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RAPID MARKET ASSESSMENT OF THE OFF-GRID SECTOR IN MYANMAR

USAID BURMA RESPONSIBLE INVESTMENT & TRADE ACTIVITY

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank
AFD	Agence Française de Développement
AI	Artificial Intelligence
C&I	Commercial & Industrial
DC	Direct Current
DCA	Development Credit Authority
DRD	Department of Rural Development
EMP	Energy Master Plan
EPC	Engineering, Procurement, and Construction
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GOM	Government of Myanmar
HPP	Hydro Power Plant
IFC	International Finance Corporation
INGO	International Non-Governmental Organization
IRR	Internal Rate of Return
IPP	Independent Power Producer
JICA	Japan International Cooperation Agency
KPI	Key performance indicator
LCOE	Levelized Cost of Energy
MW	Megawatt
MEB	Myanma Economic Bank
MEDA	Myanmar Economic Development Association
MFI	Micro-Finance Institutions
MHDA	Myanmar Hydropower Developers' Association
MOEE	Ministry of Electricity and Energy
MOU	Memorandum of Understanding
NEP	National Electrification Plan
NGO	Non-Governmental Organization
O&M	Operation and Maintenance
PnP	Plug-and-Play
PULSE	Productive Use Leveraging Solar Energy
PV	Photovoltaic
RBF	Responsible Business Fund
REAM	Renewable Energy Association Myanmar
RET	Renewable Energy Technology
RITA	Responsible Investment and Trade Activity

SBFIC	Saving Banks Foundation for International Cooperation
SBIC	Savings Banks for International Cooperation
SHS	Solar Home System
SME	Small and Medium-Sized Enterprise
TVET	Technical and Vocation Training
USAID	United States Agency for International Development
VEC	Village Electrification Committees
WWF	World Wildlife Fund

1. EXECUTIVE SUMMARY

1.1. Background and Objectives

The USAID Responsible Investment and Trade Activity (the Activity) is a five-year (2020–2025) USD 18.7 million activity that works with a broad range of international and domestic private sector firms and civil society actors to promote civilian ownership of the Myanmar economy. Through a facilitative and ecosystem-strengthening approach, the Activity helps increase responsible trade and private investment in Myanmar, and supports firms operating in or entering the market in Myanmar to improve corporate governance, business transparency, and competitiveness. As the Government of Myanmar implements liberal policy reforms, a stronger and more diverse private sector is needed to achieve inclusive growth.

The Activity's approach to strengthening the private sector is guided by four objectives: 1) Increase fair and responsible trade and investment in Myanmar; 2) Improve corporate governance, business transparency, and competitiveness of local firms; 3) Promote economic integration, investment, and trade for the benefit of people in non-urban areas; and 4) Empower women to more fully participate in the economy.

The Activity achieves these objectives by identifying and supporting transactions that bring new investments into Myanmar, increasing gender-lens investing in Myanmar, de-risking investments in firms located in non-urban areas, building the capacity of businesses to improve corporate governance, increasing private sector capacity to comply with new regulations, strengthening corporate accountability through civil society and media, and building the capacity of business-support organizations to promote trade and investment.

The Activity focuses on four core sectors: garment and textiles, agriculture, aquaculture, and off-grid energy. Information and communications technology (ICT) and transportation and logistics are supported as cross-cutting enablers of growth in the targeted core sectors. As part of the Activity's foundational assessments, its subcontractor Thura Swiss conducted rapid market assessments for each targeted sector. This report focuses on the off-grid sector.

The objective of this assessment is to provide the Activity team and USAID a greater understanding of the dynamic trends and market growth opportunities in the sector, the key constraints to increased trade and investment, the ecosystem actors in the sector, and recommendations of priority areas where the Activity can intervene to help boost sector growth and achieve its programmatic objectives. This report presents a rapid assessment of opportunities and constraints tailored to the objectives of the Activity, rather than a comprehensive deep-dive assessment of the sector. The assessment will be used by the Activity team to inform its private sector engagement strategy and areas where the activity should channel its efforts.

1.2. Methodology

This rapid market assessment used both qualitative and quantitative data and relied on secondary and primary research. The Thura Swiss team first conducted a desk review of all relevant, previously conducted studies. The team then interviewed a sample of 15 to 20 actors in the sector, including private sector firms with representation all along the value chain (input suppliers, producers, and end market buyers), sector-specific industry associations, enabling ecosystem actors, development partners, and industry experts.

In addition to sector actors, interviews were conducted with a range of cross-sectoral organizations, including private sector associations, equity investors, finance providers, development partners, and government agencies. The research team used a structured interview guide to inform qualitative information gathering.

This report covers an overview of the sector and key trends (Section 2); analysis of the end markets (Section 3); structure of the sector, value chain maps, and key ecosystem actors (Section 4); constraints to trade and investment, including ICT and transportation/logistics-related constraints (Section 5); inclusive development constraints with a focus on women and non-urban areas (Section 6); and recommendations (Section 7).

1.3. Key Findings

1.3.1. Recommendations

The Activity is encouraged to primarily support the solar product sub-sector as this represents the most viable opportunity to increase responsible trade and investments within off-grid electrification. This would include activities to support the ecosystem around:

- High quality solar home systems; and
- Solar powered productive use appliances such as solar water pumps.

The activities to support these two areas overlap significantly, and the implementation could be either joined into one activity or run in parallel with many similarities. The activities recommended include:

- Consumer awareness and product demonstrations
- Business and partnership development support
- Facilitate debt financing and de-risking mechanisms to increase financing
- Promote women's participation in the solar products industry
- Strengthen advocacy for improved standards and regulatory framework

Similar recommendations are described for the mini-grid sub-sector, but significant support is already provided in this sub-sector from other parties, making supporting the solar product sub-sector the key recommendation.

2. OVERVIEW OF THE SECTOR AND KEY TRENDS

2.1. Overview of the Sector and Recent Developments

Fifty-eight percent of Myanmar's 11 million households are not connected to the national electricity grid. Among those households that are off the electrical grid, 4 million have no access to electricity and are using fossil fuels for domestic electricity needs. The remaining 2.5 million households have access to electricity through off-grid solutions, which comprise of diesel, solar, mini-hydro, and biomass generation systems.[1] Presently, Myanmar has more than 8,800 MW of installed capacity, 37.5 percent of which comes from renewable energy sources.[2] The annual need for power consumption in Myanmar is increasing annually at the rate of 15 -17 percent, and to fill the growing gap of energy needs, the government plans to implement an energy mix that includes hydropower, natural gas, coal, and renewable energy.[2] Under the 2014 Myanmar Electricity Law, state and regional governments are authorized to permit and regulate small and medium electrical businesses under 30MW.[3] There are currently no exports generated from off-grid solutions.

The Government of Myanmar (GOM) launched the Myanmar National Electrification Plan (NEP) in 2014 and the Myanmar Energy Master Plan (EMP) in 2015, which have established national electrification benchmarks to provide 76 percent of electrification rates in 2025 and 100 percent in 2030. The NEP proposes a coordinated application of grid roll-out and off-grid pre-electrification[4] via mini-grids and solar home systems (SHS). The NEP divides rural villages into five electrification phases in accordance with their maximum distance from existing medium voltage substations. The cost for the nationwide implementation of the NEP is estimated at approximately USD 6 billion by 2030. The EMP aims to rebalance the energy mix to increase the power generated from renewable energy sources (excluding hydropower) from 2 percent in 2020 to 8 percent in 2030, which would translate into more than 1,880 MW out of 23,594 MW planned installed capacity coming from renewable energy sources like solar and wind. Meanwhile, hydropower, including mini-hydro projects, is expected to contribute 32 percent, or more than 7,000 MW, of the energy mix in 2030.[5] Thus far, only 15 percent progress has been made with developing mini-grids (5,271 households out of targeted 35,500), which means that Myanmar is likely to miss its mini-grid targets by the time the first phase of the NEP ends in 2021. On the other hand, more than 240,000 households out of the planned 465,500 have received solar home systems, representing 53 percent of the target met.[6] Meanwhile, there have been very few enabling initiatives toward the development of other sub-sectors such as mini-hydro, wind, and biomass.

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[1] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://smartpowermyanmar.org/wp-content/uploads/2019/04/Decentralised-Energy-Market-Assessment-in-Myanmar-Full-Report.pdf

[2] export.gov. 2019. "Burma – Energy." https://www.export.gov/apex/article2?id=Burma-Energy#:~:text=Currently%2C%20Myanmar%20has%20a%20total,Megawatts%20by%20renewable%20energy%20sources

[3] Burma library. 2013. "Electricity Bill." https://www.burmalibrary.org/docs18/2013-Electricity_Bill-en.pdf

[4] In the context of NEP "pre-electrification" refers to pre-grid electrification by off-grid solutions such as mini-grids and solar home systems.

[5] EuroCham Myanmar. 2019. " https://eurocham-myanmar.org/uploads/460d5-energy-guide-2019-web-.pdf

[6] Frontier Myanmar. 2020. "Slow grid rollout shows why Myanmar should join the personal energy revolution." https://www.frontiermyanmar.net/en/slow-grid-rollout-shows-why-myanmar-should-join-the-personal-energy-revolution/

There are more than 4,300 mini-grid systems in Myanmar, of which 69 percent are powered by diesel generators, followed by small hydroelectric systems (25 percent) and solar mini-grids (4 percent). Biomass gasification or biomass/biogas systems make up the remaining 2 percent of the total number of mini-grids. Myanmar does not currently have any wind power plants.

2.1.1. Key Sub-Sectors

DIESEL GENERATORS

Diesel generators are the most common mini-grid technology, with nearly 3,000 mini-grid systems. They were mainly developed decades ago by local communities on an ad-hoc basis utilizing available hardware at a time when renewable-energy based mini-grid technology was non-existent in Myanmar. They are often small (under 10 kVA) and made with Chinese-manufactured agricultural diesel motors powering inexpensive single-phase or three-phase synchronous generators with sufficient generation capacity to provide electricity to multiple households. Most diesel generators are inefficient and old with poor voltage and frequency regulations. Moreover, the average cost of electricity is very high, ranging between 510 and 1,000 MMK/kWh due to volatility in fuel prices. As a result, access to reliable and constant fuel supply can be challenging in remote regions.[7] Today, hybrid solar/battery/diesel systems are gradually replacing stand-alone diesel generators, and there is almost no private investment taking place in them. Since the market is shifting away from non-renewable generation, this report will not focus on diesel generators.

MINI-HYDRO POWER

There are more than 2,400 hydro mini-grid units, which are below 1 MW of generating capacity for village electrification across Myanmar, with the majority being concentrated in Shan, Kachin, and Chin States.[8] Mini-hydro systems are developed through three business models: household or individual-led mini-hydro projects, village-led mini-hydro projects, and government-led mini-hydro projects. Most of the small-scale hydropower plants were built and managed with self-financing from villages, rather than government subsidies. There are four major small-scale hydropower developers with more than 100 mini-hydropower projects installed, all headquartered in Shan State.

SOLAR POWER

Myanmar's total solar power potential is estimated at around 35 gigawatts-peak. However, only 1 percent of total solar power generating potential has been installed as of 2019, presenting huge untapped potential and making Myanmar an attractive destination for solar energy investment and deployment.[9] The average yearly photovoltaic (PV) power production total varies between 1,150 kilowatts-hour/kilowatts-peak (kWh/kWp) and 1,600 kWh/kWp, with high values in the Central Dry

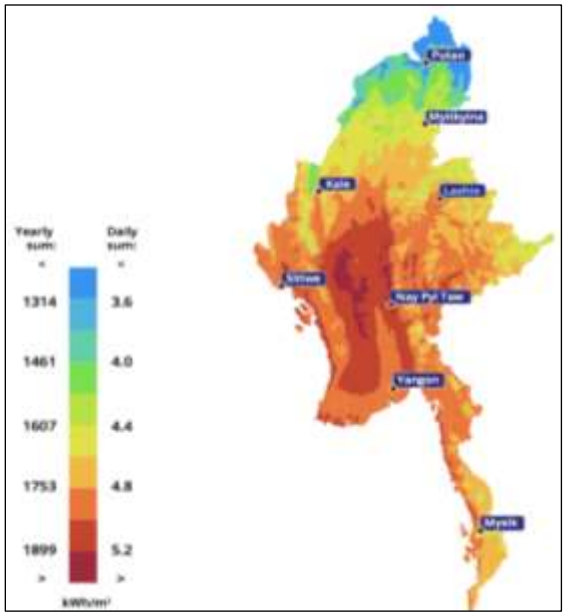
[7] Greacen, Chris. 2016. Role of Mini-grids for Electrification in Myanmar – SWOT analysis and a roadmap for scale-up. The World Bank. https://energypedia.info/images/e/ed/20160530_Minigrids_in_Myanmar_-_SWOT_and_roadmap_for_scaleup.pdf

[8] Energypedia. 2018. "Financing Economically Viable Decentralized Renewable Energy: Biomass Gasifiers and Micro/Mini Hydropower in Myanmar." https://energypedia.info/images/9/9b/Financing_Viable_Mini_Grids_Dipti_Vaghela.pdf

[9] Solar Magazine. 2019. "Myanmar Solar: Lots of Potential, But a Cloudy Outlook for Solar Energy Development and Growth." https://solarmagazine.com/solar-profiles/myanmar/

Zone. In mountainous regions such as Shan State, solar power production is about 20 percent lower due to terrain shading.[10]

FIGURE 1. MYANMAR IRRADIATION LEVELS



Source: Solargis

Solar power is currently driving the growth of the off-grid energy sector in Myanmar, with growing support from international development institutions and government as well as increasing investments from the private sector. As of the end of 2019, Myanmar had cumulatively installed 88 megawatt (MW) of PV capacity.[11] This sub-sector presents more viable growth opportunities than the other less developed mini-hydro and biomass power sub-sectors as a result of the ongoing technical and financial support. In this report, the solar power sub-sector is divided into three areas: Solar Products, Solar Mini-Grids, and Rooftop PV Systems.

SOLAR PRODUCTS

Solar products refer to both systems and appliances. Solar systems are stand-alone systems that provide a range of services and are typically split into sub-categories, although the terminology varies. Solar products include *pico solar products* (such as solar-powered flashlights), *solar home systems (SHS)* (such as ready-to-use plug-and-play (PnP) systems with single or multiple lights) and *component-based systems*, where panel, battery, lamps, and other parts are produced separately and connected according to use case.

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[10] Lee, Alden & Aleksanova, Anna. 2019. Myanmar: Solar Investment Opportunities. Brussels: Solar Power Europe. https://www.solarpowereurope.org/wp-content/uploads/2019/09/20190507_SolarPower-Europe_Myanmar-Solar-Investment-Opportunities.pdf

[11] pv magazine. 2020. "Myanmar launches 1 GW solar tender." https://www.pv-magazine.com/2020/05/19/myanmar-launches-1-gw-solar-tender/

Solar products also include solar-powered and often energy-optimized appliances and devices for residential or productive use. In the definition in this report, these appliances are either powered by one of the solar systems outlined above or by a separate solar power source typically supplied with the appliance. We consider solar products to include the small-scale applications that are powered by less than 1kW power (say, a small water irrigation pump), while larger productive use equipment (e.g. for industrial milling) that are often powered by a mini-grid are considered as a separate element in this sub-sector. Appliances could for example include TVs for residential use or agricultural water pumps for productive use. Lighting Global and ESMAP use the term PULSE (Productive Use Leveraging Solar Energy) in their market opportunity research report, and the products we would consider as solar products in this report align with their definition of micro-PULSE.[12]

Solar systems and appliances are typically distributed in Myanmar in one of three ways:

- Public distribution of solar home systems directly to rural households as part of the off-grid component of NEP. The Department of Rural Development (DRD) had a public procurement program that initially distributed and installed SHS to households for free. When NEP was launched in 2014, this program became part of NEP and since then, with World Bank funding, DRD has been conducting International Competitive Bidding tenders with stricter quality standards and distributing SHS for residential households (where households contribute up to 20 percent of the total SHS cost). In addition, public facilities such as monasteries, schools, and clinics are equipped with solar systems.[13,14]
- Systems and appliances are distributed through electronics shops and hardware retail stores across Myanmar that sell hardware typically imported from China via wholesalers. Rural customers either visit the shop in town centers or buy the products through informal connections outside the village.
- Distribution by companies selling directly to rural households often selling on installment plans. These distribution companies have emerged since 2015 and typically use regional distribution hubs and build a network of rural sales agents. IFC's Lighting Myanmar program (2016-2022) has been actively supporting the companies that distribute Lighting Global quality-verified solar products.[15] The companies currently active in direct rural household distribution primarily sell solar home systems, but also distribute some appliances this way, for example solar water pumps distributed directly to farmers.

SOLAR MINI-GRIDS

A mini-grid is a decentralized grid that typically covers an entire village and distributes electricity from a central power source via cabling to households. This includes mini-grids combining solar PV generation with storage and backup diesel generation. Mini-grids have sufficient size and scale to cover entire villages and townships with more power than stand-alone solar products. Currently, there are more

[12] Lighting Global. 2019. The Market Opportunity for Productive Use Leveraging Solar Energy (PULSE) in Sub-Saharan Africa. Washington: International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf

[13] Mohinga. 2021. "Rural Electrification Programme – SHS Component." https://mohinga.info/en/profiles/activity/MM-FERD-ID8974/

[14] Department of Rural Development. "Solar Home System." https://www.drdnepmyanmar.org/en/page/solar-home-system

[15] International Finance Corporation. "Lighting Asia." https://www.ifc.org/wps/wcm/connect/528901bf-88d3-40fc-be69-f6a289058c79/Lighting+Myanmar.pdf?MOD=AJPERES&CVID=lPONXQV

than 230 solar mini-grids in Myanmar, typically with generating capacity between 10KW and 250KW; the term mini-grid in other countries covers grids with capacity of up to 10 MW.[16] With subsidized funding from the World Bank, the Asian Development Bank, and other international development finance organizations, mini-grid solar projects have played a key role in the electrification in Myanmar. Mini-grids have mostly been utilized in rural communities where the mini-grid serves households and public facilities like schools and clinics.

