Chapter 5

Mini-grid Operator Model: The Case of Shan State

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Chapter 5

Mini-grid Operator Model: The Case of Shan State

This chapter compares mini-grid operators in the context of Energy for Peace to identify feasible and realistic options for providing energy in conflict-prone regions. In Shan, semi-structured interviews were conducted with the participants, revealing limitations of the private operator model in conflict areas. Implementation by the community is recommended. To expand the community model into conflict regions all over the country, significant public financial support is necessary. As in Thailand, for example, funds can be set up with secured sources such as a petroleum tax. Such radical reform requires institutional reforms to integrate electrification policies.

1. Mini-grids for Rural Electrification

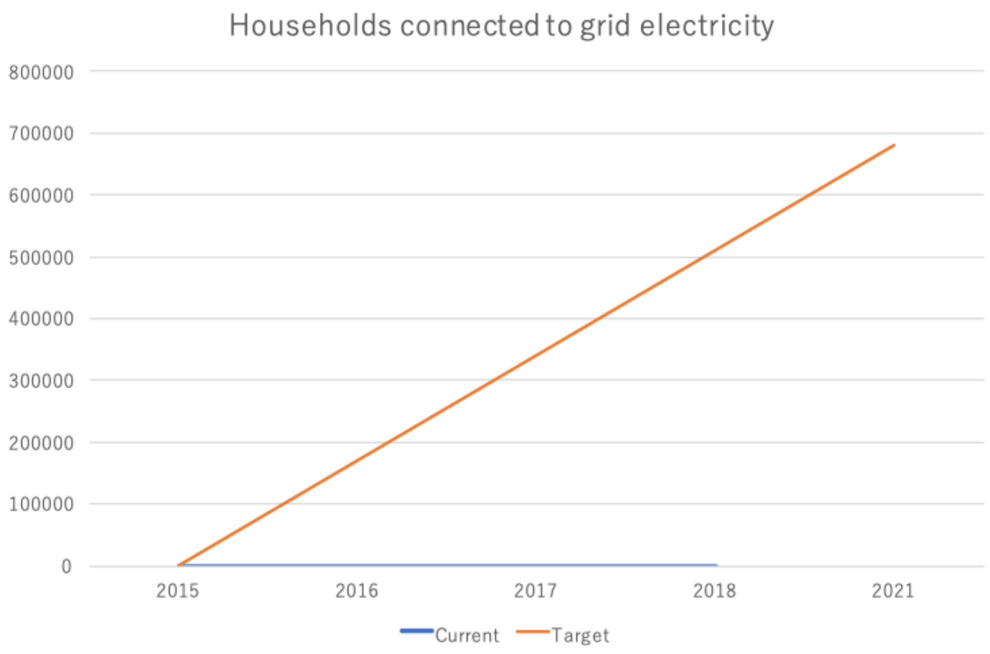
1.1. Situation of Rural Electrification

Connecting to the national grid is one of the main ways to access power. Since a single huge power plant with hydro, nuclear, and thermal power can produce a large amount of power, it can potentially be the most efficient way to cover power demand by the national grid. A number of off-grid solutions, however, may provide better access. These solutions have developed in the last 3 decades in Asia and the Pacific (Tumiwa, 2014).

Rural electrification is vital for rural economic development (Bose, 1994; D. Miller, 1995; Foley, 1992) and leads to redistribution of welfare and social equality (World Bank 1995). Electrification by the national grid in Myanmar has not met the targets shown in Figure 5.1, although off-grid solutions, including mini-grids and SHSs have been installed Figure 5.2 and Figure 5.3. Off-grid solutions are expected to be realistic options to achieve rural electrification (ERIA, 2018).

