tsp, Dawei Tsp, Launglon Tsp
- Swisscontact - Swiss Foundation for Technical Cooperation
- United Nations High Commissioner for Refugees (UNHCR), Palaw Tsp, Dawei Tsp, Yebyu Tsp
- World Vision, Thatyetchaung Tsp, Palaw Tsp

Off-grid electrification

Tanintharyi, in particular, shows the great electrification needs. Compared to Myanmar's national average (32%) and other states and regions, Tanintharyi has the country's lowest electrification rate at 8% (in 2014). According to the 2014 Census, the main source of lighting is formed by private diesel generators (47%), kerosene (18%), candles (22%), grid electricity (8%), followed by solar systems (3%). Cooking is done using firewood (52%), and charcoal (44%)

The national grid is slowly being extended from Mon State (Tanintharyi's northern neighbor) while major town will have local grid systems. Most of the Region's 18 towns have electricity (provided by gas or diesel generation), but out of a total of 1,236 villages, 256 villages have been electrified by natural gas, diesel generator, and small hydropower. However, the Government plans to reduce the number of unelectrified villages top about 500 by stand-alone solar and solar mini-grid systems,

Exhibit 19 Mini-grid systems installed in Thanintharyi

Type	Number of plants
Minihydro (0-1 MW)	6
Minihydro (1-10 MW)	0
Biomass and biogas	11
Wind turbines	25
Diesel	68
Steam / cogeneration / natural gas	0

Source: MEE Net, 2018

In the absence of the national grid and government tariff structure, which heavily subsidizes domestic users, private power suppliers in Tanintharyi often charge relatively high electricity rates[30]. Furthermore, rural communities outside the reach of the private power companies can spend a significant share of their income on candles, batteries, and kerosene to light their homes after dark. Electronics shops in purchase solar products and batteries from wholesalers in Yangon who import products mainly from China, however, often warranty or after-sales support with their solar products.

The number of stakeholders promoting off-grid renewable energy access in Tanitharyi is relatively small. Myanmar EcoSolutions is developing a 400-kilowatt pilot project in one of Myeik's islands to use solar for powering commercial facilities (e.g., cold storage, fish processing, shipyard) and local communities. Another example is Techno Hill Engineering, which has set up a 40-63 solar kW mini-grid systems in four villages on Kenti Island (in Palaw Township), visited by the PPG Team[31]

Shan

- Area: 105,801.3 km^2
- Total population: 5,824,432 in total (female 2,913,722 - 50.03% , male – 2,910,710- 49.97%), 2014
- Rural: 76%, urban: 24%
- Percentage of female headed households: 21.4%
- Main ethnic groups: Shan, Pa-O, Intha, Lahu, Lisu, Taungyo, Danu, Ta'ang, Ahka, Jinghpaw, Burmese
- Administrative divisions: 14 Districts,
- Capital: Taunggyi
- Main economic activities: Forestry, Mining, Agriculture

Socio-economic characteristics

Livelihood activities

Agriculture is the largest economic sector in Shan State, even in urban areas, followed by mining and (in Shan South) by tourism. However, access restrictions and lack of infrastructure have inhibited the development of tourism outside a few well-known spots, while the local population is not generally involved in mining, even as labourers. Weaving is an additional potential income-generating activity.

30 The tariff rate varies depending on source types, e.g., 200MMK/kWh for natural gas; 500 to 600 MMK/kWh for diesel; and 70-80 MMK/kWh for basic lighting with micro/mini-hydro (source: field work by PPG Team, January 2019)

31 In Kenti village, 310 households are powered with 63 kW installed capacity though there is a plan to extend the capacity by adding another 48 kW due to high demand. Other villages are powered by Techno Hill with 40 kW installed capacity, each with a diesel generator backup system prepared for long cloudy days or rainy days. The PPG field visit report mentions that "Many residents prefer solar mini-grids to diesel power to reduce their expenditure on electricity from MMK 650/kWh to MMK 350/kWh by shifting their power source"

Livelihoods activities by rural women

Potential livelihood activities designed for women may include grocery retailing, tailoring, livestock rearing and farming (agriculture and horticulture). On issue regarding gender is land ownership. It is mostly men who end up officially owning land or farms as registered owners. This is because villagers have to go to town in order to register their land, and women rarely travel, since men deal with Registration Office's officials. Thus, men end up registering land in men's names.