ROOFTOP PV SYSTEMS

Rooftop PV systems are mainly used for commercial and industrial (C&I) facilities where solar panels are mounted on the roof or integrated into the façade of a building such as a warehouse or a factory. In off-grid areas, rooftop systems can serve as the main electricity source, either replacing diesel generators entirely or reducing diesel generators use as backup power when conditions are not optimal for rooftop solar power. In on-grid areas, rooftop systems can reduce dependency on the unreliable grid, reduce exposure to grid electricity pricing, and reduce the dependency on diesel generators. In Myanmar, there are both off-grid and on-grid rooftop PV systems. Off-grid systems are mainly installed at tourist lodges such as Chaung Thar Lodge, with diesel generators used for backup in case of insufficient electricity. On-grid systems are typically grid-connected factories such as Coca-Cola Myanmar and shopping malls like Junction Square and Junction City in Yangon. An IFC study in 2019 estimated that there is more than 700 MW worth of potential C&I solar projects in Myanmar, equivalent to around 10 percent of the existing electric power generating capacity in the country.[17]

BIOMASS POWER

Biomass power utilizes organic materials and waste, including wood, rice husks, bagasse, corn cobs, and coconut shells to generate heat, steam, and/or electricity. In Myanmar, biomass power contributes more than 50 percent of the total energy consumption; the two most common sources are wood and rice husks. The report will look at systems that use rice husks and other organic waste products to generate biomass power. Biomass energy is consumed mainly through traditional methods such as fire-stoves for lighting, cooking, and heating by 93 percent of rural households. Fuel wood comprises a more than 42 percent share of biomass sources in Myanmar compared to rice husks (3 percent). Myanmar produces more than 3 million MT of rice husks annually, the majority of which are used as cooking fuel (in briquette form or for husk-compatible cookstoves) while only 10 percent is used as a feedstock for steam and electricity generation using boiler or gasification engines.[18] Rural households are not using biomass for gas or electricity; their main source is fuelwood for cooking purposes. Currently, there are no biomass-powered mini-grids supplying electricity for residential use to households in villages or townships. Only rural small and medium-sized enterprises (SMEs) such as rice mills are burning biomass feedstock like rice husks using direct combustion methods and gasification systems to convert them into electricity, but this is not environmentally friendly. Moreover, because of limited biomass feedstock, many rice mills still do not view biomass power as their main electricity source and so they destroy their agricultural waste.

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[16] Techno-Hill Engineering Ltd. Interview

[17] Mizzima. "IFC study highlights potential solar help power businesses Myanmar." http://mizzima.com/article/ifc-study-highlights-potential-solar-help-power-businesses-myanmar

[18] Tun, Maw & Juchelková, Dagmar. (2019). Biomass Sources and Energy Potential for Energy Sector in Myanmar: An Outlook. (https://doi.org/10.3390/resources8020102)

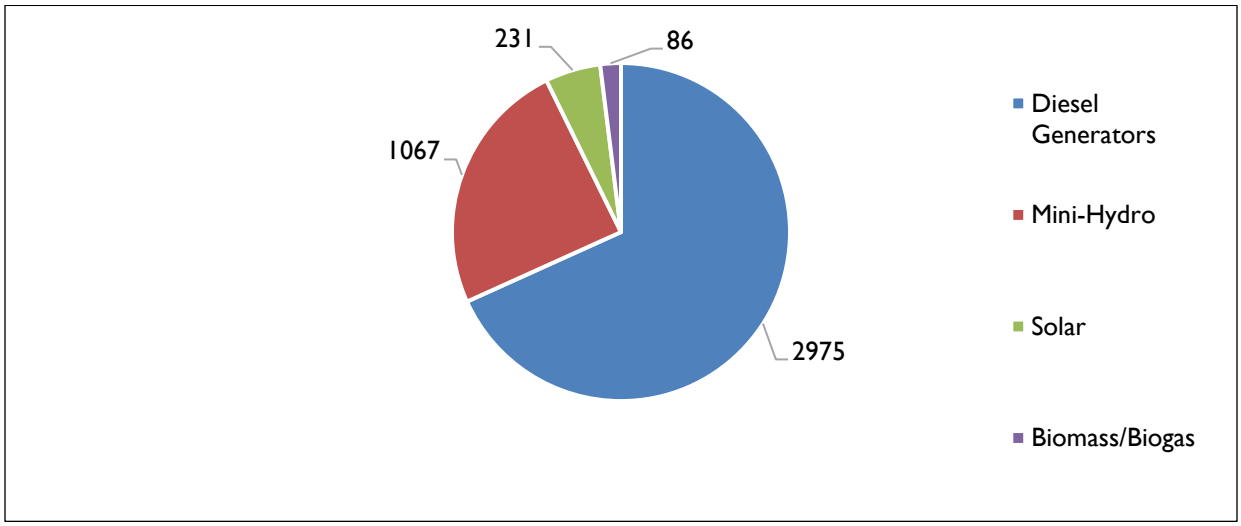
WIND POWER

Apart from the wind turbine at Ngwe Saung Beach, which was developed by Thiri Lwin Co., Ltd. in 2006 for private use, Myanmar does not have any wind power plants. The country's first wind power farm project, which was to be developed by China's Three Gorges Corporation, was stopped in 2020 due to a lack of sovereign guarantee. The country's wind power generation capacity is estimated to be on the order of 365.1 terawatt-hours per year, largely generated in mountainous and coastal regions of the country. The Ministry of Electricity and Energy (MOEE) conducted feasibility studies with Thailand-based Gunkul Engineering Co., Ltd. and Singapore-based Asia Ecoenergy Development, as well as with local firms such as Primus Advanced Technologies Co., Ltd. in three regions and six states.[19] Local company Zeya & Associates signed a Memorandum of Understanding (MOU) with Denmark-based wind turbine manufacturer Vestas in 2015 to construct a 32 MW wind farm in Mon State, but this project has yet to materialize. This report will not focus on the wind power sub-sector because there is low interest from both public and private sector stakeholders in developing it due to its high financial, regulatory, and technical barriers.

2.2. Key Figures and Geographic Footprint of the Sector

Solar mini-grids are mainly present in regions with high off-grid populations and higher demand for productive use of power such as the Delta and Central Dry Regions like Mandalay and Magway. Mountainous areas such as Shan State and Kachin State have a high prevalence of hydro mini-grids.

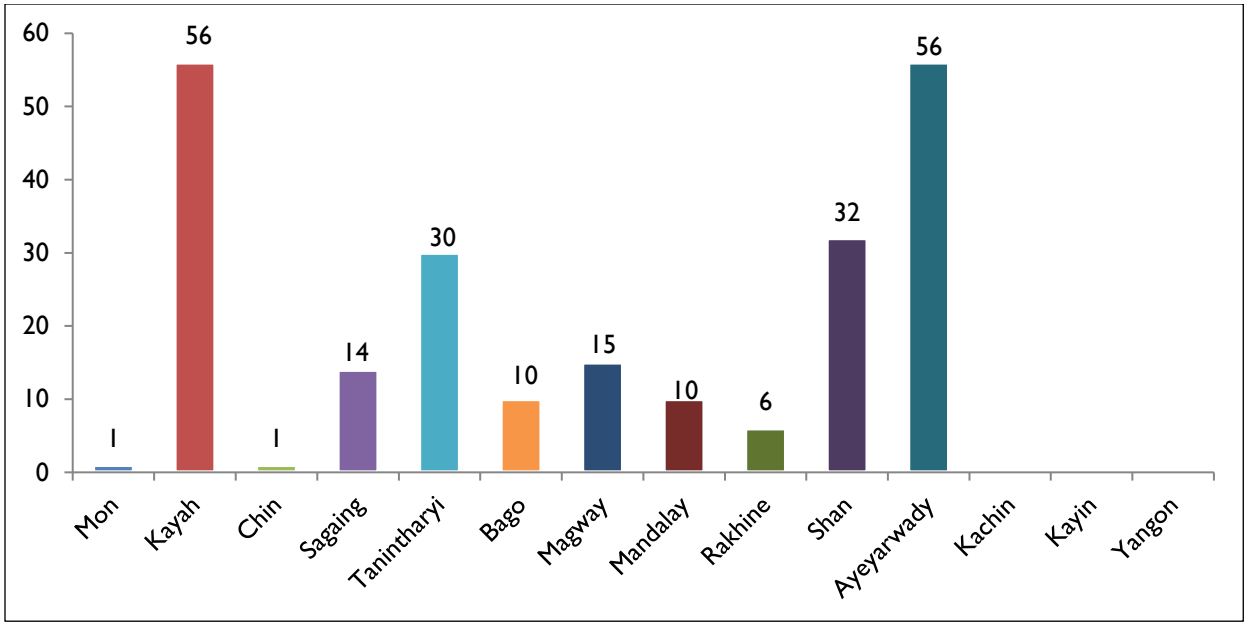
FIGURE 2. EXISTING MINI-GRID SYSTEMS IN MYANMAR BY TYPE (2019)



Source: Smart Power Myanmar

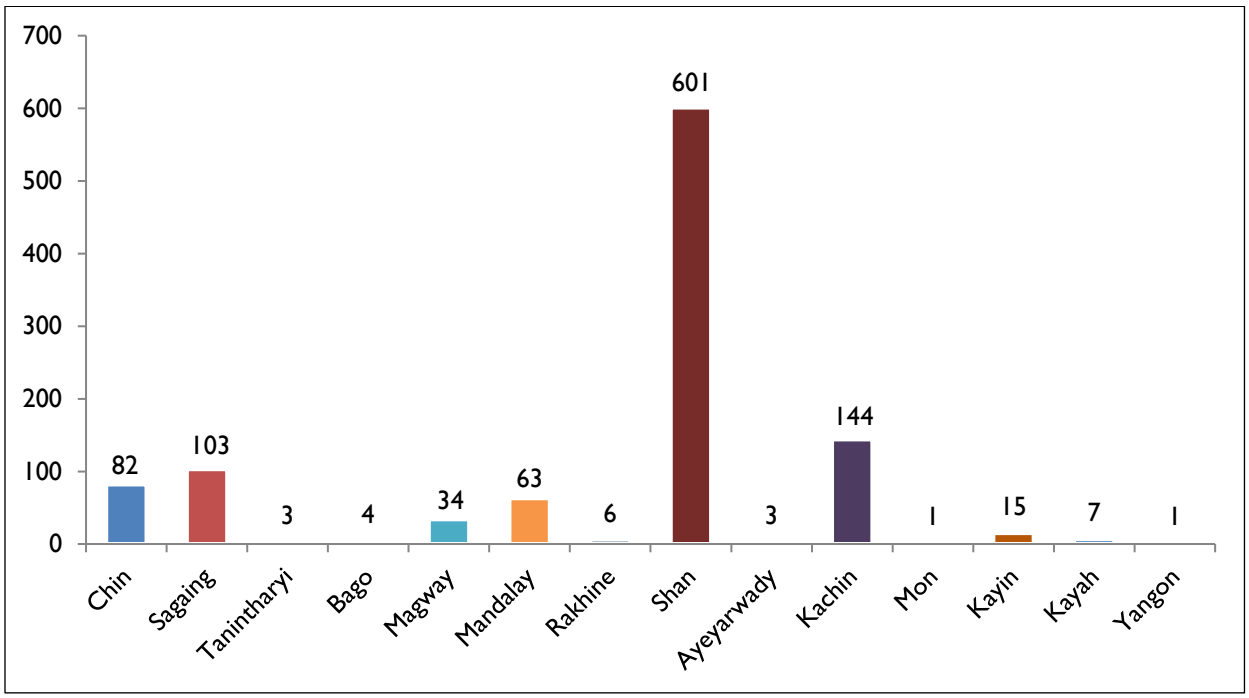
[19] Tilleke & Gibbins. 2020. "Renewables in CLMVT and the Potential for Wind Power." https://www.tilleke.com/insights/renewables-clmvt-and-potential-wind-power/; China Dialogue. 2020. "Plans for wind power from Chinese firm fall apart in Myanmar." https://chinadialogue.net/en/energy/myanmar-wind-power-project-by-chinese-firm-stalled/

FIGURE 3. EXISTING SOLAR MINI-GRIDS BY REGION (2019)



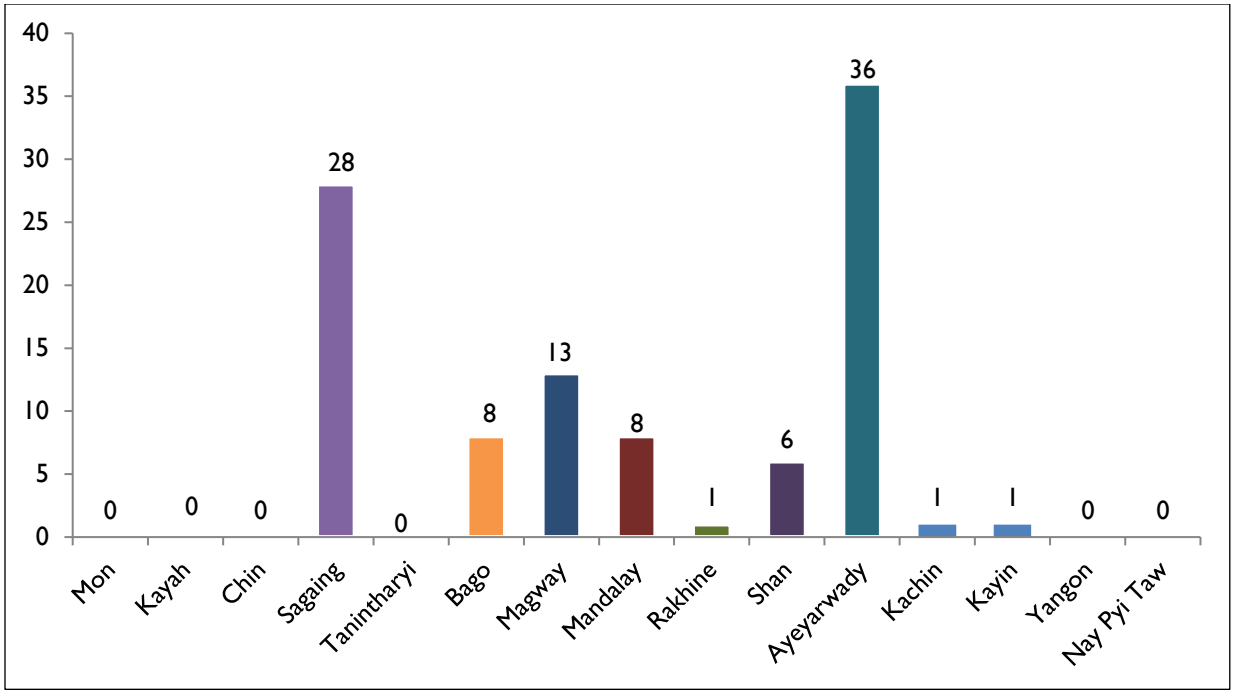
Source: Department of Rural Development

FIGURE 4. EXISTING HYDRO MINI-GRIDS BY REGION (2019)



Source: Smart Power Myanmar

FIGURE 5. EXISTING BIOMASS/BIOGASS MINI-GRIDS BY REGION (2019)



Source: Smart Power Myanmar

NUMBER OF PLAYERS

There are more than 50 local and foreign solar companies (including mini-grid project developers and solar products distributors) currently active in Myanmar. More than 70 percent of these are local SMEs, while 30 percent are large developers and distributors that are subsidiaries of international conglomerates and/or players with international investments, such as Yoma Micro Power, and foreign-owned companies, such as Indigo Energy Ltd. They are engaged in providing turn-key solutions of mini-grids, providing commercial and industrial rooftop solar solutions and distributing solar equipment for household usage.

There are around five mini-hydro developers with more than 100 mini-hydro plants, most in Shan State. There are no foreign-owned or foreign-invested mini-hydro developers yet; existing players are all owned by local entrepreneurs.

Biomass power plants are currently used by rice mills to reduce electricity costs and are not used to distribute power for residential use. Recently, several local players started partnering with international investors to adopt modern biomass gasification power plants adjacent to large-scale rice mills. There are only a few biomass power plant developers collaborating with foreign players to develop modern biomass technology in Myanmar. Among them, Japanese company Fujita Corp. entered into a joint-venture agreement with Myanmar Agribusiness Public Co., Ltd. (MAPCO) to form Myaung Mya FM

Biomass Power Co., Ltd. to develop the country's first biomass gasification power plant.[20] There are also biomass power plant developers such as Yangon Sino Technology Co., Ltd. which is partnered with China-based Kunming Dianyan New Energy Technology Development Company to develop biomass technology in Myanmar using Chinese technology.[21]

EMPLOYMENT

There are no official statistics on employment in the off-grid sector. Anecdotal evidence suggests that solar employs the most women of any off-grid sub-sector. Interviews with firms active in solar sub-sector have indicated that anywhere between 25 percent and 50 percent of their workforce are women, mainly in office-based functions such as design and planning, as well as in core-business activities such as sales and marketing.[22] There are also solar developers headed by women as well as those that involve women at middle and senior management levels such as Earth Renewable Energy Co., Ltd., Myanmar Solar Power Trading Co., Ltd., Talent and Technology Co., Ltd., and Techno-Hill Engineering Co., Ltd.[23] Women's participation in the mini-hydro power sub-sector is low due to the perception of suitability due to the physical nature of the work.

IMPACT ON NON-URBAN AREAS

Non-urban regions such as parts of Shan State, Tanintharyi Region, Sagaing Region, and Kachin State have significant irradiation levels and water resources to support the development of mini-grids powered by solar, hydropower, and/or hybrid systems. Therefore, the development in the mini-grid sub-sector in these regions will be able to bring economic integration, investment, and trade to these areas. In addition to state/regional government authorities, some of these regions have armed ethnic groups that developers (especially mini-hydro developers) need to interact with in order to get project approval. Many of the existing mini-hydro power projects received partial funding and/or access to land from these armed ethnic groups in the past as they view rural electrification crucial for regional development.[24]

Ayeyarwady Region and Sagaing Region are among leading producers of rice in Myanmar while Shan State is also a major producer of maize, therefore, rice-husk and corncob-based biomass power generation is relatively more suitable for off-grid electrification in these regions.