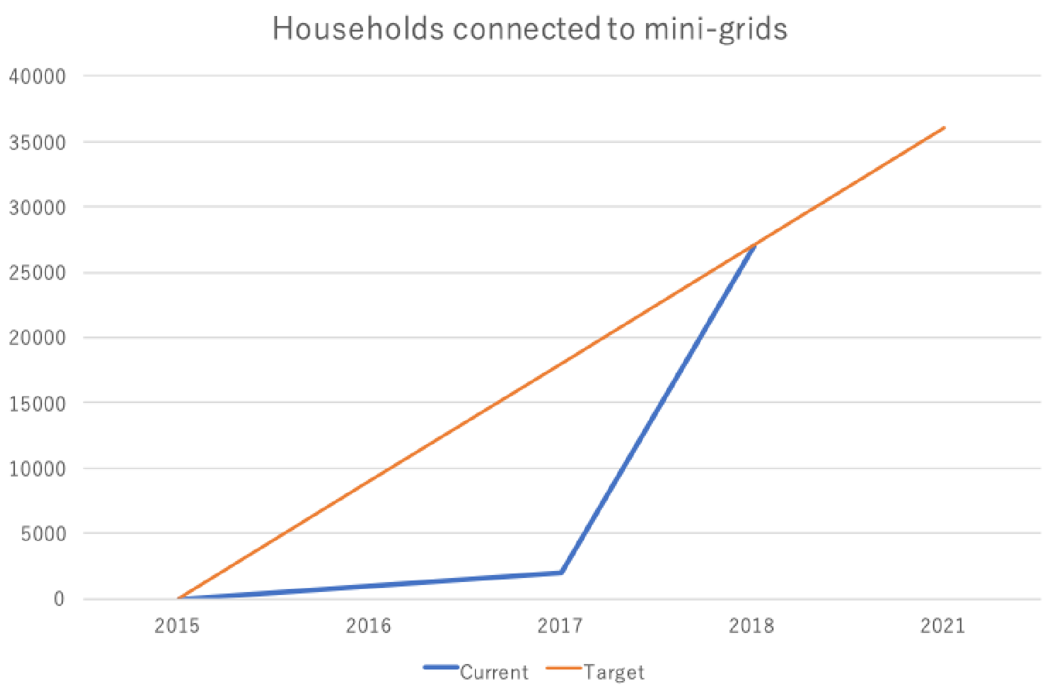
Mini-grids are preferred to SHSs because they have greater benefits: they enable socio-economic development by providing basic electricity services for households, and they enable rural industrial development by ensuring the productive use of electricity by small and medium-sized enterprises (European Union Energy Initiative Partnership Dialogue Facility, 2014). Africa50 Infrastructure Fund (2016) points out mini-grids' flexibility in design and scale.

Figure 5.1: Progress of Electrification by National Grid



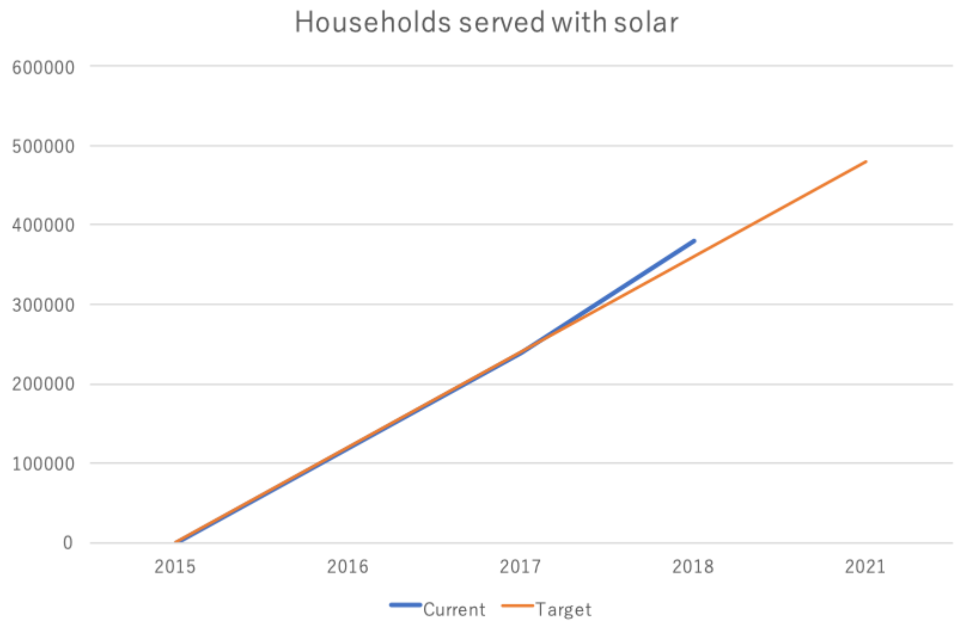
Source: World Bank (2019).

Figure 5.2: Progress of Electrification by Mini-grids



Source: World Bank (2019).

Figure 5.3: Progress of Electrification by Solar Home Systems



Source: World Bank (2019).