Organisations working on livelihood in Shan State

Regional CSOs and gender organizations offer capacity-building support to help ensure women's income generation[32]. The State's One Village-One Product Programme is of interest to be involved in the Project's PUE activities. The programme intends to promote local products and markets. Youth entrepreneurship association in Taunggyi (under the Myanmar Entrepreneurship Development Association) offers training designed for value-added products using local produce, e.g., training in fruit processing.

Agriculture

Potential crops include garlic, onion, potatoes, green tea, coffee, and maize in addition to seasonal fruits such as jackfruit, orange, jengkol beans, dog fruit, mango, and sebesten.

The performance of the agriculture sector and its potential for growth have been enhanced by recent progressive agricultural policy reforms such as (i) land law reforms; (ii) abolition of the rice production quota, allowing farmers to choose which crops to cultivate; (iii) liberalization of domestic and international marketing of rice in 2003, and of industrial crops in 2004; (iv) removal of the export tax on key agricultural commodities; (v) a law allowing the establishment of microfinance institutions; (vi) use of crops as loan collateral; and (vii) passage of a plant pest quarantine law in 1990, a pesticide law in 1993, and a fertilizer law in 2000. In spite of this progress, the need remains to adopt a more coherent and comprehensive approach to agriculture and rural development and to make agriculture more commercially oriented, as has been done by

Exhibit 20 Administrative divisions, Shan State

Shan (South)

Taunggyi
- Taunggyi
- Nyaung Shwe
- Hopone
- Ceesine
- Kalaw
- Pintaya
- Ywar Ngan
- Yat Saut
- Pinlaung
- Phal Khone

Loilem
- Loilem
- Lanchar
- Nansam
- Kunheim
- Kyaythee
- Minekhine
- Mineshu

Linkhay
- Linkhay
- Moenal
- Maunthal
- Minepan

State
District
Township

Source mao: UNICEF (2013)

[32] Eastern Shan State suffers from human trafficking. DSW, IOM and Anti- Trafficking Taskforce provide trafficking survivors with financial assistance to help with their reintegration. UNICEF covers travel expenses for survivors to help them return to their homes. DSW provides gender-based violence survivors with services such as financial support, referral to necessary services, and vocation training depending on their needs and consent. DSW has one-stop service center for GBV survivors in Mandalay and Yangon.

the leading ASEAN members that have sizable agriculture sectors. To accomplish this, the government has been adopting a value-chain approach to agriculture since 2011, which will facilitate the job creation and income growth needed to achieve not only rural development but also sustainable inclusive growth.

Recently, Myanmar government launched the *Myanmar Agricultural Development Strategy and Investment Plan (2018-2023*). It responds to the need (1) for the consolidation and integration of various plans, strategies and roadmaps and approaches currently developed by various stakeholders, (2) for systematic approaches to operationalize agricultural policy implementation, (2) to coordinate activities, projects, programme and policies and (4) to build a dialogue with domestic and foreign investors and harmonize foreign aid to the sector. The agricultural sector is estimated to contribute nearly 30% of GDP while industry accounts for about 25% and services about 45%. Agriculture accounts 60-70% of employment and 25-30% of export. Section3.5 of the strategy, it highlights the current condition of agricultural infrastructure and the importance of infrastructure development. Expanded rural electrification will be necessary for the development of both farm and non-farm sectors.

The cost of seeds and other inputs, and reliance on imports from China and Thailand, insecure land tenure, lack of knowledge and lack of infrastructure are barriers to improving farming techniques. While local markets are generally easy to access, farmers often have little access to more distant internal or international markets. The State has a potential for a number of cash crops (coffee, green tea, ginger, avocado, mango, soybean). Maize thrives in the temperate highlands, especially in Shan State.

Off-grid electrification

According to the 2014 Census, main source of lighting is electricity (33%), followed by solar systems (27%), candles (17%) and mini/micro hydropower (10%). Cooking is done using firewood (77%), and electricity (15%). In Southern Shan, most towns have electricity from the main grid or local grid systems (one diesel and one solar-powered). However; out of a total of 4,787 villages, 256 villages have been electrified by natural gas, diesel generator, and small hydropower. In rural areas, 1722 villages out of a total of 4787 have been electrified by the national grid, diesel generator, solar, or small hydro systems.