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[20] Bioenergy Insight. 2017. "Rice husk-fuelled biomass project launched in Myanmar." https://www.bioenergy-news.com/news/rice-husk-fuelled-biomass-project-launched-in-myanmar/

[21] Xinhua. 2018. "China-assisted biomass gasification power generation demonstrated in Myanmar." http://www.xinhuanet.com/english/2018-08/30/c_137431570.htm

[22] Interviews with Sunlabob Renewable Energy Myanmar Co., Ltd., Myanmar Solar Power Co., Ltd., Renewable Energy Association Myanmar

[23] PACT. 2020. "We can find our way around any barriers: The women driving change in Myanmar's energy sector." https://www.pactworld.org/features/"we-can-find-our-way-around-any-barriers"-women-driving-change-myanmar's-energy-sector

[24] Kyaw Soe Win Hydropower Co., Ltd. Interview

2.3. Current and Emerging Trends Driving the Growth of the Sector

2.3.1. Solar Power

SOLAR PRODUCTS

Solar products became available to rural off-grid populations in Myanmar in the early 2010s through the Department of Rural Development's public procurement program, as well as through private solar companies. During this period, solar products were mostly sufficient for lighting, mobile phone charging, and limited hours of operation of radios and small TVs. Since then, increasing demand among rural households for consumer electronics such as larger TVs and the desire to use the appliances for prolonged periods of time have been the major growth-drivers for higher capacity or higher-quality solar products.

Since 2015, solar companies distributing Lighting Global[25] certified systems directly to rural households on a pay-as-you-go basis have been active in Myanmar. These quality-verified products meet Lighting Global Quality Standards, which implement minimum requirements for quality, durability, truth-in-advertising, warranty, and lumen maintenance for both pico products and SHS kits up to 350 W.[26]

SolarHome is one example of a company operating in Myanmar providing Lighting Global-verified SHS products to rural households under a lease-to-own pay-as-you-go business model. SolarHome received nearly USD 2 million in the Series A financing round led by investment firm Trirec and Insitor Impact Asia Fund in December 2020. The company has raised more than USD 8 million in debt and equity financing and provided solar energy solutions to an additional 4,800 rural households over the past six months, bringing the total number of households covered to more than 35,000 across Myanmar.[27]

IFC launched the Lighting Myanmar project in 2016 to catalyze the market for Lighting Global quality-verified solar products in Myanmar by assisting international and Myanmar-based companies selling these products.[28] Under this project, which was active until end of 2020, IFC supported the companies active in Myanmar to scale and sell 800,000 Lighting Global quality-verified products in off-grid communities in Central Myanmar by mid-2022.[29] As part of the project, the Htein Htein Thar campaign was launched, which aimed to inform local consumers about Lighting Global quality-verified off-grid solar products and the benefits of quality solar equipment in rural areas. These public engagement campaigns involved traditional media, digital outreach, and rural events such as traditional Myanmar theatre shows to share

[25] Lighting Global was the name for both the World Bank Group program to catalyze off-grid solar markets and the name of the quality verification program. In 2020, the verification program rebranded to be Verasol, but for consistency with references, this report uses Lighting Global.

[26] Lighting Global. 2020. Off-Grid Solar Market Trends Report 2020. Washington: International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2020/03/VIVID%20OCA_2020_Off_Grid_Solar_Market_Trends_Report_Full_High.pdf

[27] TechinAsia. 2020. "Myanmar-based solar-powered products provider bags $2m in series A2 round." https://www.techinasia.com/forumbacked-solar-provider-solarhome-bags-2m-series-a2

[28] The World Bank. 2020. "Turning on the Lights for 450,000 People in Rural Myanmar." https://www.worldbank.org/en/news/press-release/2020/07/08/turning-on-the-lights-for-450000-people-in-rural-myanmar

[29] Lighting Global. "Myanmar." https://www.lightingglobal.org/where-we-work/lighting-asia/myanmar

information on the Lighting Global quality standards and companies that supply quality-verified products.[30]

In 2020, the Government of Myanmar received a USD 3.45 million grant from the World Bank to pilot a results-based financing facility to catalyze the sales of Lighting Global-certified quality solar products to benefit more than 450,000 people.[31] This pilot is the first of its kind in Myanmar, and the program promotes the commercial sales of solar products to support an overall transition from subsidized SHS distribution to a market-based approach where the subsidy is paid to the companies as a distribution incentive. The project encourages distributors to sell Lighting Global-certified quality solar products up to 50 Wp, with payment linked to product performance and verification of sales. The level of payment increases with the performance level of the system, and the program encourages after-sale services by requiring companies offer minimum warranty periods, provide maintenance and repair within that warranty period, and supply spare parts on an ongoing basis.
Support from international development finance organizations like the World Bank and IFC working together with DRD, in addition to the continuous reduction in system costs, have been the major growth trends for solar products in the recent years.

SOLAR MINI-GRIDS

The DRD-backed mini-grid subsidy scheme has been the main factor driving the growth of solar mini-grids in Myanmar. Under this scheme, Parami Energy commissioned the first phase of Southeast Asia's largest mini-grid system, located on Yesagyo Island, Magway Region, where there are more than 4,000 households across 48 villages. The first phase of the project, which has connected more than 1,400 households into the mini-grid system with a 288 KW peak capacity, cost USD1.6 million. The next two phases will be commissioned through 2021 and will provide electrification to the project's remaining 3,000 households. The mini-grid system employs solar PV technology with a diesel generator as back-up.

Availability of debt and equity financing is the key to the growth of solar mini-grid companies. However, this is only available to a limited degree, for example to select mini-grid developers such as Yoma Micro Power Co., Ltd. The firm secured USD 68 million in debt and equity financing from shareholders including the IFC, Philippine-based AC energy (a subsidiary of conglomerate Ayala Corporation), and Singapore-listed Yoma Strategic Holdings Ltd. In mid-2020, the IFC was considering a further USD 87 million loan package to the company.[32] Yoma Micro Power focuses on a key anchor customer (telecommunications towers), which creates a different business model than most solar mini-grid companies.

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[30] Myanmar Insider. 2018. "Htein Htein Thar Nationwide Campaign." https://www.myanmarinsider.com/htein-htein-thar-nationwide-campaign/

[31] Borgen Magazine. 2020. "The Lighting Myanmar Program." https://www.borgenmagazine.com/the-lighting-myanmar-program/; GPRBA. 2020. "Turning on the Lights for 450,000 People in Rural Myanmar." https://www.gprba.org/news/turning-lights-450000-people-rural-myanmar; The World Bank. 2018. "Myanmar RBF for Off-grid Solar." https://projects.worldbank.org/en/projects-operations/project-detail/P166413

[32] Myanmar Times. 2020. "IFC to boost funding for off-grid solar power in Myanmar." https://www.mmtimes.com/news/ifc-boost-funding-grid-solar-power-myanmar.html

ROOFTOP PV SYSTEMS

Commercial and industrial demand for solar systems has driven the necessity to save on electricity costs and reduce exposure to grid blackouts. Recently, with the government's increase of electricity tariffs in 2019, demand is likely to increase as the business case for building a rooftop system is stronger. However, adoption of solar rooftop systems is still slow due to the high up-front project costs, which either must be funded by the factory owner or the solar power developer. Developers with access to funding can take a credit risk and receive payments for the electricity used over time, but credit risk appetite and debt financing is a challenge. Grants such as the Responsible Business Fund (RBF), which is part of development assistance from Denmark, has helped SMEs adopting rooftop solar PV systems by subsidizing the up-front cost on a project-by-project basis. Both grid-connected and off-grid solar PV systems are present in Myanmar, and main users include commercial and industrial establishments like tourism establishments, offices, hospitals, SMEs, and factories. Examples of off-grid solar PV systems include Birmanie Atelier Travels & Tours Co., Ltd.'s solar PV system installation at an ecolodge next to an elephant retirement sanctuary in Bago State and the off-grid solar PV installation at a teak plantation owned by the National Resources Development Company. Both of these solar projects were funded using RBF grants.[33] Another recent and notable solar investment in the commercial and industrial space is Mandalay Yoma's agreement with Coca-Cola Myanmar to install and operate Myanmar's largest solar rooftop plant, which is able to generate 1.1MW at the company's Hmawbi factory.[34]

2.3.2. Mini-Hydro Power

There have been no international investments in the mini-hydro sub-sector as of now. Growth is mainly driven by increasing demand for electrification from villages in off-grid areas, which are either inviting mini-hydro developers to develop plants with community funding or to collaborate with developers to get electrification and jointly invest in SMEs such as agriculture and livestock businesses in more-developed regions such as Pyin Oo Lwin Township in Mandalay Region.[35] Growth of business activity in agriculture, livestock, and small-scale industry in villages would increase productive loads and demand for electricity, and increase profitability for mini-hydro developers.

2.3.3. Biomass Power

Although biomass is the largest contributing energy source in Myanmar, this is mostly burning firewood directly at the household level for non-electricity generating purposes such as cooking and at small-scale industries (e.g. boiling fish and shrimp on fishing rafts). Rice mills also use biomass to generate electricity through direct combustion, although more and more of these mills are using more modern technologies, such as gasification to fuel generators. This adoption of modern biomass technology by larger rice-milling enterprises has driven growth in this sub-sector over the past few years. In 2017, Myaung Mya FM Biomass Power Co., Ltd. (a joint venture between Fujita-MAPCO) launched Myanmar's first modern biomass gasification power plant worth USD4.7 million in Nay Pyi Taw. This plant, which has a 0.5 MW generation capacity, reduces consumption of electricity from the national grid and provides enough electricity not only to power the plant, but also to supply surplus electricity to nearby

[33] RBF Myanmar. http://www.rbfmyanmar.com/supported-sme-list
[34] https://www.facebook.com/mandalayyoma/posts/3705986426102274
[35] Sai Htun Hla Brothers Co., Ltd. Interview

villages.[36] Myaung Mya FM Biomass Power Co., Ltd. plans to generate biomass power in the future from rice mills located in other regions. In 2020, Fengyi Myanmar Rice Co., Ltd. which is a subsidiary of Singapore's Fengyi International, signed a contract with Dongfang Electric Group International Cooperation Co., Ltd. to develop two biomass boilers driving a steam turbine generator under a turnkey basis.[37]

2.4. Impact of COVID-19

Like all other sectors, off-grid energy has been affected by COVID-19. The following key impacts have been identified:

- Planned installation projects have been postponed, as logistics around moving the key equipment and materials used in the construction and the maintenance of the existing facilities were delayed.[38]
- Over 90 percent of solar-related products are imported mainly from China and India,[39] and the pandemic has also significantly affected the manufacturing capacities in those countries.
- Business development activities have come to stop, as they typically require active engagement with the clients including conducting site-visits, which have been stopped temporarily due to movement restrictions.[40]

[36] Myanmar Times. 2017. "Rice husk power plant opens in Myanmar." https://www.mmtimes.com/national-news/nay-pyi-taw/25477-rice-husk-power-plant-opens-in-myanmar.html
[37] https://www.seetao.com/details/24351/en.html
[38] Indigo Energy Interview
[39] Myanmar Solar Power Co., Ltd. Interview
[40] Indigo Energy Interview

3. END MARKET ANALYSIS

3.1. Key Domestic Markets

End market analysis for each of the sub-sectors faced data limitations in terms of available statistics on the overall size/sales revenues for each sub-sector and product segments, as well as projected market growth rates. The analysis therefore relied on available secondary sources and qualitative insights from stakeholder interviews.

3.1.1. Solar Power

SOLAR PRODUCTS

The main buyers of solar products are rural households. Among them, solar home systems are among commonly used solar products, with different price and quality options and mass availability. All available products on the market are imported; there are no locally manufactured solar products although some assembly and production of subcomponents takes place in Myanmar.

According to IFC's 2020 estimate, at least 3.5 million solar products are being used in Myanmar, reaching around 30 percent of the population. Of these, the DRD's public procurement program accounts for around 380,000 units while Lighting Global quality-verified estimated sales are around 100,000 units. The remaining 3 million units include both smaller portable lanterns and component-based systems that use low-quality solar panels, often paired with lead-acid batteries of inferior quality and reliability compared to for example the Lighting Global quality-verified products.[41]

Pico products include small, portable lanterns and flashlights, some which practically replaced kerosene lamps and candles previously used for lighting purposes. These systems are packaged mainly as a simple, one-light system, with some models featuring USB charging for mobile phones. Solar panels for pico products typically generate up to 10Wp.

Solar home systems are systems comprising of battery, a solar panel, lamps, and/or ports for mobile charging or other devices, suitable for both home lighting and powering smaller consumer electronics. SHS can be divided into plug-and-play and component-based systems. Plug-and-play (PnP) home systems comprise an all-in-one packaged kit with LED lights for multiple rooms and a solar panel with power rating up to 100Wp for small SHS and higher for large SHS, and a rechargeable battery. These systems may include assorted energy-efficient appliances such radios and TVs etc. In component-based systems, the individual components, such as the solar panel, battery, lights, inverter, wiring, and appliances, are sourced and assembled independently by either a product aggregator, like a local electronics shop, or an individual for their own household, sometimes even piecemeal over a long period of time. SHS typically utilize solar panels with power ratings above 11 Wp, although some are smaller.

Solar-powered appliances include both household appliances (such as televisions and refrigerators) and productive-use appliances (such as water pumps and agricultural processing equipment) and are typically powered by direct current (DC) and optimized for energy efficiency.

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[41] Lighting Global. 2020. Off-Grid Solar Market Trends Report 2020. Washington: International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2020/03/VIVID%20OCA_2020_Off_Grid_Solar_Market_Trends_Report_Full_High.pdf

Before 2016, DRD invited tenders for private companies to supply SHS that were selected on a technical specification basis. Many companies supplied Chinese-manufactured SHS products that met the technical specifications stated in the DRD tenders but had limited external quality validation. In 2016, the IFC collaborating with DRD launched Lighting Myanmar Project (2016-2020) to assist international and Myanmar-based affiliate companies including SolarHome Myanmar Co., Ltd., GreenLight Planet Co., Ltd. (Sun King brand), d.light and ovSolar Myanmar Co.,Ltd in creating a sustainable market for Lighting Global quality-verified solar products.

Several companies sell solar products in Myanmar that are not certified by Lighting Global. These include AETHER Solar Engineering Co., Ltd, which imports and distributes Chinese brand Bluesun; Myanmar Solar & Lighting Trading, which sells JD brand, also from China; and Pyae Phyo Aung Co., Ltd., which is the sole importer and distributor of Universal Solar brand, said to be manufactured in China using German technology. Products that are not Lighting Global quality verified represent 95 percent of all sales of solar products in Myanmar. Component-based systems assembled and produced most often by non-affiliate manufacturers are common in Myanmar as the country is close to Chinese manufacturing centers.[42]

In 2017, Lighting Global Quality Assurance identified 17 top-selling, non-quality-verified products from five countries including Myanmar and tested them against the Lighting Global Quality standards across three categories: truth-in-advertising, safety, and durability. Ninety-four percent of these products failed to meet Lighting Global standards. Although all products met requirements for physical protection from ingress, 88 percent lacked consumer-facing warranties, consumer electronics safety certification, and correct advertisement of battery capacity.[42]

Price is the main decision-making factor when buying solar products, with only a small percentage of the population interested in and able to afford the quality-verified products. The majority of households also prefer individual components to packaged systems due to availability, price, capacity, and modular replacement costs (easier to replace individual parts than the whole system).[43] Lighting by itself and lighting plus mobile phone charging are the most common requirements from off-grid households with a growing interest in SHS products that are able to fulfill the electricity demands of larger appliances such as televisions and refrigerators. Today, the market is still dominated by lower quality systems, but there has been a push to support the market for quality-verified products through efforts by The World Bank, IFC, and DRD. This includes the Lighting Myanmar program with customer-awareness campaigns and quality assurance, business-to-business support, and access to finance activities.

[42] Lighting Global. 2020. Off-Grid Solar Market Trends Report 2020. Washington: International Finance Corporation. https://www.lightingglobal.org/wp-content/uploads/2020/03/VIVID%20OCA_2020_Off_Grid_Solar_Market_Trends_Report_Full_High.pdf

[43] Lighting Global. 2016. "IFC Energy Access – Myanmar (Lighting Myanmar) Market Assessment." https://energypedia.info/images/7/70/IFC_Lighting_Myanmar_Market_Assessment_%28Part_1%29_28_Jan_2016_01.pdf

Many rural consumers require education on how to use solar products properly. Due to weak regulations and enforcement by the government on solar products, low-quality SHS are common in the market, and they are having a negative impact on the image of adopting solar products among rural consumers due to frequent equipment failures (primarily a rapid drop in battery performance, sometimes requiring battery replacement as often as every six months) and occasional fire hazards.[44] Because of their limited power-generating capacity, SHS are perceived as short-term solutions while mini-grids are considered better suited for last-mile energy connectivity and productive use solutions.[45] On the other hand, since solar home systems only require individual households to make the purchase decision, the consumer uptake can be much faster. SHS can provide basic off-grid electrification for many remote households.