The best way to provide electricity varies according to objective, population density, industry, and affordability. To promote economic development, mini-grid solutions are preferred to SHSs because they can provide community-scale electricity at a lower tariff (Africa50 Infrastructure Fund, 2016).

The MoALI's DRD is in charge of off-grid rural electrification. The electricity law of 2014 permits states and regions to authorise electrification projects that have less than 30 MW generation capacity. Whilst the national grid, which extends the transmission network centred on power stations, will promote a centralised management system, the mini-grid is a measure to supply electricity at a single-community level. A decentralised management organisation in each state or region is expected to promote rural electrification, using private and limited government funds.

1.2. Classification of Mini-grids by Operator

Vital issues challenge mini-grids, such as who should manage and own them. As the initial and running costs of mini-grids are much larger than those incurred for a small-scale power management system such as an SHS, their business sustainability needs to be considered carefully (ERIA, 2018; GNESD, 2014; Seguin, 2014). The power capacity of a mini-grid is much larger than that of an SHS, and it needs to be more resilient to prevent any sudden loss of power. Rural electrification projects are often not thought of as private businesses because they meet social needs. The projects must be economically viable, however, if they are to be sustainable. Since companies and organisations have different specialties, a company should act as operator.

An analysis using the business operator model lends an effective perspective to the discussion (Safdar, 2017). It is the generic name for the business models of different business entities (European Union Energy Initiative Partnership Dialogue Facility, 2014; GVEP International Global, 2011; Knuckles, 2016). Focusing on operators makes it possible to analyse the structure of the business, the flow of funds, among others. An appropriate business model can be chosen based on the advantages and disadvantages for business operators.

We focus on utilities (government organisations), private enterprises, and communities as the main business operators and describe the advantages and disadvantages of four business models (European Union Energy Initiative Partnership Dialogue Facility, 2014; Shirley, 2018): utility operator, private operator, community operator, and hybrid, which differ in scale, maintenance, and cost of business. Each model has different advantages and disadvantages. Several studies have analysed specific projects. This study focuses on the mini-grid operator model.

Utility Operator Model

A mini-grid is installed and operated by state-owned or private utility companies (European Union Energy Initiative Partnership Dialogue Facility, 2014; SBI, 2013) (Table 5.1). Electrification by national grid is conducted mainly using this model. Government organisations such as the MOEE and its Electricity Supply Enterprise (ESE) division manage the national grid. The utility operator model for the mini-grid is the same as for the national grid and distributes the power generated by government organisations and local governments to consumers. Consumers can use electricity by paying for it; subsidies may reduce the electricity bill.

Utility operators have several advantages. First, in developing countries, government-affiliated organisations have more human and financial resources than private companies, which makes it possible to establish many mini-grids. Since the national grid and mini-grids are managed by the government, establishing links between them is easy and so is power sharing or transmitting extra mini-grid power to the national grid. Second, the lack of restrictions eases managing the project. Third, when the government, not the private sector, carries out the business, residents can use power more safely because the government takes smaller risks than the private sector does.

The model has drawbacks. First, the mini-grid business is small and cannot be the operator's main business; there is a high possibility that the business will not progress unless the government invests in it and international financial institutions extend loans to it. Second, the government is less capable than the private sector in reducing costs and managing human resources, so mini-grids might need to be compensated by taxes. The third is political risk. If a country's political situation is unstable, the business risks being altered or suspended due to a change in the political situation, such as a coup d'etat. Since funds from international financial institutions such as the World Bank and ADB are concentrated in the government, politicians and military people might illegally rent-seek or engage in corruption if the political system is not transparent.

Table 5.1: Utility Operator Model

Operator	Public organisation, government-owned enterprise
Maintenance	Public organisation, government-owned enterprise
Owner	Public organisation, government-owned enterprise
Resource	Public organisation, government-owned enterprise
Advantages	● Abundant resources and prompt construction ● Easy management ● Easy connectivity to national grid
Disadvantages	● Governance risk

<u>Private Operator Model</u>

The project is managed by a private enterprise or strong local leaders, and generates and sells electricity to connected customers (European Union Energy Initiative Partnership Dialogue Facility, 2014; SBI, 2013) (Table 5.2). Sources of funding exist in cases where private investment is all out, but they are often funded with government subsidies and grants (UNEP, 2015). Sometimes, loans are given based on the business' outcome or they have a low interest rate.