Exhibit 21 Mini-grid systems installed in Shan State

Type	Number of plants
Minihydro (0-1 MW)	4494
Minihydro (1-10 MW)	11
Biomass and biogas	62
Diesel	4081
Coal	1

Source: MEE Net, 2018

In Myanmar, there is significant micro/mini-hydro electrification potential and many existing sites throughout the country, and Shan State can be viewed as the most resourceful and actively developed area. There are several developer-manufacturers of <1MW hydropower in Shan State, who have developed a total of almost 4500 projects below 1MW. These developers are skilled in engineering and developing Crossflow, Francis, Turgo, and Propellor turbines. The majority of these projects have been fully paid for by the benefitting communities, with upfront costs supported by the local developer-manufacturers. Most of these developer-manufacturers are second-generation family-based, social enterprises, building upon the work of their fathers who were raised in villages with micro-hydro projects.

The mini/micro hydropower sectors is expanding, there are at least 20 greenfield projects below 1MW and 50+ brownfield projects that are in need of being upgraded. They are located in southern, central, and eastern Shan State (info provided by HyCEM, 2018).

Bibliography

ADB (2014)

Draft, Myanmar Renewable Energy Policy, by Asian Development Bank, National Energy Management Committee (NEMC) and Ministry of Science and Technology (MoST)

ADB (2015b)

Myanmar Energy Master Plan, for Asian Development Bank by Intelligent Energy Systems (IES) and Myanmar International Consultants (MMIC)

ADB (2016)
Myanmar, Energy sector, Strategy, and Roadmap, Asian Development Bank

ADB (2017a)
Off-Grid Renewable Energy Demonstration Project, Project Number: 47128-001, completion report prepared by the consultant, Nexant Asia Ltd. for the Asian Development Bank

ADB (2017b)
ADB Off-grid Renewable Energy, Investment Forum, prepared by Nexant for the Asian Development Bank

ESMAP-WB (2017)
Role of Mini-grids for Electrification in Myanmar, Energy Sector Management Assistance Programme, World Bank

Doberman, J. (2016)
Energy in Myanmar, International Growth Centre (IGC)

PACT (2018) - SPM
Bridging the Energy Gap: Demand Scenarios for Mini-Grids in Myanmar, by PACT/Smart Power Myanmar (SPM), https://www.pactworld.org/library/bridging-energy-gap-demand-scenarios-mini-grids-myanmar

GIZ (2018)
Workshop MOEE Grid-Connected Small Scale Electric Power Enterprise Regulations, Naypyitaw, March 2018. Isolated Small Sccale Electricity Enterprise Regulations (by J. Schmidt-Reindahl). Grid-Connected Small Scale Electricity Enterprise Regulations (C. Graecen)

Numata, M. (2018)
Technoeconomic Assessment of Microgrids in Myanmar, ERIA Discussion Paper Series, ERIA-DP-2018-05

Said, A. (2018)
Myanmar's Renewable Energy Potential – Open source re-sources mapping for electrification of rural communities, Master's thesis, Aalto University, Finland

Soe Soe Ohn, Dr. (2016)
Off-grid Electrification in Myanmar, PowerPoint presentation, Department of Rural Development

Soe Soe Ohn, Dr. (2018)
Utilization of Renewable Energy for Off-grid Rural Electrification in National Electrification Project, PowerPoint presentation, Department of Rural Development

Spectrum (2017)
Developing a renewable energy policy for Myanmar: Insights from the 2014 census. Energy Briefing Paper. Spectrum – Sustainable Development Knowledge Network

Ross, R. (2015)
Myanmar's Path to Electrification; The Role of Distributed Energy Systems, Center of Strategic and International Studies (CSIS)

Tint Lwin Oo (2017)
The Role of Renewable Energy in Myanmar's Future Energy Mix, Ministry of Electricity and Energy (MoEE)

Vaghela, D. (2017)
Energy Democracy in Myanmar: Scaling up Renewable Energy Social Entrepreneurs, PowerPoint, UK Low Carbon Development Network (LCEDN) Conference

World Bank (2017)
Upscaling Minigrids for Low-cost and Timely Access to Electricity (2017).

Wang, X. (2016) and Maung Win
Myanmar: Towards Universal Access to Electricity by 2030, World Bank-ESMAP and Ministry of Agriculture, Livestock and Irrigation (MoALI)