SOLAR MINI-GRIDS

Mini-grids can play a crucial role in accelerating off-grid electrification in Myanmar. Unlike SHS, mini-grids are not only able to generate power for residential loads such as lighting, charging, and electrical appliances, but also fulfill productive loads, such as welding machines, carpentry machines, water pumps, and agricultural processing equipment, as well as commercial loads like large-scale industrial factories or telecom towers.[47]

Mini-Grid Impacts on Villages

- Direct impacts include creation of mini-grid related jobs such as technicians and operation and maintenance (O&M) jobs.
- Indirect economic impacts include opening of new businesses such as grocery stores, food and drinks stalls, and tailoring shops for women, and growth in existing businesses such as expanded hours of agriprocessing, carpentry, and welding businesses, leading to increased production.
- Social impacts include longer working and studying hours, increased access to information through the Internet, safety of public spaces, and powering of public facilities such as clinics and schools.[46]

According to Smart Power Myanmar's 2019 extensive study, grid-ready mini-grids are costly, and mini-grids serving residential and productive loads are only financially viable with subsidy support provided by government and international development organizations. Although subsidies are important, there is also a significant need for private sector investments to drive productive loads in order to create demand for and attract mini-grid investments. Consumer support and demand-side interventions such as encouraging the growth of energy-dependent productive loads, for example agricultural machinery usage in villages, are also crucial as they drive village electricity demand, which in turn increases utilization of current and future mini-grids and increases business viability for mini-grid developers.[48]

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[44] Asia Solar Co., Ltd. Interview

[45] Smart Power Myanmar Interview

[46] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf

[47] Residential loads are mainly used at households for lighting and other purposes such as watching television or charging mobile phones. Productive loads include electricity used for industrial and commercial purposes such as machinery, pumps and for agricultural processing (such as rice mills and oil mills) and at SMEs like tailors, food and beverages stalls and retail stores. Commercial loads are used by large-scale industrial and commercial entities such as factories or telecom towers.

[48] PACT. 2018. Bridging the Energy Gap: Demand Scenarios for Mini grids in Myanmar. Munich: TFE Consulting GmbH. https://themimu.info/sites/themimu.info/files/assessment_file_attachments/Bridging_the_Energy_Gap_Demand_Scenarios_for_Mini-Grids_in_Myanmar.pdf

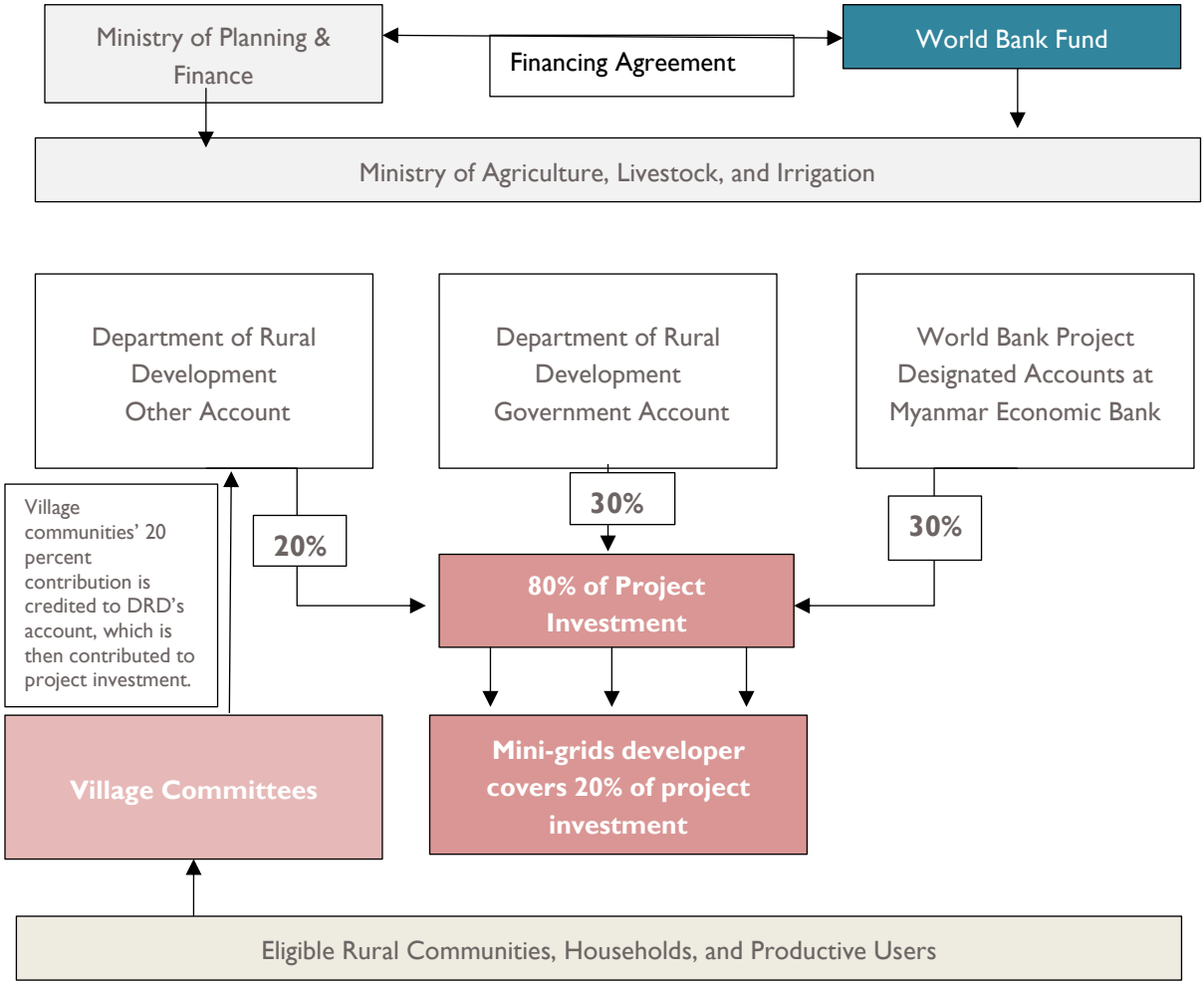
In addition, there is currently no clear regulatory framework on the status of mini-grids after national grid arrival. Without a comprehensive regulatory framework detailing the transition schemes for mini-grids after the grid arrival, there are increased investment risks for developers of mini-grids near the national grid. As a result, most private mini-grid developers target remote sites under Phase 4 and Phase 5 of the NEP, which includes villages with a low probability of grid arrival. Under the current regulatory framework, government subsidies will cover the installation of approximately 590 mini-grids by 2030, which covers only 2.3 percent of the off-grid population.

The DRD-backed mini-grid subsidy scheme shown in Figure 6 has been the main factor driving the growth of solar mini-grids in Myanmar. The primary targets for subsidies are mini-grid projects in areas where on-grid electricity is unable to arrive in the next ten years and eligible projects have a less than 1MW capacity. The current system involves three flows of funding complementing investment from private developers. Village communities raise funds to pay part of mini-grid investment, typically around 20 percent of the total investment costs. The funds are channeled through a dedicated account managed by the DRD. DRD funds subsidies from a loan obtained by the World Bank contributing to 30 percent of project investment. DRD also funds subsidies from its own budget contributing typically 30 percent of the total project investment matching the World Bank loan. Therefore, under the current subsidy scheme, mini-grid developers contribute the remaining 20 percent of investment.

Although most of the mini-grid developers under the subsidy scheme are residential, there are also some commercially focused mini-grid developers, where the private developer supplies most of the electricity generated to commercial facilities such as industrial sites or telecom towers, often called an "anchor customer." In this model, the private developer and the telecom tower company agree on a fixed price per kWh, which is negotiated prior to project development and periodically reviewed. This model has potential for nationwide scale, as 80 percent of the approximately 15,000 telecom towers are owned by six companies, which facilitates multi-site agreements and roll-out of standardized power systems. Private developers such as Yoma Micro Power, SolaRiseSys, and Voltalia are among leading players utilizing this model.[49]

[49] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf

FIGURE 6. MINI-GRID SUBSIDY SCHEME



Source: Smart Power Myanmar

There are two metrics defining the viability of mini-grids: cost-competitiveness and financial viability. For cost-competitiveness, the Levelized Cost of Electricity (LCOE) reflects the sum of the capital costs for developing mini-grids and the operational costs to run the mini-grid divided by the expected electricity supplied over the mini-grid's lifetime. It represents average cost per unit of electricity supplied by the mini-grid. The lower the LCOE, the more cost-competitive the mini-grid becomes. To assess financial viability, an Internal Rate of Return (IRR) metric is used to quantify the annualized return on investments. A mini-grid project is viable if it has an IRR that is higher than or equal to the cost of capital in building the mini-grid.

If subsidies or community contributions were removed, LCOE in 2020 varies from approximately 1,950 MMK/kWh (for villages located in the non-dry zone with small population cluster, residential-only loads) to 598 MMK/kWh (for villages located in the dry zone with small population cluster and includes different types of loads). IRR can reach up to 11.1 percent. Therefore, assuming no economies of scale,

no subsidies, and no community financing, an LCOE threshold of maximum 481 MMK and an IRR threshold of minimum 20 percent, none of the mini-grid configurations would be viable.[50]

Table 1 summaries potential market projections for mini-grids under two different scenarios: continuation of the current "business as usual" scenario and a development scenario with additional subsidies, demand-side measures, and access to finance.

TABLE 1. MINI-GRIDS UNDER DIFFERENT SCENARIOS

SCENARIO	POTENTIAL MARKET METRIC	POTENTIAL MARKET PROJECTION		
		2020	2025	2030
Business as usual scenario: Subsidy budget unchanged at USD 18.6 million; No regulatory reforms to de-risk grid arrival	Number of viable mini-grids	229	229	584
	Population covered	108,000	108,000	570,000
	% of off-grid population covered	0.4%	0.4%	2.5%
	Investment required to roll out all viable mini-grids	USD 31 m	USD 31 m	USD 202 m
Scenario with additional measures: Demand-side measures; Access to finance; De-risking of grid arrival; Subsidy budget at USD 100 million; Economies of scale	Number of viable mini-grids	2,253	8,051	16,444
	Population covered	1,954,000	5,894,000	10,229,000
	% of off-grid population covered	6.4%	21.9%	45.2%
	Investment required to roll out all viable mini-grids	USD 537 m	USD 1,844 m	USD 3,356 m

Source: Smart Power Myanmar

Under the current model, private developers supply electricity mainly to villages and townships with pay-as-you-go tariffs under prepaid schemes. Private mini-grid developers charge tariffs ranging from 350 to 700 MMK/kWh.[51] This model is less scalable than the commercial-focused model, as project development relies on subsidies as well as negotiations and site-specific engineering on a village-by-village basis. However, private developers believe that if current subsidies should decrease, there would be more financial burden for them since their investment capital to develop a mini-grid project would increase significantly and there are few alternative financing options available. There are many existing developers adopting a subsidies-driven model, ranging from large firms like Mandalay Yoma to small and medium-sized developers such as Techno-Hill Engineering Co., Ltd. and Myanmar Solar Power Co., Ltd.

Under a scenario where additional development measures are applied to support the growth of mini-grids, such as de-risking of grid arrival via government regulations, development of financing options, and increased private investment in businesses to increase productive loads, the development of mini-grids could result in an increase of GDP by up to USD 539 million and creation of more than 32,000 direct

[50] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf
[51] Asia Solar Co., Ltd. Interview

jobs and 118,000 indirect jobs in 2025,[52] in addition to providing power to millions of households across the country.

ROOFTOP PV SYSTEMS

Rooftop PV system development is in a nascent stage in Myanmar, but the market is developing despite a lack of clear government policy. Major players include Mandalay Yoma, Indigo Energy, Yoma Micro Power, and Myanmar Eco Solutions, which build, own, operate, and maintain grid-connected rooftop solar systems. Increasing opportunities in the rooftop PV system segment are fueled by the increase in the on-grid tariff rates, which are influencing commercial and industrial owners to save on electricity costs by installing rooftop solar. Moreover, a recent boom in tourism (pre COVID-19) led to increased number of tourism facilities in off-grid areas, such as eco-lodges, installing rooftop PV systems.

Private organizations such as factories and business-owners, the main buyers of rooftop PV systems, are now becoming more interested in installing solar energy in order to save on costs. COVID-19 could accelerate the demand for rooftop solar as businesses strive to cut down on operational expenses but other effects of COVID-19 such as the economic slowdown and a drop in tourism may have an opposite effect. Business-to-business marketing between rooftop PV developers and commercial and industrial owners is more prevalent, using strategies such as social media marketing, direct selling, and reputation management.

3.1.2. Mini-Hydro Power

Off-grid mini-hydropower projects were first developed in Myanmar in mountainous regions such as Shan State as early as the 1970s.[53] Individual household-led mini-hydros, village-led mini-hydros, and government-led mini-hydros are three main development models. End markets for mini-hydro power mainly consist of rural households and businesses.

Household mini-hydros are small-scale and mostly limited to individual household usage, with extra power being sold to neighbors. These systems mainly use low head propeller turbines to generate capacities between 100W and 1KW. Due to their low power capacity, the main usage is for lighting. System generators are mostly being imported from China, while mechanical components are fabricated locally. There are domestic manufacturers of mini-hydro components who fabricate mechanical components such as turbines, penstock pipes, and transformers. Local technicians (developers) often act as intermediaries between manufacturers and users in developing mini-hydro projects.

Private-led mini-hydros, community-led mini-hydros, and DRD-led mini-hydros have capacities ranging between 5KW to 100KW. Private-led mini-hydro plants have been implemented by developers including equipment manufacturers. They are able to generate capacity not only for lighting, but also for electrical appliances such as TVs and small-scale machinery. There are both appliance-based tariff rates and energy meter systems. Developers are responsible for transactions, operations, and maintenance of village Hydro Power Plants (HPPs). Under community-led mini-hydros, the role of developers is to act as intermediaries connecting villages with equipment suppliers. Households are responsible for both management and the capital costs. Developers' main involvement is during the initial stage when they

[52] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf

[53] Kyaw Soe Win Hydropower Co., Ltd. Interview

provide financial and technical advice to the Village Electrification Committees (VECs). VECs collect money from villages based on the developers' estimate of the project cost.

Unlike solar mini-grids that are mainly initiated by developers with DRD financing, most of the mini-hydro projects are initiated by the villages. Thus, there is willingness to pay for electrification. Financial feasibility of such projects is primarily determined by the business opportunities to use the generated electricity, and the usage of mini-hydro power differs by region and can be commissioned for both residential and commercial use. In southern Shan State, for example, mini-hydro is being used to power small-scale tea leaf processing factories and commercial loads. In Pyin Oo Lwin Township of Mandalay Region, mini-hydro is used to power agricultural enterprises such as poultry farms, as well as small-scale industrial workshops. Mini-hydro tariff rates are lower than grid tariff rates, so in off-grid areas, mini-hydro developers such as Sai Htun Hla & Brothers Co., Ltd. are not only designing and installing mini-hydro plants under private-led model, but also diversifying their investments into local SMEs since having access to electrification improves productivity and profitability significantly.[54] Meanwhile, developers like Kyaw Soe Win Hydro Power Co., Ltd. do not focus on community-led mini-hydro, as most of their mini-hydro plants are located in regions with low productive loads and villages mostly use electricity for residential use.[55]

With funding from international development organizations such as UNDP, DRD selected developers to develop mini-hydros through an open tender process. Skilled labor, machinery, and equipment were supplied by the contractor, and after commissioning, the operation and maintenance of the mini-hydro plants was the responsibility of VECs. DRD has no monitoring system after commissioning the project. Under MOEE-developed mini-hydros, there was no community involvement. Most of these projects are located in Chin State and were implemented in the 1980s with turbine upgrades during the 2010s. The national grid energy rate is applied, and they are used mainly for lighting and electrical appliances.[56]

Local topography and hydrological conditions are crucial in determining the actual viability of mini-hydro projects. Areas with low topographical gradients require large civil works to achieve suitable level of heads to drive a hydro-powered system, increasing investment costs. Locations with irregular seasonal water flows are also not suitable. An estimated 1,100 hydro-powered mini-grid sites have been identified (which do not overlap with mini-grids that could be powered by other renewable energy sources) corresponding to 3 percent of off-grid villages or 290,000 rural households. These potential sites are concentrated in non-urban areas such as Chin and Kachin States and Sagaing Region. The corresponding mini-grid capacity would be 54MW. Therefore, hydro-powered mini-grids also play a crucial role in providing electrification to specific regions where other renewable energy sources such as available solar irradiance is not sufficient.[57]

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[54] Sai Htun Hla & Brothers Co., Ltd.

[55] Kyaw Soe Win Hydro Power Co., Ltd.

[56] Kumara, P G Ajith. 2015. Report of Off-grid Hydro Power Assessment of Myanmar. https://energypedia.info/images/3/3e/REVIEW_REPORT_OF_OFF-GRID_HYDRO_POWER_Jan_23_2015.pdf

[57] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf

3.1.3. Biomass Power

Rice husk gasifiers have been an important energy source for rural off-grid communities, with estimates showing as many as 15,000 rice mills and hullers and more than 500 biomass power units in Myanmar using them. However, the majority of these are small-scale systems that do not have the capacity for electrifying households. Moreover, they are mainly burning rice husks directly, and they require reliable feedstock and advanced technologies to generate consistent and clean energy. Only 18 percent of the population has access clean and modern bioenergy. Eighty to 90 percent of these biomass power plants were developed by local self-financed entrepreneurs, as co-operatives and village committees are promoting husk-to-energy usage. Biomass power is suitable for mini-grids if there is a sufficient and constant supply of biomass feedstock such as nearby rice mills. Residues from harvesting are less suitable because they need to be collected from wide geographic areas, which is time-consuming and has higher costs.[58] Growth opportunities for rice husk-based biomass power plants are mainly present in the major rice-producing regions of Myanmar such as Yangon, Bago, and Ayeyarwady. Major rice milling enterprises such as KZL Co., Ltd. are also looking for potential investment partners to establish rice-husk biomass power plants.

3.2. High Growth Potential Market Opportunities

The SHS and appliance market represents a high growth potential due to low electrification in rural areas. A large part of these underserved households is in remote areas where density is too low for viable mini-grids or are in areas closer to the grid than the villages targeted by solar mini-grid companies. The sustainable private market for SHS is nascent in Myanmar and represents a large opportunity for growth.