Private companies can adopt various forms of management. Consumers can use electricity by paying for it. A subsidy may reduce the electricity bill. Private companies can increase the number of franchisees and adopt a method that reduces operation and management costs. The advantages of using strong local leaders as business operators are they are always on site, in charge of operations, and own some of the power generation and distribution assets. By using established local social networks, administrative and operating costs can be reduced for security, customer relationship management, collection, among others.

A private model can potentially meet large demand. For example, in Kenya, Powerhive operated a few solar PV mini-grids, supplying around 1,500 customers. Then the company secured US$11 million in equity finance and US$20 million in venture capital finance to expand coverage to serve 90,000 customers (SolarServer, 2016).

The advantages of the private enterprise model are (i) its technical capabilities can reduce the price of electricity and sell it at a much lower price than a public utility; and (ii) business can be developed flexibly and efficiently, both financially and technically, based on the area's characteristics. Once the market has grown, private operators will enter it, giving rise to price competition and lower costs. Local private organisations such as NGOs can expand business in cooperation with projects other than electric power, such as hospitals. Private operators who were doing business in the area before the mini-grid was set up can run the new business more efficiently; already existing procurement routes and fund collection can be deployed for maximum efficiency. Because they receive private investment, large-scale mini-grids can be undertaken even with limited government funding.

One risk is that if a problem arises in the connection with the national grid due to future expansion, the mini-grid operators could collide with the government corporation managing the national grid. Another risk is that if the government changes the regulations, private operators will have to pay additional costs to comply. In the case of a business that relies entirely on private investment without government support, the private company may not make a profit, the business may become overwhelmed, and usage fees may rise, burdening consumers and possibly eroding service quality.

Table 5.2: Private Operator Model

Operator	Private enterprise
Maintenance	Private enterprise
Owner	Private enterprise
Resource	Public organisation, private enterprise
Advantages	● Business form adjusts to the region ● Utilisation of private enterprise ability ● Utilisation of private investment
Disadvantages	● Regulation by government ● Possibility of no public subsidy ● Difficulty of quality control ● Conflicts between private enterprises

Community Model

Mini-grids are owned, managed, and operated by local communities (European Union Energy Initiative Partnership Dialogue Facility, 2014; GVEP International Global, 2011; SBI, 2013) (Table 5.3). Funding is often difficult to obtain from only the local community, and support from the government is essential. Since most community models do not have specialised technical capabilities, procurement and installation of mini-grids are outsourced to private companies. Charges are minimal, enough only for operation and maintenance costs. A firm structure must be put in place to increase charges and prevent conflicts between communities. It is a model adopted in areas where a private enterprise or a government organisation cannot make profits: i.e. rural areas where the annual household income is low.

Its advantage is that it is managed by the community and can be flexible. Although the electricity usage fee is extremely low, collecting it from the local residents is not easy because their incomes are low. But collecting fees is easier than in other models because residents exert mutual pressure and encourage cooperation amongst themselves. The construction of a new power plant will improve local people's capabilities and create local jobs, thereby helping raise living standards.

The biggest disadvantage is that local communities are technically and economically unskilled and incapable of running a sustainable business, which will lead them to rely on third parties and private companies to establish the power plants. The community will have difficulty bearing the initial costs and the government may provide subsidies and loans. Community decision making is crucial: unless clearly established, conflict may arise amongst the residents.

Table 5.3: Community Model

Operator	Private enterprise, community
Maintenance	Community
Owner	Community
Resource	Public organisation, private enterprise, community
Advantages	● Strong community bond ● Community economic growth ● Easy to gather tariffs
Disadvantages	● Lack of technical and economical ability ● Conflicts between communities

Hybrid Operator Model

Private companies, government organisations, and local communities cooperate to operate the mini-grid, including transmission and distribution (Table 5.4) in a kind of public–private partnership. One project, for example, outsources maintenance to the Renewable Energy Service Company (RESCO), and the government oversees fee collection to pay RESCO. How RESCO collects charges and residents perform routine maintenance varies. Senegal has been successful with this model (European Union Energy Initiative Partnership Dialogue Facility, 2014).

The model adapts the good parts of other models, which may result in efficient operations. But where different organisations perform different roles, the required complex structures may be difficult to find. Conflicts may arise between profit-seeking private companies' electricity rate plans, for example, and the hopes of the community.