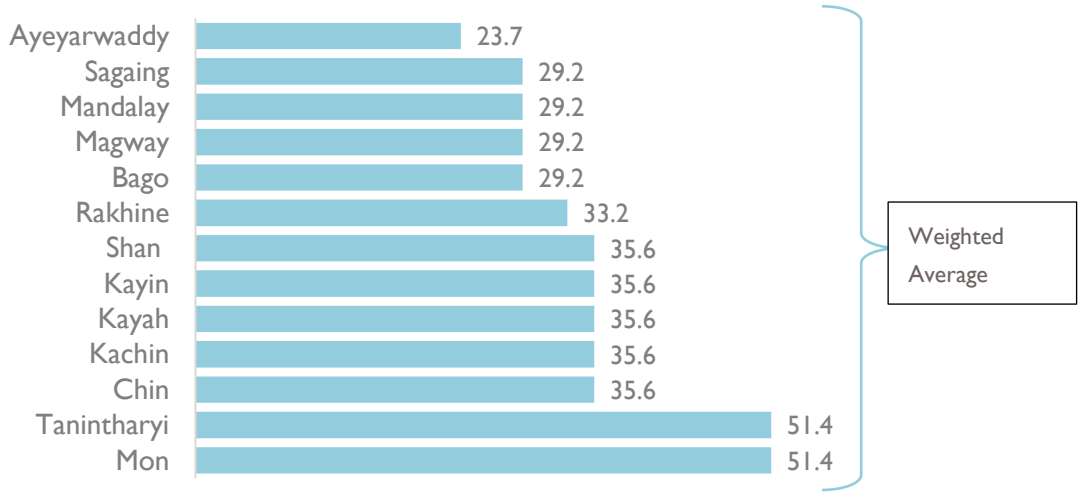
Significantly more effort has already been made in the mini-grid space by organizations such as Smart Power Myanmar. The solar mini-grid sub-sector presents a high growth potential market opportunity due to its higher power generating capacity and being better suited for last-mile energy connectivity and productive electricity loads. Increasing electricity demand from off-grid regions is the main driver for growth of mini-grids. The main determinant in the financial viability of mini-grids in terms of costs, investments, and revenues is the demand of load size, density, and type of loads (residential, productive, commercial, or public buildings). Of all electricity generated from mini-grids, currently an estimated 49 to 66 percent is being used for productive loads, while the remainder is used for residential and commercial loads. Productive demand is crucial for mini-grid viability as the level of demand per connection—the demand density—is much higher than from residential demand.

Mini-grids with high demand density are more viable than mini-grids where demand is scattered because they require less distribution infrastructure per unit, thus reducing costs. According to a review of energy consumption in Myanmar conducted by the Asian Development Bank in 2017, Mon State and Tanintharyi Region have the highest yearly off-grid electricity demand per capita at 51.4 kWh, giving

[58] Asian Development Bank. 2017. Developing Renewable Energy Mini grids in Myanmar (A Guidebook). Metro Manila: Asian Development Bank. https://www.adb.org/sites/default/files/institutional-document/391606/developing-renewable-mini-grids-myanmar-guidebook.pdf; Tun, M.M. and Juchelková, D. Biomass Sources and Energy Potential for Energy Sector in Myanmar: An Outlook. https://doi.org/10.3390/resources8020102; Vaghela, Dipti. 2018. Financing Economically Viable Decentralized Renewable Energy: Biomass Gasifiers and Micro/mini Hydropower in Myanmar. https://energypedia.info/images/9/9b/Financing_Viable_Mini_Grids_Dipti_Vaghela.pdf

these regions' high growth market potential for mini-grid developers.[59] Figure 7 shows different states and regions with average yearly electricity demand per capita at 510 MMK/kWh.

FIGURE 7. AVERAGE YEARLY OFF-GRID ELECTRICITY DEMAND PER CAPITA IN MYANMAR[60]



Source: Smart Power Myanmar

[59] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf

[60] For 510 MMK/KWH electricity tariff

4. STRUCTURE OF THE SECTOR AND KEY SUB-SECTORS

4.1. Key Value Chain Actors

Key value chain actors within the solar power, mini-hydro, and biomass sub-sectors include importers, distributors, and developers.

Solar products importers and distributors: Two main distribution channels are prevalent across the solar products value chain: 1) affiliate companies working together with IFC and DRD to market and distribute quality-verified solar products to off-grid households; and 2) non-affiliate companies, which are importing and distributing non-quality-verified products mainly from China and selling them through in-house sales and distribution teams or regionally appointed retailers across Myanmar.

Solar mini-grids developers: Mini-grids have all the key components of the electricity supply chain, from power generation and distribution to sales and billing. Mini-grid developers in Myanmar implement turn-key solutions from importing equipment from original equipment manufacturers to designing, engineering, and construction of the mini-grids including integration and optimization of components. Ninety percent of equipment and components in solar mini-grids are imported. In addition, they operate and are responsible for maintenance of the power generation, distribution, metering, and billing infrastructure. Finally, they manage all key business processes related to sales and billing.

Rooftop PV systems developers: Rooftop PV system developers build, own, operate, and maintain grid-connected rooftop solar systems for commercial buildings as well as diesel abatement solutions for off-grid areas and islands. Either the factory pays for the project up-front, or the developer invests, builds, and sells electricity on a monthly basis to clients. A rooftop PV system has the same value chain as a mini-grid with only the off-takers being different.

Mini-hydro developers: Depending on the HPP model, the mini-hydro value chain is different. Unlike solar-power off-grid systems, there are local equipment manufacturers of mini-hydro components such as turbines and penstock pipes. Mini-hydro developers are also importing some components such as generators from China. For community-backed HPP, mini-hydro developers' role in the value-chain is complete after installing and commissioning of the HPP. For HPP developed with developer and community financing, mini-hydro developers collect monthly electricity tariffs and are responsible for the operation and maintenance of the HPP.

Biomass developers: Biomass developers develop biomass power plants for large-scale rice mills. Major biomass developers either operate as engineering, procurement, and construction firms on behalf of their clients or invest as a joint-venture business with local partners to implement biomass power plants adjacent to rice mills.

Table 2 provides examples of significant players in sub-sector but is not a comprehensive list of all or the largest players.

TABLE 2. KEY VALUE CHAIN ACTORS

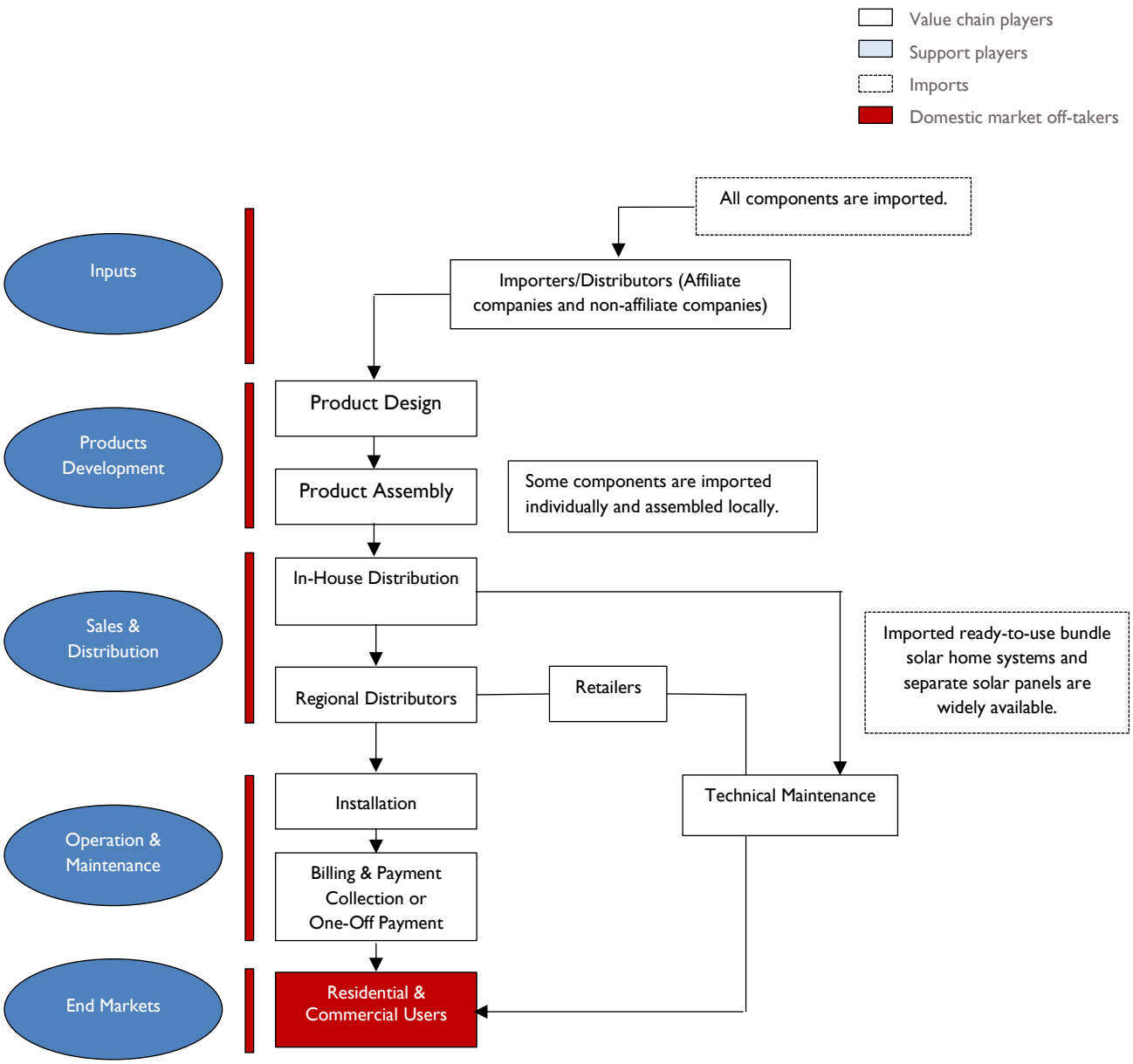
TYPE OF PLAYERS	ESTIMATED NUMBER OF PLAYERS	KEY PLAYERS
Solar Products (Importers & Distributors)	Approx. 10	SolarHome oV Solar Myanmar Co., Ltd. AETHER Solar Engineering Pyae Phyo Aung Co., Ltd. GreenLight Planet
Solar Mini-Grids (Developers) Grow-out Farms	25-30	SolaRiseSys Yoma Micro Power Mandalay Yoma Parami Energy Techno-Hill Engineering
Rooftop Solar PV System (Developers)	Approx. 10	Yoma Micro Power Mandalay Yoma Indigo Energy SolaRiseSys Earth Renewable Energy
Mini-Hydro (Developers)	5-10	Sai Htun Hla & Brothers Kyaw Soe Win Hydropower
Biomass (Developers)	< 5 local and international developers	Myaung Mya FM Biomass Power

4.2. Value Chain Maps

4.2.1. Solar Products Value Chain

In the inputs stage, all solar product components are imported as ready-to-use bundles or as separate components that are then assembled locally. Some of the non-affiliate importers have appointed regional distributors and retailers, others also do marketing and distribution in-house by directly selling to end markets. Residential households are the main end market for solar products, although solar pumps and lanterns are also used by agricultural and rural SMEs.

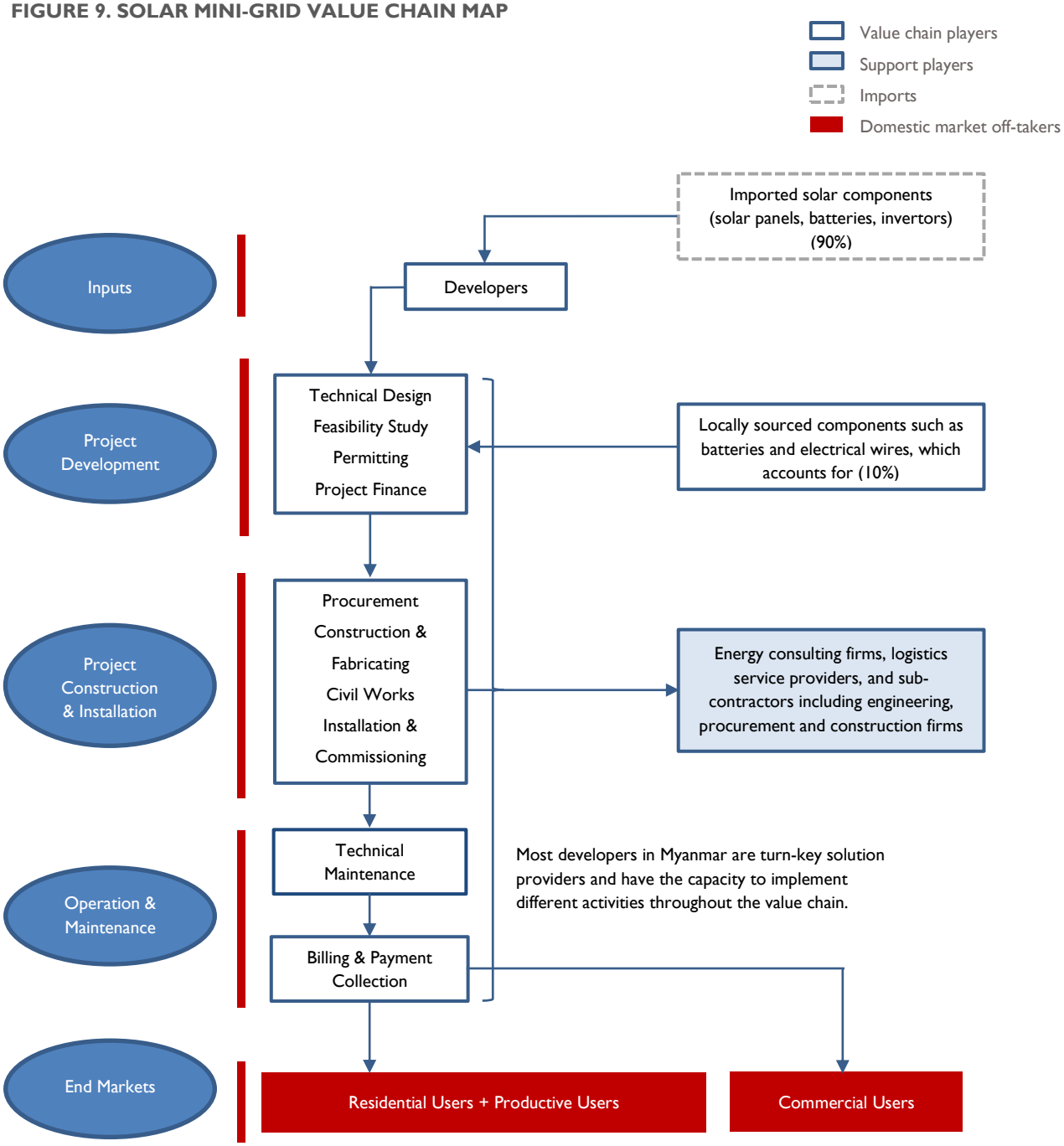
FIGURE 8. SOLAR PRODUCTS VALUE CHAIN MAP



4.2.2. Solar Mini-Grid Value Chain

The majority of solar components used in mini-grids are imported, although some mini-grid developers use locally sourced components such as batteries. Major mini-grid developers are turn-key solution providers and are able to implement project development as well as operation and maintenance, while SME mini-grid developers often out-source part of their activities to third parties such as energy consulting firms, logistics service providers, and sub-contractors including engineering, procurement, and construction (EPC) firms. End markets include households and businesses, including rural SMEs, factories, and telecom towers.

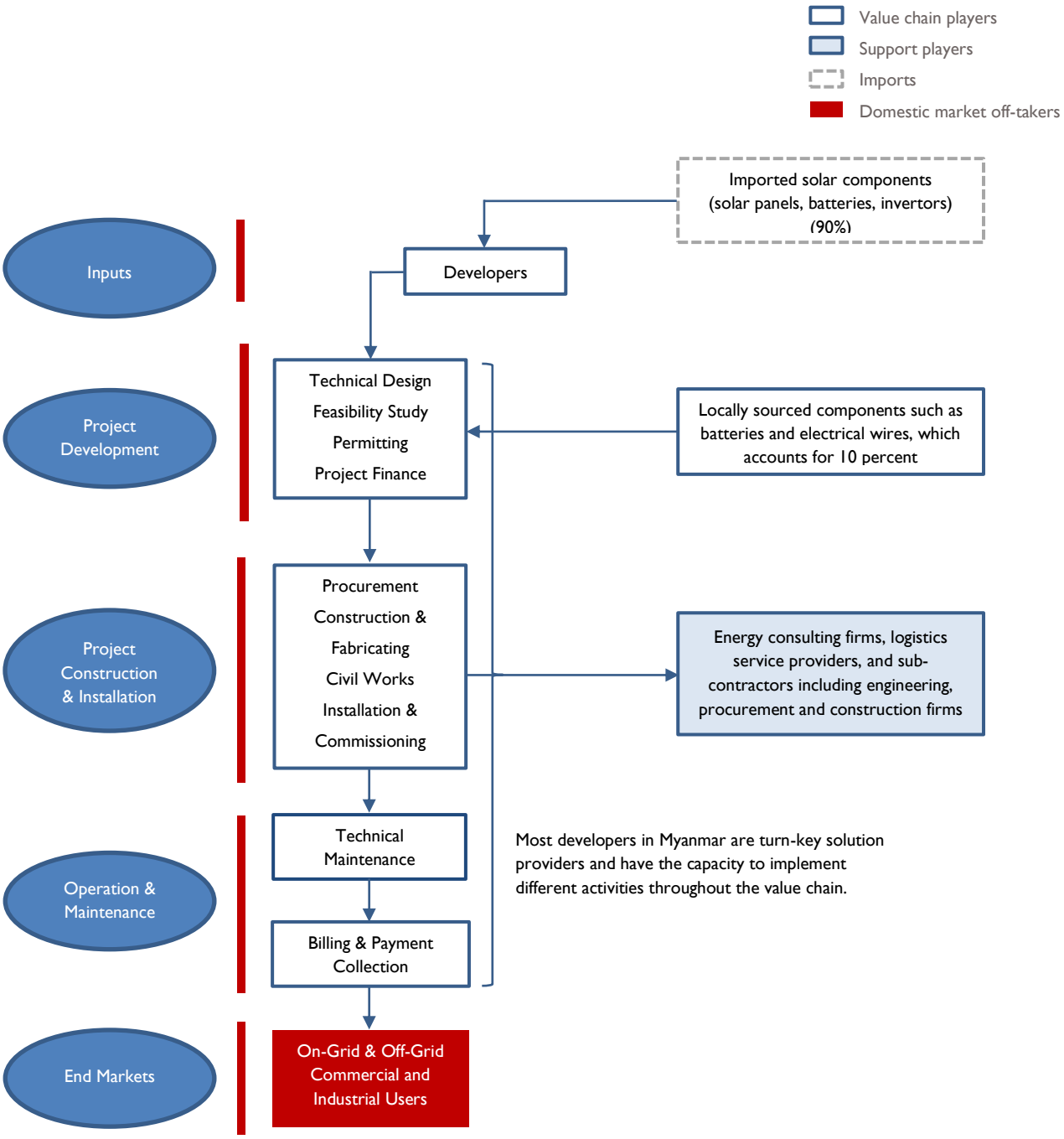
FIGURE 9. SOLAR MINI-GRID VALUE CHAIN MAP



4.2.3. Rooftop PV Solar System Value Chain

The majority of solar components used in rooftop solar systems are imported. Many developers are turn-key solution providers and are able to implement project development to operation and maintenance, while SME developers often outsource part of their activities to third parties such as energy consulting firms, logistics service providers, and sub-contractors such as EPC firms. End markets mainly include businesses like SMEs, industrial users like factories, and tourism establishments such as eco-lodges, which can be either grid-connected or completely off-grid.

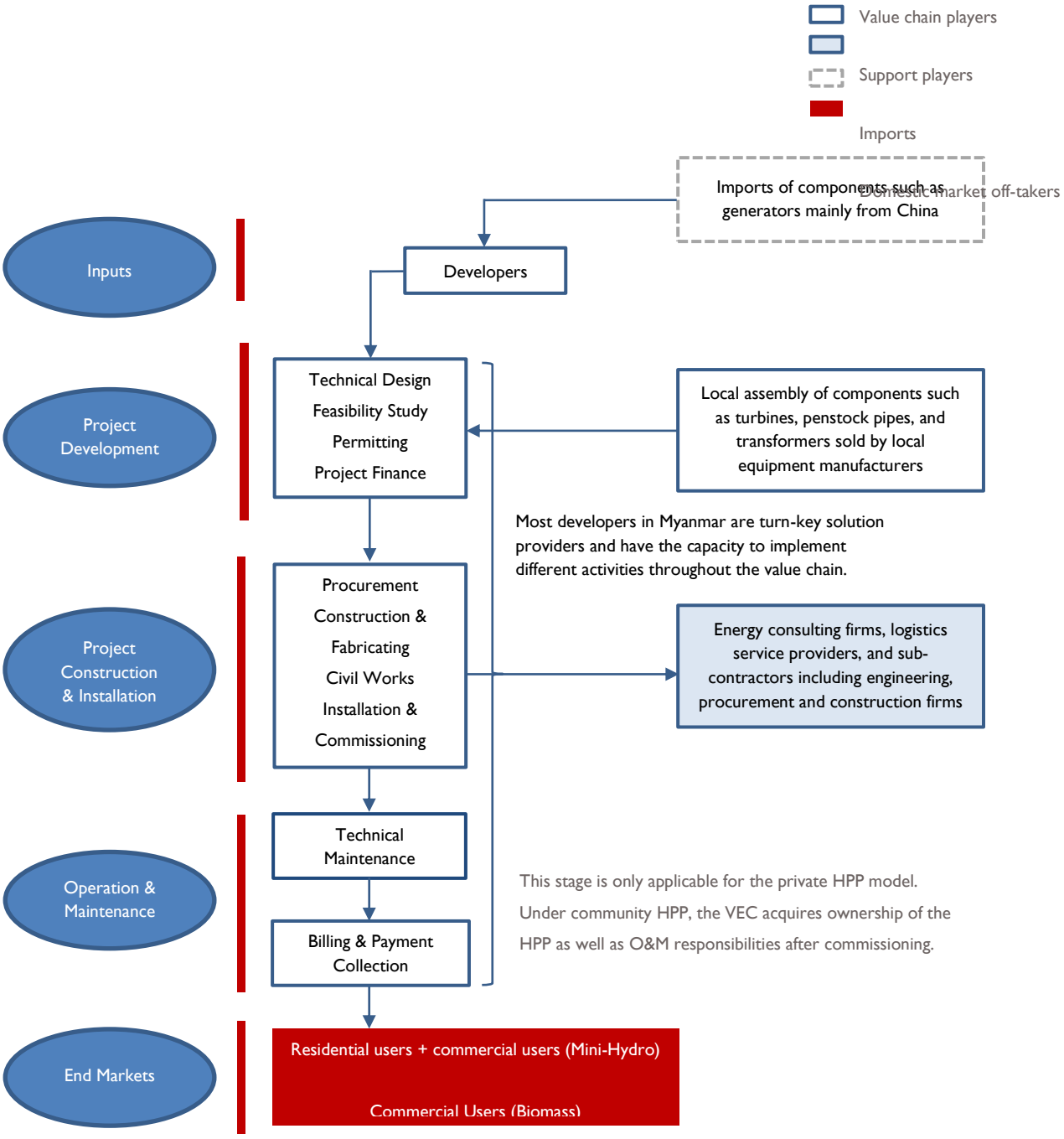
FIGURE 10. ROOFTOP PV VALUE CHAIN MAP



4.2.4. Mini-Hydro and Biomass Value Chain

Many mini-hydro and biomass developers are turn-key solution providers and are able to implement project development as well as operation and maintenance. There is even local assembly of components used in mini-hydro and biomass power plants, although their technology may not be comparable with international standards. Biomass value chains are the least-developed and similar to the mini-hydro value chain. End markets include households and businesses (for mini-hydro) and rice mills (for biomass).

FIGURE 11. MINI-HYDRO AND BIOMASS VALUE CHAIN MAP



4.3. Key Eco-System Actors

TABLE 3. KEY ECO-SYSTEM ACTORS

CATEGORY	ECOSYSTEM ACTORS
Government	**State/Regional Governments**: Permitting and regulation of small and medium electrical businesses (less than 30 MW) not connected to the national grid are under the authority of the respective state and regional governments where projects are located.[61] **Department of Rural Development:** For off-grid electrification, DRD under the Ministry of Agriculture, Livestock, and Irrigation is the leading government entity to implement off-grid solar (both SHS and solar mini-grids), mini-hydropower and biogas projects.[62] DRD's role in the NEP is to electrify off-grid areas that are designated as Phase 4 and Phase 5, which are usually at least 10 miles from 11 kV sub-stations of the national grid. The exception is in mountainous areas, where villages less than 10 miles from the national grid may be designated as Phase 5.[63] The department cooperates with development partners such as the World Bank, IFC, and GIZ in implementing off-grid electrification programs.
Associations	**Renewable Energy Association Myanmar (REAM):** Established in 1999 by local private renewable energy developers, REAM works with local stakeholders including industry experts, SMEs, and other non-governmental organizations (NGOs) and international NGOs (INGOs) to increase the awareness and support the living standard of rural and urban populations by promoting renewable energy. REAM's three main objectives are to alleviate the energy problem by using Renewable Energy Technology (RET); protect the environment and save natural resources; and develop grassroots communities. Information, education, and communication are the three main services provided by REAM: the collection and dissemination of information on RET and its related affairs; educating the community on RET development and related environmental conservation affairs; and providing communication services between RET system providers and users who want to establish particular projects or RET applications and development activities. The association also lobbies government on renewable energy adoption.[64] **Myanmar Hydropower Developers' Association (MHDA)**: Established in 2016 with initial support from IFC and the Australian Government, MHDA is an independent, Myanmar-registered association offering private sector perspective on hydropower policies and the sector's evolving legal and regulatory frameworks and development. It has four focus areas: the development of model transactional documents; project procurement; environmental and social matters; and mini-hydropower. Members benefit from tailored seminars on topics such as social risk management, stakeholder engagement, and grievance mechanisms.
Business service providers	**Energy consulting firms**: Energy consulting firms provide wide-ranging consultancy services including due diligence studies (financial, contractual, technical), contractual reviews, energy yield analysis and irradiation studies, energy feasibility studies, system design, O&M planning, training and project development, and management assistance of mini-grids and rooftop solar PV systems for clients including individuals, businesses, and organizations such as INGOs and development agencies. Major developers such as Mandalay Yoma provide consulting services as part of their offerings, while companies such as Sunlabob Energy Myanmar Ltd. focus on energy consulting as their main business **Logistics services providers**: While large players such as Earth Renewable Energy, Parami Renewable Energy and Yoma Micro Power etc. are subsidiaries of conglomerates and have in-house logistics, SME developers often need to outsource logistics to third party logistics service providers to transport solar panels and equipment. They also include regional transport providers, which may or may not be large enough to have transportation modes consisting of trucks, motorcycles, and even boats for mini-grids located on islands on Tanintharyi Region. **Construction firms:** Civil construction works and electrical installation of solar mini-grids and SHS are often outsourced to local construction companies and EPC companies.
Training providers	**Technical and Vocation Training (TVET):** The Ministry of Education provides courses on installing solar at households through its "Solar Applications Training" program in Mandalay and Sagaing Regions.

[61] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf

[62] Department of Rural Development. http://drdmyanmar.org/index.php?page=bmV3ZGV0YWIsJmlkPTE5Mg

[63] Du Pont, Dr. Peter. 2019. Decentralizing Power: The Role of State and Region Governments in Myanmar's Energy Sector. The Asia Foundation. https://asiafoundation.org/wp-content/uploads/2019/04/Myanmar_Decentralizing-Power_report.pdf

[64] UCRSEA. 2017. Renewable Energy Association Myanmar. http://ucrsea.ca/our_partners/renewable-energy-association-myanmar/

CATEGORY	ECOSYSTEM ACTORS
Financial service providers	**Green Financing:** Through programs targeting energy efficiency for SMEs such as Thabarwa Project model by WWF and Germany-based Savings Banks for International Cooperation (SBIC). Local partners include A Bank, CB, MAB, and MCB banks.
NGOs, INGOs, development partners	**The World Bank:** The World Bank has approved $400 million for Myanmar's NEP, $310 million of which will go to the expansion of the national grid, with the remaining $90 million to be spent for the DRD's off-grid projects. The project also assures funding and technical assistance from other development partners including the Asian Development Bank, the German International Cooperation Agency, and Japan International Cooperation System.[65] With the IDA funds, 750,000 households will be connected to the grid by 2021, and off-grid electricity will be extended to another 500,000 households.[66] **International Finance Corporation (IFC):** Launched in 2016, the IFC-led Lighting Myanmar project will help international and Myanmar-based companies create a commercial and sustainable market for high-quality off-grid energy solutions, including solar lanterns, solar home systems, and mini-grids. The focus of this work will be in central Myanmar; although solar is already widespread in this area, most systems are low quality and unreliable, providing an opportunity for quality-assured solar lighting products to enter the market and compete.[67] **GIZ Myanmar:** Germany-based GIZ has been supporting Myanmar rural electrification projects, including the technical support and drafting of rules and regulations for mini-grids and the process of evaluating tender applications and capacity-building trainings for DRD staff.[68] **WWF Myanmar:** WWF Myanmar's Tha Bar Wa is a four-year project funded by the EU under the SWITCH-Asia Programme, promoting cleaner production in Myanmar's growing food and beverages sector, especially SMEs. Tha Bar Wa Project partner, Saving Banks Foundation for International Cooperation (SBFIC) from Germany, supported national partner banks (i.e., A Bank and Myanmar Citizens Bank) to sign MOUs with seven solar, gasifier, and wastewater companies in order to provide efficient support and services to SMEs for cleaner production practices. SBFIC is working with two additional banks (CB and Myanma Apex Bank) in signing similar MOUs with cleaner production technology suppliers.[69] Additionally, WWF is also implementing a program called "Women in Power" which is training rural woman to become employed directly in the mini-grid sector as technicians.

[65] Consult-Myanmar. 2018. "Myanmar Boosts Electricity Access Through Off-Grid Solutions." https://consult-myanmar.com/2018/01/09/myanmar-boosts-electricity-access-through-off-grid-solutions/

[66] The World Bank. 2015. "Electricity to Transform Rural Myanmar." https://www.worldbank.org/en/news/feature/2015/09/16/electricity-to-transform-rural-myanmar

[67] International Finance Corporation. Lighting Asia (Catalyzing markets for modern off-grid energy Myanmar). https://www.ifc.org/wps/wcm/connect/528901bf-88d3-40fc-be69-f6a289058c79/Lighting+Myanmar.pdf?MOD=AJPERES&CVID=IPONXQV

[68] Department of Rural Development. 2015. "National Electrification Project (off-grid) Background." https://www.drdnepmyanmar.org/page/nep-background

[69] WWF. 2019. "Cleaner production: a sustainable future for industry." https://www.wwf.org.mm/en/thabarwa/

5. CONSTRAINTS TO GROWTH AND INVESTMENT

5.1. Access to Production Technologies and Skills

5.1.1. High Capital Expenditures and Low Economies of Scale in Solar Power

The operating environment for developers in Myanmar is more challenging compared to in other countries, which results in higher operating costs. Capital expenditures such as key equipment for power generation, energy storage (batteries), and inverters are among the major components that affect LCOE and IRR and, therefore, the viability of mini-grid projects. There is a lack of a local parts manufacturing industry in Myanmar, and hardware costs are relatively higher than in other developing countries, which negatively affects the viability of mini-grids. Only LED batteries are manufactured in country, but they are of low quality and used for SHS. There is no local production of batteries or invertors for mini-grids. Most of the components used in solar mini-grids are imported, including solar panels, inverters, and batteries.[70] Developers face challenges importing solar components at cost-effective prices. Solar panels and accessories imported by brokers from China are often of questionable quality, and developers need to purchase such inputs directly from manufacturers to avoid factory rejects and low-quality equipment.[71]

Economies of scale can only be achieved if large private developers with a significant market share develop multiple projects in parallel using standardized mini-grid system designs.[72] The mini-grid LCOE can be reduced by 20 percent by leveraging continuous decline in hardware costs, bulk purchasing and streamlined procurement, and standardized design for large-scale deployment. Furthermore, simplified construction methods along with standardized mini-grid systems can lower engineering time by a third and installation time by 80 percent, and ultimately reduce LCOE by a further 20 percent.[73]

5.1.2. Project Development Challenges for Mini-Hydro Power

Hydropower plants are very site-specific and often located in remote areas. It is not uncommon for project costs to increase significantly during construction because of unanticipated factors in the terrain or delays caused by severe weather conditions.[74] The design of a hydropower plant requires a considerable amount of specialist know-how since it uses unique design and construction techniques. These techniques differ from those used in large-scale plants and are not always available to local communities. In addition, at present off-grid hydro power schemes are operated under minimum monitoring, quality control, and supervision by government authorities. As a result, many mini-hydro plants have very high operation and maintenance costs and suffer from poor performance and quality of electricity provided to end users.[75]

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[70] Smart Power Myanmar Interview
[71] Sunlabob Renewable Energy Myanmar Co., Ltd. Interview
[72] Smart Power Myanmar Interview
[73] Power For All. 2019. "Fact Sheet." https://www.powerforall.org/application/files/4415/6700/7650/FS__Mini-grids_costs_can_be_reduced_by_60_by_2030.pdf
[74] Kyaw Soe Win Hydropower Co., Ltd. Interview
[75] Kumara, P G Ajith. 2015. Report of Off-grid Hydro Power Assessment of Myanmar. https://energypedia.info/images/3/3e/REVIEW_REPORT_OF_OFF-GRID_HYDRO_POWER_Jan_23_2015.pdf

5.1.3. Project Development Challenges for Biomass Power

Feedstock sourcing is one of the key challenges for biomass power project implementation. Annual yields of biomass feedstock fluctuate, and it is also costly and time-consuming to collect, transport, and store. Therefore, biomass to energy generation is more suitable for regions with close proximity to high production of feedstock, such as Ayeyarwady and Sagaing Regions with high rice production and Shan State with high maize production, which results in reliable access to rice husks and corn cobs, respectively. Regions without a substantial feedstock supply face increased limitations for the use of biomass power technology.

In addition, there is a lack of local standards for biomass systems, technology, and equipment. Insufficient or inaccurate data and information on biomass energy utilization at the community level makes it challenging for energy planners and project developers to estimate the financial viability of biomass power plants in Myanmar. Although system design for biomass mini-grids is more standardized compared to mini-hydro, project development involves multi-year on-site collection of data on biomass feedstock availability to understand seasonality and build procurement plans. This process can be lengthy and costly and limits the ability of local communities to implement these projects without outside assistance.

5.2. Access to Finance and Investment

5.2.1. Lack of Financing Options for Solar Power Projects

The companies selling Lighting Global solar products are able to sell to low-income consumers by offering installment plans, also called pay-as-you-go or lease-to-own financing. This requires the company itself to finance the product up-front and then collect monthly installments from the customers over a time-frame of typically 18-24 months. The company usually even pays for the product at the time of production, which due to import and distribution logistics may be months before the product reaches the consumer. This requires significant working capital to finance the asset and implying that solving the consumer access to finance challenge leads to an increased amount of financing needed for the companies instead. Lack of debt funding is a central constraint limiting sub-sector growth.

There is currently no established practice of project financing in Myanmar. Most project finance is provided by international development banks and institutions. The local banking sector has very limited capital to provide financial services required to support project financing in the country.[76] Local banks are either unwilling to lend to developers due to lack of a Central Bank policy that guides and harmonizes financing instruments for off-grid projects or they have high interest rates that are often not affordable for developers. DRD implements mini-grid projects using funding from international financial institutions and development organizations but this is not sustainable in the long term. As existing subsidy funds for mini-grid development are running out, a slow-down is expected in the mini-grid segment over the next 12 months.