Table 5.4: Hybrid Operator Model

Operator	Public organisation, private enterprise, and community
Maintenance	Public organisation, private enterprise, and community
Owner	Public organisation, private enterprise, and community
Resource	Public organisation, private enterprise, and community
Advantages	● Combination of advantages ● Cost reduction
Disadvantages	● Management of complex structures ● Conflict between stakeholders

2. Operators of Mini-grids in Conflict: The Case of Shan State

2.1. Objective, Data, and Method

To discuss an appropriate model for the mini-grid, a field survey, including interviews, was conducted in Shan, a conflict-prone region and site of several mini-grids. Before our unstructured interviews, we conducted focus group interviews with local stakeholders to identify the category of operator and the typical case of each category. Avoiding a region where violence was ongoing, the field survey interviewed 12 people from six villages with mini-grids.

The interview guide was based on the pros and cons of each utility, as suggested by previous studies, and data were mainly collected from semi-structured interviews from October to December 2018. The interviewee data are summarised in Table 5.5 including dates, locations, names, and positions, although real names and locations are not used to protect personal information. The respondents were mainly local leaders and users of the mini-grids, which were installed to meet increasing demand for energy. All were familiar with their towns and their mini-grids. Environmental factors (e.g. income level, market integration, and grid proximity) were controlled to observe the impact of the type of utilities as an independent factor.

The data collected from the interviews were analysed and described briefly for each town, with information on the specific model (owner, operator, and so on), the context of introducing the mini-grid, scale, tariffs, and advantages and disadvantages. Data were collected until theoretical saturation. Interviews were conducted until no further additional information was available regarding the advantages and disadvantages of each operator.

Table 5.5: General Information from Interviews

Interview no	Date	Location (Township)	Name	Position
1		Town A	Interviewee A	Parliament member
2		Town A	Interviewee B	Parliament member
3		Town B	Interviewee C	Kyaing Taung Energy Co., Ltd (management level)
4		Town C	Interviewee D	Kan Loan Co., Ltd. (management level)
5		Town D	Interviewee E	Local community (public)
6	22 October 2018	Town E	Interviewee F	Township manager
7	22 October 2018	Town E	Interviewee G	Great Hor Kham Public Co., Ltd. (management level)
8	23 October 2018	Town E	Interviewee H	Parliament member
9	23 October 2018	Town E	Interviewee I	Parliament committee member
10	25 October 2018	Town F	Interviewee J	Township manager
11	25 October 2018	Town F	Interviewee K	Parliament member
12	26 October 2018	Town F	Interviewee L	Member of community hydropower system (management level)

2.2. Description of Interviews

The information derived from the interviews is briefly described below.

① Town A, Loilem, southern Shan (interviews 1 and 2)

Community Model

<u>Overview</u>

The solar grid system and all the materials were granted by Japan International Cooperation System to the village through the DRD. The owner and the management body handed them over to the local community. Six members took on all the responsibilities of utility and distribution, supervised by the DRD. On the DRD's advice, the village community set the monthly electricity fee at MMK1,000. Initially, only 51 households received solar energy. All the fees were reinvested. The committee paid the fee collector MMK20,000 per month.

Since the solar distribution system is meant only for lighting, each beneficiary household is allowed only two 11 V bulbs. Power generation capacity is 5 kW and energy is distributed to 51 households only from 18:00 to 21:00 daily. The management body provides electricity for social welfare needs and students' learning time. The villagers requested the DRD to eventually provide them with solar panels. The DRD expects the solar grid system to be connected to the main grid once the systems are upgraded.

A German organisation, KfW, is also assisting the DRD to expand its solar energy capacity in 2019–2020, but the project is still in the planning phase.

Village Electrification Committee

The committee members are responsible for distributing and maintaining the solar energy grid. Information about the members is in Table 5.6.

Table 5.6: Members of the Rural Electrification Committee

No.	Name	Position
1	U Sai Mai	Leader of village and committee
2	U Tun Aung	Member
3	U Maung Hla Maung	Member
4	U Sai San Nyunt Oo	Member
5	U Sai San Mya	Accountant
6	U Aung Thein	Member

Connectivity to the National Grid

As the population increased in Town A, the number of households relying on the grid rose to 103. In mid-2018, the government started to provide the village with electricity from the national grid. This led to all the households being connected to the main grid, including those who used solar energy, to their satisfaction as they now had enough energy for their needs.