[76] Lee, Alden; Aleksanova, Anna. 2019. Myanmar: Solar Investment Opportunities (Emerging Markets Task Force Report). Solar Power Europe. https://www.solarpowereurope.org/wp-content/uploads/2019/09/20190507_SolarPower-Europe_Myanmar-Solar-Investment-Opportunities.pdf

"Private banks have high interest rates and borrowing from them for project financing is not attractive at all. Meanwhile, grid tariff rates are low compared to international rates and operation costs are higher meaning it would take four to six years for solar developers to break even, which impacts the cash flow."

- Operations Consultant, Sunlabob Renewable Energy Myanmar Co., Ltd.

Many existing developers start to experience substantial capital restrictions after developing three or four mini-grids.[77] There is limited availability of financing instruments for further project developments, and existing developers who plan to develop more mini-grids are unable to acquire sufficient bank loans for expansion due to high interest rates and requirements of collateral.[78]

In addition, due to a lack of aggregated energy consumption data, stated electricity demand during feasibility studies does not always match the actual demand after commissioning of mini-grids. This often leads to over- or under-power utilization of households and businesses and makes it challenging for mini-grid developers to accurately forecast revenues for new mini-grids and access their viability and profitability.[79]

Related to rooftop PV systems, C&I customers are often hesitant to adopt the new technologies due to high up-front costs and limited financing options.

5.2.2. Limited Financing Instruments for Mini-Hydro Power Projects

Project financing is also required for developing mini-hydro plants. Local financial providers have limited experience in conducting technical and profitability analyses of hydro mini-grids loan proposals and a lack capacity to determine whether these proposals are financially viable. Available project financing comes with high interest rates and short repayment periods, which makes it difficult for developers to access financing for new project development.

5.2.3. Low Viability of Large-Scale Biomass Power Plants

Large-scale biomass power plants require substantial capital investment as evident by existing biomass power plants, which struggle to operate efficiently due to high maintenance and repair costs as well as a lack of skilled labor. This results in higher risks and lower investment attractiveness compared to small-scale biomass power plants. Therefore, it is challenging to gain economic benefits from large-scale biomass power plants in Myanmar.[80] In addition, there is a lack of government support programs for sub-sector development and subsidies such as subsidized interest rates and tax concessions for biomass power plant developers, as well as capital subsidies for processing industries, which results in low investments.

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[77] Asia Solar Co., Ltd. Interview
[78] Techno-Hill Engineering Ltd. Interview
[79] Power for All. https://www.powerforall.org/insights/myanmar-mini-grids-near-100-market-growth-cross-roads
[80] Tun, Maw & Juchelková, Dagmar. (2019). Biomass Sources and Energy Potential for Energy Sector in Myanmar: An Outlook. https://doi.org/10.3390/resources8020102

5.3. Access to Markets

5.3.1. Low Affordability of Quality Solar Products

The majority of rural populations cannot afford quality-verified solar products, as more than 24 percent of the population lives below the poverty line. Furthermore, the majority of farmers and SMEs are also unable to afford solar-powered equipment such as solar water pumps and agricultural processing machinery due to high up-front costs and a lack of companies broadly offering hire-purchase installment plans. As a result, productive usage of solar power products remains low.

In addition, awareness of and education about the benefits of switching to solar energy is low. Many potential commercial and industrial users are yet to fully understand the benefits and value of using solar energy.[81]

5.3.2. Shortage of Skilled Labor for Biomass Power Projects

Public demand for modern biomass power remains low, and although the majority of local communities are familiar with consuming biomass power via traditional methods, their interest in and knowledge of modern biomass technologies is limited. A shortage of skilled labor and biomass experts in rural areas has also created significant human capital costs for investors.[82]

5.4. Business Enabling Environment Constraints

5.4.1. Weak Quality Enforcement for Solar Products

There is a weak enforcement of quality standards for solar products to protect against low-quality SHS equipment imports. Prevalence of low-quality products on the market, such as solar panel factory rejects from China, has a negative impact on the consumer perception of solar products, especially SHS. There is no standardization for the importation of SHS and since most customers are cost-sensitive, solar companies offering better quality products are unable to compete with poor-quality products on the market. Consumer Protection Law is still not fully developed, and consumers are unable to claim money back on defective products.[83]

5.4.2. Lack of Legal Framework and Policy on Mini-Grids

The rules for mini-grids, including their legal status and rights, are ambiguous as there are no laws on them specifically. There is a lack of a clear licensing system regulating mini-grids and clear legal treatment of mini-grid transition after national grid arrival. Currently, no transition mechanisms are in place to ensure business continuity after national grid arrival or compensation offered for developers. Therefore, villages located near the national grid are considered non-investible by developers due to higher risks.

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[81] Ibid.
[82] Ibid.
[83] Renewable Energy Association Myanmar. Interview

5.4.3. Lack of Policy for Rooftop PV Solar Systems

The growth of the rooftop PV market in Myanmar is hindered by the a lack of policy and billing mechanisms such as net metering, which credits solar energy system owners for the electricity they add to the national grid, and feed-in tariffs, a proportional payment to the amount of power generated made to households or businesses for generating their own electricity through the use of renewable energy sources. These mechanisms have accelerated investments in rooftop PV solar systems in other countries. Due a lack of legal structure guiding the market, potential consumers, both residential and commercial, are more cautious in making decisions to install rooftop solar systems.

5.4.4. Lack of Technical Standards and Specifications for Mini-Hydro Power

Clear rules and regulations should be in place establishing technical standards and specifications for mini-hydro power projects. This would allow mini-hydro developers to better estimate costs and profitability of new projects.[84] However, there is a lack of coordination between MOEE and state/regional governments on introducing rules and regulations for mini-hydropower projects. In addition, rivers and streams are typically under the government's jurisdiction, so their use for hydropower may require several permits and licenses before the start of construction.[85]

5.5. Transportation and Logistics Needs and Opportunities

Transportation and logistics in off-grid solar energy mainly involves careful handling of equipment such as solar panels. Developers have to transport panels using boats and motorcycles to villages located on islands or mountainous areas where road connectivity is poor or might not be suitable for all seasons. To minimize transportation costs, all components must arrive on schedule, which requires communication and coordination between developers, third party logistics partners, and local transportation providers to ensure project completion within budget and on time. Currently, there are a limited number of third-party logistics and warehousing providers specializing in transportation and logistics of off-grid energy-related machinery and equipment. With the growth of this sector, the demand for specialized expertise will increase. Development of road infrastructure is also crucial as it affects the productive use demand in off-grid regions, which in turn affects the investment attractiveness of developing mini-grids in those areas. Villages with reliable road networks to neighboring towns and villages tend to have higher productive load due to higher local business activity.[86]

There are also transportation and logistics challenges associated with transporting biomass feedstock from different regions across the country and shipping them to biomass power plants. The activities required to supply biomass from its production to a power station include harvesting and collecting biomass feedstock from plantations (such as rice and maize fields), and handling, transporting, and storing biomass feedstock. Many types of biomass feedstock have seasonal availability and need to be

[84] Kyaw Soe Win Hydropower Co., Ltd. Interview

[85] Asian Development Bank. 2017. Developing Renewable Energy Mini-grids in Myanmar (A guidebook). Metro Manila: ADB. https://www.adb.org/sites/default/files/institutional-document/391606/developing-renewable-mini-grids-myanmar-guidebook.pdf

[86] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.rockefellerfoundation.org/wp-content/uploads/Decentralised-Energy-Market-Assessment-in-Myanmar-Research-Report.pdf

stored for power station use on a year-round basis. Therefore, development of cost-effective storage solutions is required to reduce costs.[87]

5.6. ICT Needs and Opportunities for Sector Growth

In countries where the off-grid sector has matured, digital innovations such as artificial intelligence (AI) and big data, and reduced cost for digital technologies have promoted the digitalization of the energy sector. Analysis of substantial amounts of data and connection of smart devices have increased the flexibility and management efficiency of energy systems worldwide. Mini-grids require digital technologies to balance electricity supply and demand to ensure efficient system operation. Furthermore, digital innovations can optimize project development processes, improve the design and planning of mini-grids, and improve maintenance, management, and customer relationships, as well as contribute to the productive use of energy. Adoption of information and communications technology (ICT) in this sector is still low, and there are few local experts who have knowledge and competence in emerging technologies such as AI.

According to the Germany-based Institute for Advanced Sustainability Studies, opportunities for application of ICT technologies in the off-grid sector exist both in improving the functionality of the energy systems as well as in improving value chain development. Specific applications include:

- Technical functionalities and system balancing: generation and storage (forecasting algorithms, intelligent battery management, optimal hybrid operation); distribution and control (remote monitoring, supervisory control and data acquisition); and demand-side management (smart meters, demand limiting devices, smart appliances, demand forecasting).
- Value-chain activities: finance (crowdfunding, solar coins); planning and design (geospatial portfolio planning, drone imaging, demand estimation, design software); operation and maintenance (smart maintenance, cloud-based management platforms); customer management (mobile payments, smart contracts, electricity sharing, smartphones); and productive uses of energy (Internet cafes, telecom equipment, telephone charging, e-learning services).[88]

[87] Rentizelas, Athanasios, Tolis, Athanasios, and Tatsiopoulos, Ilias. (2009). Logistics issues of biomass: The storage problem and the multi-biomass supply chain. Renewable and Sustainable Energy Reviews. 887-894.

[88] Fritzsche, Kerstin; Shuttleworth, Luke; Brand, Bernhard; Blechinger, Philipp. 2019. Exploring the nexus of mini grids and digital technologies. Potsdam: IASS. https://www.iass-potsdam.de/sites/default/files/2019-08/2019_Mini-grids%20and%20digital%20technologies_IASS_Study.pdf

6. INCLUSIVE DEVELOPMENT CONSTRAINTS

6.1. Constraints to Women's Participation

The main constraints limiting women's participation across different off-grid energy sub-sectors include:

- The nature of work that requires travel to remote areas to conduct site-surveys and working at project construction sites, which discouraged women due to safety and security concerns.
- Misconceptions about women's capabilities in non-traditional job roles such as engineering where men are more often employed.[89]
- Cultural and religious rules that do not permit women to climb up to rooftops.[90]
- Government actions such as Township Electrification Committees requesting women be removed from VECs, stating "too much responsibility for women."[91]
- Societal norms and practices failing to recognize the needs of female employees such as a lack of measures like paid maternity leave.

6.2. Constraints Faced by Non-Urban Areas

Due to remoteness, political instability, poor infrastructure, and limited market access, private developers are reluctant to self-finance mini-grids in remote non-urban areas, particularly those affected by conflict. Off-grid hydro power plants are more prevalent in conflict-affected regions such as Kachin and Shan States due to the mountainous nature of these regions. Such projects were implemented by local entrepreneurs with active participation from local communities and even in some cases, local armed ethnic groups. Donor-funded solar-powered infrastructure projects such as public lighting are active in Rakhine State, but mini-grids are not common.

"Mini-grid developers look for villages with higher productive loads. Due to ongoing conflicts and instability, many local communities cannot engage in economic activities as many would become displaced by conflicts. Therefore, mini-grid developers tend to avoid these villages and most of the projects implemented are related to distributing solar appliances, such as solar home lanterns, and public projects, such as those providing solar energy for street lights, schools, and clinics."

- Managing Director, Asia Solar Co. Ltd.

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[89] Smart Power Myanmar Interview

[90] PACT. 2020. "We can find our way around any barriers: The women driving change in Myanmar's energy sector." https://www.pactworld.org/features/%E2%80%9Cwe-can-find-our-way-around-any-barriers%E2%80%9D-women-driving-change-myanmar%E2%80%99s-energy-sector

[91] The World Bank. 2015. Myanmar National Electrification Project (Preliminary Poverty and Social Impact Assessment to Inform Environmental and Social Management Framework. http://documents1.worldbank.org/curated/en/252311468285909453/pdf/SFG1098-IPP-P152936-Preliminary-PSIA-Box391468B-PUBLIC-Disclosed-5-28-2015.pdf

7. RECOMMENDATIONS

7.1. Introduction

The sections below detail recommendations based on the findings in this report. The primary recommendation is to support the uptake of solar home systems and solar-powered productive use appliances.

7.2. Solar Home System and Solar Productive Use Appliances

7.2.1. The Rationale for Supporting Quality Solar Home Systems and Solar Water Pumping

Solar home systems and mini-grids complement each other and have different pros and cons. Solar home systems offer a rapid path to off-grid electrification, given the relative low cost of the systems, consumer preferences for selecting a system that fits their household, and the rapid potential of individual households' decision making. Low quality solar products are widely available in Myanmar, but the service level and benefits delivered to the customers can be low. These systems are less expensive than those with quality products, but need frequent replacements (e.g., batteries), which increases the total cost of ownership over time. The solar home system companies that are distributing Lighting Global quality systems have a radically different business model, where they offer the systems on installment with a warranty, significantly lowering the consumer risk. This transition to quality solar and growth of this segment can be catalyzed with the right support to both companies selling these products and the surrounding ecosystem.

Solar home systems offer basic electrification with lights and mobile charging and basic appliances. This enables revenue-generating activities for the rural consumer, such as keeping retail shops open in the evening, extended working hours, and increased studying opportunities for children.

There are already several companies in Myanmar selling high quality solar home systems. The most successful companies in the industry have received multiple investments in the past and are operating at scale, but they need additional support to grow faster and improve their business case so as to attract additional investments. The industry has moved through a learning curve, and the companies that are still operating with a track record behind them will be able to benefit from support.

While several development organizations are supporting mini-grids, there is a gap in organizations actively supporting the growth of solar home systems and appliances, especially after the IFC Lighting Myanmar project ended in 2020. There are results from Lighting Myanmar and other projects, both in terms of effective intervention strategies and results already present in the ecosystem, that can be built upon.

Solar powered productive use appliances offer a significant benefit to rural farmers and present a good opportunity to increase trade and investments in this sector. This report recommends focusing on solar water pumps for several reasons.

Firstly, agriculture is the primary source of income in the rural off-grid areas, and correct irrigation increases agricultural yields. This impact happens at the individual farmer level, and while the products used vary greatly, the typical applicable product is a DC-powered water pump, which has a high maturity

and a relatively low cost, compared to other agricultural appliances.[92] Another solar-powered appliance that could be considered is refrigeration for food or dairy products. Products in this category powered by solar are also available although slightly less mature, but cooling makes best economic sense for high-value low-volume products such as milk. Myanmar has a relatively limited diary industry and low milk consumption, and demand for refrigeration is lower in rural are compared to solar water pumping. However, in time, cooling, cold storage, and many other products could enter the same ecosystem and sales channels.

Furthermore, there are similarities between the type of company that today offers quality solar home systems and that which now or in the future can provide solar water pumping. This includes a rural reach to end users, integrating financing into the product in the form of installments and addressing a learning curve in the mind of the consumer before purchase. This means that supporting solar water pumping can be achieved with similar activities as those for solar home systems. Compared to the ecosystem of companies selling solar home system products, there are fewer companies selling solar productive use appliances and they are less mature, but this is likely to change during the Activity's timeline. Current providers of solar home systems are also considering providing solar water pumps and other solar-powered appliances in the future, which is a natural progression once they have established customer relations, and brand recognition and understand the credit risk of the customers. This means that there is a rationale to support the type of appliances where customer segments overlap with solar home system companies' customers. Solar water pumping is an example of this.

Larger appliances, e.g., mechanical equipment for agricultural processing, require larger power sources than solar home systems and stand-alone panels typically provide, and are therefore more viable in villages with a solar mini-grid. This type of productive use equipment in a central part of building the demand side in a mini-grid improves commercial viability. Several initiatives from Smart Power Myanmar have supported such appliances.

There are positive side effects in supporting companies providing solar home systems and solar productive use appliances. This industry requires significant local employment, and the increased availability and utilization of mobile money represents an opportunity for increased financial inclusion in the communities. Increased yields and revenues for farmers have a positive effect on poverty alleviation in a rural economy largely dependent on agriculture. The ability to light up homes and extend working hours also creates additional opportunities for women, who often work from the home in agricultural families.

The following sections discuss the activities that can be implemented to support SHS and appliances.

7.2.2. Consumer Awareness and Product Demonstrations

Consumers are hesitant to purchase high quality products due to the higher price of the product, fear of product failure, and a lack of trust in the quality. The products are typically sold on installments to address the up-front cost issue, and since the product typically lasts longer, this provides the consumer with a good value. However, even with this built-in financing, consumers still need to trust that the

[92] Lighting Global. 2019. The Market Opportunity for Productive Use Leveraging Solar Energy. Washington: IFC. https://www.lightingglobal.org/wp-content/uploads/2019/09/PULSE-Report.pdf

product will be functional during the time of installment payments and afterwards. Quality product retailers, such as SolarHome and Greenlight Planet, have a significant branding and education task when they meet customers that have not heard about their products before. Companies like Agrosolar, which sells solar-powered water pumps for multiple applications including agriculture, face similar challenges but typically also encounter a training challenge in helping consumers understand how to most optimally use their products. The costs that each company incurs to overcome these awareness gaps can be reduced through industry-wide consumer-awareness activities. In addition, consumer awareness and product trainings would not have the negative effects that alternatives such as a direct subsidy to the end-user can have.

The Activity could select certain criteria that companies must meet to receive this support. This could, for example, be that the solar home systems sold must be Lighting Global quality verified. Although Lighting Global quality verification does not cover solar water pumps, it will be possible to identify companies that provide quality appliances, e.g. those offering product warranty or winners of Global LEAP awards and similar could be supported.

The supported activity could be a consumer education and marketing campaign to promote the sales of high-quality products, including sharing knowledge about the benefits of quality systems and the benefits of buying from companies that offer warranty, after-sales service, and installment payment plans. These benefits drive the sales of high-quality products, and promoting these benefits across the market reduces a key barrier for sales. This effort can be done in a way that benefits several companies in the ecosystem, so that demand and awareness is stimulated from consumer side, while several companies are supported evenly and fairly based on their products, capacity, and geographical footprint.

The campaign could be broad and nationwide communicating through an umbrella brand (like Htein Htein Thar described further below), or a more agile series of communication and local activities that stimulate demand and awareness. The media channels utilized in such a campaign could be a mix of those known from advertising. TV commercials, which intuitively seem less effective since the audience for these products does not necessarily own TVs, have been shown to have a large effect in off-grid areas, as well as vinyl posters, flyers, billboards, radio campaigns, etc. In addition to these communication elements, village-level demonstrations and activations have the highest effect on closing actual sales. Such events could include roadshows and demonstrations of the benefits of the products, e.g., at farmer's events. This would particularly benefit the productive use items such as solar water pumps. The Activity could, for example, sponsor a "solar energy corner" at various local agricultural trade shows and events, thereby reducing the costs for companies to meet potential customers. The Activity could also subsidize demo systems in high-demand rural areas with low product penetration, as a seed product often brings awareness through word-of-mouth and stimulating additional sales.

A similar approach was done by IFC in the Htein Htein Thar campaign. The Htein Htein Thar brand was designed and built by IFC's Lighting Myanmar project from 2017 to 2020 with an extensive budget for TV commercials, digital advertising, rural activations, product demonstrations, etc. The campaign ended in 2020, but the knowledge and awareness of Htein Htein Thar as an endorser of quality products still exists in rural areas. There may be an opportunity to revitalize the Htein Htein Thar campaign subject to agreement with the donors behind that campaign. The campaign was branded as Htein Htein Thar, and the implementer IFC and the donors UK Aid/DFID, Australian Aid/DFAT, and Canada were not part of official communication. This means that there would not be any confusion among end users if the

campaign was revitalized with new products within the same brand and communication framework of high quality and warranty, leveraging brand equity that would otherwise be lost.

7.2.3. Business and Partnership Development Support

Key challenges for the solar companies include gaining the trust of the rural consumers and building their last-mile rural distribution network. Both challenges can be addressed through partnerships with organizations that are already well known in the rural area and have a rural distribution network. These organizations could be either private companies, micro-finance institutions (MFIs), or NGOs.

The Activity can identify and facilitate collaboration between solar companies and potential partners for co-distribution, location and resource sharing in the field, product endorsement, and joint branding and marketing. Key criteria for identifying potential partner organizations will be having similarities to the solar company in terms of:

- The goals of the solar company and the potential partner organization, such as partnering with an education NGO to distribute lights for children to study after dark.
- The desired distribution network of the solar company and the current or intended network of the potential partner organization.
- The targeted customer segment and the targeted end-beneficiaries.

The last-mile rural distribution may also be a key financial burden for the potential partner organization, so cost-sharing could be a joint motivation.

The potential partners could be approached through the network of donors and their projects within health, livelihood, agriculture, and education. Private companies could also be relevant for partnerships, e.g., for solar water pumps, engaging agricultural companies such as fertilizer distributor Awba could be relevant.

Building successful partnerships has proven to be quite resource-heavy in the Myanmar solar industry, and it is a challenge to identify projects and develop the processes and terms behind the partnerships. Building partnerships often involves an initial pilot before a real partnership can be established on market terms. The activity could fund pilots that would provide significant value, as the parties can try out the collaboration with reduced risks.

The Activity can also conduct market intelligence activities, including rural data collection, aggregation and public reporting of consumer trends, and product and brand preferences. This will make the sector more competitive, and updated information about the market size and potential will attract donors and investors.

7.2.4. Facilitate Debt Financing and De-Risking Mechanisms to Increase Financing

A key challenge for the solar product companies is access to debt and equity funding in order to fund working capital from the point of purchase and import of the assets until the customers repays their loans.

Lack of debt funding forces some companies to require full up-front payment from consumers, which severely reduces sales. In this case, the consumer would need access to a loan from a third party, in which case an intermediary like an MFI or specialized consumer finance company like Rent2Own may be integrated in the sales process. These third parties would then similarly require debt funding.

The Activity can facilitate debt financing to the SHS and appliance companies. This would involve engaging banks and debt funds to present the opportunity and need for funding, support both parties in the process including debt pricing, and helping the companies document and communicate their financial key performance indicators (KPI) to obtain the debt funding. Additional details have been suggested by SmartPower Myanmar with focus on the mini-grid developers and are detailed in those recommendation below. Similar considerations should be made when facilitating debt finance for SHS and solar appliance companies.

De-risking mechanisms such as the Development Credit Authority[93] (DCA) would be helpful to motivate private banks to lend within the solar sector. The DCA facility is used in numerous African countries, which initiatives like Power Africa facilitated. With the provision of a DCA facility, part of the outstanding principal balance of direct loans could be extended to solar home system companies for use as working capital. The Activity could identify and facilitate local private banks' access to the DCA facility and could work within the ecosystem to increase knowledge and demand for the facility. Development organizations in Myanmar have previously suggested financing a facility to fund banks and MFIs if they extend energy loans to rural consumers, but this facility has not yet been implemented.

The Activity could also support optimal utilization of the existing limited funding options, such as supporting the solar companies' process and sales system maturity to benefit from results-based financing from the World Bank.

7.2.5. Promote Women's Participation in the Solar Products industry

The solar companies primarily employ male staff, especially in the operational field roles. This missed opportunity to attract, employ, and retain female talent has a negative effect on the companies' performance. The Activity can assist the companies to be more gender inclusive by improving their ability to recruit, train, and retain female staff. The program Powered By Women from IFC and the efforts of SmartPower Myanmar have given valuable insights and practical experience into these challenges and how to solve them. This includes activities such as designing gender-inclusive processes and rules, e.g., regarding maternity leave and equal compensation for equal work, and identifying and promoting female role models among the relatively few female employees.

Supporting women as leaders, entrepreneurs, employees, consumers and members of the community in general can be done through various activities, including:

- Female leaders can be developed through tailored leadership programs in the solar companies.
- Women as entrepreneurs can be supported by engaging women's groups to promote and sell solar products to rural households. Women's groups are often trusted in the community and

[93] Wikipedia. 2021. "Development Credit Authority." Accessed January 2021. https://en.wikipedia.org/wiki/Development_Credit_Authority

have experience with basic financials from their lending groups. Becoming a network of solar sales staff can be additional income for the women's group, thus strengthening their position in the community, but it may require training to address the cultural misconceptions about women's ability to work in solar sales and the low preference to do door-to-door sales work. There may be an additional advantage to promoting female solar entrepreneurs as the customer installments paid by mobile money and adoption of mobile wallets drives financial inclusion for both female entrepreneurs and female customers. Women as entrepreneurs can also be supported by promoting solar products' ability to increase working hours in off-grid homes after dark for entrepreneurial activities such as student tutoring, tailoring, basket weaving, and similar rural jobs, which are typically done by women in the household but limited by darkness.

- Women as employees can be supported by helping the solar companies to implement gender-inclusive processes and procedures, such as policies for maternity leave, modified working hours to avoid traveling after dark, and engaging male employees to support female employees.
- Female consumers and women in the community can be supported by developing gender inclusive communications and advertising, which may have a direct positive impact on sales to female customers. Furthermore, the utilization of some product features, such as security lights, can reduce gender-based violence and other challenges for women.

7.2.6. Strengthen Advocacy for Improved Standards and Regulatory Framework

Myanmar has not formally adopted the Lighting Global quality standard, and there are no import restrictions linked to the quality of these products, which means that the importation of less expensive low-quality products remains the norm. Adopting the Lighting Global standard as an official standard in Myanmar could be a reference for quality in public procurement programs, taxation etc.

The Activity could support industry networks in Myanmar, such as the Renewable Energy Association Myanmar (REAM), or assist private sector companies operating in the solar energy space to establish an industry association focused only on solar energy (e.g., a Myanmar Solar Energy Association).

Through such association, the Activity could advocate for regulatory support, such as lowering or fully exempting quality solar products from commercial tax, import duties, and the like. Myanmar already exempts commercial tax and import duties on import of solar panels, inverters, and charge controllers, and extending this to quality-verified SHS kits would offer a significant support to the industry.[94] Associations can also drive adoption of consumer protection measures as the industry matures.

COVID-19 demonstrated a need for associations representing both the industry and consumers. An association could, for example, advocate for the industry being declared an essential service or coordinate initiatives as happened in Togo where a free month of electricity was offered during the COVID-19 pandemic.[95]

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[94] GOGLA. 2019. "Providing Energy Access through Off-Grid Solar: Guidance for Governments." https://www.gogla.org/resources/providing-energy-access-through-off-grid-solar-guidance-for-governments

[95] GOGLA. 2020. "Global Off-Grid Solar Market Report H1 2020 (Sales and Impact Data)." https://www.gogla.org/resources/global-off-grid-solar-market-report-h1-2020-sales-and-impact-data

There are different views on whether banning imports of non-standardized systems is recommended. While it logically will reduce the official imports of low-quality products, it may risk increasing illegal imports and corruption, create bottlenecks in terms of volume, and the import regulation can itself become more complex to handle and prone to mistakes. While product standards are common in many other product areas, such standards are often linked to health and safety. When, for example, Ethiopia required in-country testing, this led to a delay in approvals that hindered import growth. A similar effect could happen if companies delay their request to get certification for their quality products or if the verification process experiences delays. It is also worth noting that while SHS are well covered by the standards, newer product categories such as water pumps are not yet included, so even if desirable, this could be complicated for products beyond solar home systems.

7.3. Mini-Grids

7.3.1. Strengthen Advocacy for Improved Standards and Regulatory Framework

Ecosystem actors like REAM and GIZ are lobbying the GOM to support regulatory reforms such as defining the status of mini-grids and establishing licensing schemes for mini-grids to de-risk grid arrival, as well as implementing strict technical standards to promote the grid-readiness of new projects and transition of mini-grid developers to independent power producers (IPPs), leveraging mini-grid generation assets to sell power to the grid.[96] For the commercial and industrial segment, policy and billing mechanisms such as net metering and feed-in-tariffs are required to accelerate adoption. The Activity could provide legal and technical advisory support to sector associations, such as REAM and MHDA, to build their capacity to advocate for a legal environment that would encourage private sector investment.

7.3.2. Support the Development of Alternative Financing Solutions

Alternative financing solutions are required to help overcome the existing funding constraints to mini-grid investments. These can include two-step loan structures[97] and direct funding through a credit mechanism. These financing solutions could potentially support a rollout of more than 2,000 mini-grids, with total project costs of approximately USD 800 million, potentially benefitting 2 million people.[98] A single two-step loan can support as many as 1,150 subsidized mini-grids, while direct funding through a credit mechanism has the potential to support hundreds of additional mini-grids that are not funded under a two-step loan, including both subsidized and unsubsidized projects.

Agence Française de Dévelopement (AFD) and JICA are currently evaluating two-step loans for mini-grid developers. The AFD's two-step loan program is expected to be implemented in early 2021, with a total funding package of USD 36 million that would cover the total project costs for 170 to 230

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[96] Smart Power Myanmar Interview

[97] Long Term Investment Loan is a special financing scheme available for Myanmar SMEs, in cooperation with private local banks, financed by Japan International Cooperation Agency (JICA) under a bilateral government agreement. Eligible businesses will enjoy a subsidized interest rate. Applying for a long-term investment loan requires immovable property such as land and buildings as collateral. The loan term is one to five years, and the maximum loan amount is 500 Million MMK. The main criteria for the JICA Two Step Loan is to invest in fixed assets at least 80 percent of the total loan amount, and to utilize 20 percent as working capital.

[98] Smart Power Myanmar. 2019. "Decentralised Energy Market Assessment in Myanmar." https://www.smartpowermyanmar.org/wp-content/uploads/2019/05/Decentralised-Energy-Market-Assessment-in-Myanmar-Executive-Summary.pdf

subsidized mini-grids. A variety of stakeholders would benefit from technical assistance to ensure successful implementation of two-step loans and includes:

- Myanma Economic Bank (MEB) – capacity building to ensure that it is able to efficiently on-lend funds to participating financial institutions;
- Financial institutions – capacity building to improve their risk management capacities and ensure they can meet the MEB reporting requirements;
- Mini-grid developers and operators – training to improve their capacity to understand the requirements and prepare bankable applications to financial institutions. For example, how to best aggregate and present mini-grid operating data and financial information;
- VEC – Financial literacy trainings that would include topics such as tariff payments, payment collection and cashflow, knowledge of accounting systems, and tools to effectively manage each mini-grid.

Another financing solution could be direct debt funding with a risk-sharing guarantee where commercial debt funding (blended with a portion of concessional debt funding or grant funding) is provided directly to special purpose entities that own the mini-grids and repay the financing to funders directly from the project's free cash flows. A variety of development finance institutions as well as the multi-donor backed Partnership for International Development Group provide these guarantees. In Myanmar, USAID's Development Credit Authority (DCA) is a provider of such a guarantee and has interest in the mini-grid market. Based on previous discussions with DCA, a traditional cash flow lending facility would be easier to cover than a project finance loan since DCA does not have the technical capacity to assess risk of a project finance structure and would need to hire an independent engineer at an additional cost. Therefore, DCA requires a minimum loan amount of USD 50 million to amortize this cost.

Furthermore, a catalytic first loss mechanism could help crowd in a funder and guarantor by improving the risk-return profile of the transaction. Such a credit enhancement tool provides just enough protection to entice financing from a funder and should be used prove commercial viability of the project.[99] There has been no adoption of catalytic first-loss capital in the off-grid sector in Myanmar yet, however its use could be a long-term alternative to some subsidies.

7.3.3. Build Capacity of Solar Mini-Grid Developers

In 2020, U.S.-based Miller Center for Social Entrepreneurship, in collaboration with Smart Power Myanmar and with support from a USD 250,000 grant by Chevron, launched a pilot Mini-Grid Accelerator program to work with early and growth stage mini-grid developers. Thirteen mini-grid companies worked with international mentors during the six-month program to increase skills in product and service development, financial modelling, and sales and marketing.[100] Implementing a similar

[99] DELPHOS. 2019. Closing the Finance Gap: Assessing Options for Decentralised Renewable Energy Mini Grids in Myanmar. Smart Power Myanmar. https://www.smartpowermyanmar.org/wp-content/uploads/2019/12/Financing-Assessment_Smart-Power-Myanmar_final_Dec-2019.pdf

[100] PACT. 2020. "Miller Center, Smart Power Myanmar & Chevron launch mini grid accelerator program." https://www.pactworld.org/news/miller-center-smart-power-myanmar-chevron-launch-mini-grid-accelerator-program; Smart Power Myanmar. 2020. "Myanmar Mini grid Accelerator." https://smartpowermyanmar.org/wp-content/uploads/2020/06/Mini-Grid-Accelerator-Program.pdf

initiative in partnership with enablers like Smart Power Myanmar and expanding training to other solar mini-grid developers will be beneficial for building their capacity both in core business skills as well as in new technologies, such as the ICT-enabled technologies for mini-grids. In addition, short-term capacity building trainings for employees of mini-grid developers, with participation of international mini-grid experts, will also contribute to skill building in the sub-sector.

7.3.4. Promote Women's Participation at the Community-Level

Community participation is critical for success of subsidized mini-grid projects.[101] To be able to increase women's participation at community level, development partners can consider three different initiatives:

- First, ensure at least 50 percent women's participation in all training and capacity-building activities at VECs. For example, the Off-Grid Renewable Energy Demonstration Project implemented by ADB in 2017 ensured 50 percent of the trainees and 50 percent of individuals elected to VECs to manage the projects were women. Women led the cooperation with the developer and took responsibility for the financial management of the project from the village side.[102]
- Second, increase the literacy of rural women in solar technologies. For example, Barefoot College's Solar Mamas program implemented training programs via visual learning tools and manuals on how to build LED lamps; charge controllers, lanterns, and home lighting systems; and store and repair components.[103] Collaborating with IFC to adopt initiatives of a similar nature under its Lighting Myanmar program will promote women's participation at the community level.
- Third, promote women's employment at the community level. For example, mini-grid developers like MREF Power Co., Ltd. work through the Myanmar Economic Development Association (MEDA) to train villagers on how to operate their grid themselves and develop electrician skills. MREF works with WWF to train women to be electricians through a program called Women in Power, where women are trained on solar energy maintenance and basics of grid operations.[104]

7.3.5. Support Female-Owned Businesses in Newly Electrified Villages

Most of economic benefits of mini-grids are derived indirectly from the impact of electrification on business growth and the resulting increases in productive loads, which not only increase the viability of mini-grid, but also affect economic growth, job creation, and improved living standards in rural areas.[105] In regions with moderate to high productive loads, supporting female-owned businesses or businesses employing a significant percentage of women would not only increase demand for electricity from

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[101] Asia Solar Co., Ltd. Interview

[102] Nexant Asia Ltd. 2017. Asian Development Bank TA 8657-MYA: Off-grid Renewable Energy Demonstration Project. ADB. https://www.adb.org/sites/default/files/project-documents/47128/47128-001-tacr-en.pdf

[103] Renewable Energy World. 2019. https://www.renewableenergyworld.com/2019/05/14/doing-business-better-empowering-women-through-solar-energy/#gref

[104] Forbes. 2020. "Accelerating Mini-Grids in Myanmar and Expanding Energy Access to Villagers." https://www.forbes.com/sites/annefield/2020/11/22/accelerating-mini-grids-in-myanmar-and-expanding-energy-access-to-villagers

[105] Smart Power Myanmar Interview

productive loads but also promote job opportunities for women. This includes working with local banks, microfinance institutions, and other financiers to design and offer loan packages and other financing schemes targeting female-owned businesses, particularly to support purchasing electrically powered agricultural machinery and equipment instead of fuel-powered.

Mini-grids development has shown to boost women's entrepreneurship in other countries. Development partners such as ILO's Women Entrepreneurship Development program support regional female-focused or female-led civil society organizations and women's empowerment groups. Opportunities also exist to provide basic business and vocational skills trainings for women in newly electrified villages such as short business management and finance courses and technical courses, for example in dessert making and sewing. This will increase the number of women in business leadership roles.

8.2. Annex B: Bibliography

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