- Interview no. 1

NLD Parliament Member

Loilem District

Mr. Pyoe Wine (chairman of Loilem NLD) and U Sai Thaung Htike (secretary of Loilem) explained that there used to be a much smaller hydro system, but that the national main grid is extending its coverage, rendering community generation unnecessary. Other townships will soon be identified for coverage. Most rural people were using individual SHSs. A conflict occurred between an armed ethnic group and the government around Kar Li township but was soon resolved.

- Interview no. 2

Union Solidarity and Development Party Parliament Member

U Khin Maung Thi

Loilem District

The Shan State Army (SSA) had been demanding its rights for decades. The government and the SSA should consider the NCA. Shan has many ethnic groups such as the Shan, Pa O, La Hu, Wa, and so on, and it would be foolish for the union government to apply one policy to all of them.

Many rural areas in Shan are remote and transportation access is difficult. Electricity from the national government is lacking and the local people have started using individual SHSs. Near Kar Li township, the SSA has been producing hydro energy and distributing it to the local people. The national government discussed ways to work with the SSA but they could not come to any agreement.

The MOEE’s ESE division is negotiating with armed ethnic groups on energy issues.

Hydro is the most sustainable form of energy in Myanmar as it does not have any running costs and has many advantages. However, remote areas cannot benefit from it, and a solar grid system with a community base would be more appropriate. The system is easy to access and handle and depends only on sunlight.

② Town B, Eastern Shan (interview no. 3)

Private Operator Model

Overview

Town B, in eastern Shan, has been powered by a local company, Town B Energy, since 2013. The company has four shareholders: Naung Tong, Loi Mway, Kyi Thein, and Sein Lin Kyi Company Ltd. It produces 6,300 kW of hydro energy and supplies 20 other villages. The government lent funds to local businesses through contracts that included power plants and distribution assets. The company built two new power plants and provided seven diesel generators for MMK1 billion to operate in summer (Table 5.7).

Table 5.7: Overview of Power Plants

Power Plant	Generation Capacity	Owner / Contract	Hire / Construct
Nam Latt Plant	160 kW x 3	Hired from government with contract	Hired in 2012
Nam Woat Plant (1)	1,000 kW x 3	Hired from government with contract	Hired in 2012
Nam Woat Plant (2)	650 kW x 3	Company constructed the power plant	Constructed in 2014
Nam So Plant	1,250 kW x 2	Company constructed the power plant	Constructed in 2016

Source: Based on interviews conducted by authors.

The government made new contracts with the company every year, stating that if the government did not extend the contract, all assets would belong to the government. The government never pays back the number of subsidies invested by the company. The company manages all related activities such as maintenance, operation, and energy charge collection.

There have been minor conflicts between suppliers and consumers. Consumers prefer to have energy supply 24 hours a day, 365 days a year, while companies do not have the capacity to provide it. However, when the company built the new power plant in 2014, it became easy to supply energy.

Suppliers, including state governments and parliamentarians, and residents (consumers) met several times to revise unit price–based policies. They agreed that normal lighting would be MMK100/unit and large-scale commercial use would cost MMK160/unit.

Small-scale industries such producers of noodles and snacks depend on energy supply. Since health was not adversely affected by electricity use, small-scale management of such industries has improved since 3 years ago. Education has improved significantly, as it is directly related to energy supply.

Residents of Town B and the surrounding 20 villages have access to electricity, and their living standards have improved. Mini-grids depend on rainfall each year and have been in good condition from the beginning. Companies believe that climate change may affect the sustainability of energy production. During the dry season, February to June, hydro energy is insufficient. The company has to operate seven generators, which need about MMK5 million per month for fuel.

③ Town C, Eastern Shan (interview no. 4)

Private Operator Model

Overview

The hydropower plant was installed by a local company in April 2013. Local companies have four shareholders, including local armed ethnic groups. Local companies invested all their assets and human resources for hydro energy generation and distribution. Initially, the company invested in only one 320 kW capacity unit in April 2013, and then started selling meter boxes in September 2015, linking power generation and distribution to Town C and the surrounding villages. Meter box prices are different for regular lighting (MMK650,000) and commercial use (MMK2.5 million). Another hydropower plant was expanded to a capacity of 320 kW in October 2018. So far, companies have invested about MMK1.5 billion.

Local businesses are licensed by local and federal governments and must pay taxes. Companies pay taxes to the local government every month. The unit price is MMK200 for lighting and commercial use, only for small and medium-sized businesses. Companies manage and arrange all necessities for beneficiaries. The government supplies energy with generators, and only in the evenings (18:00–21:00), at MMK35/unit. Most consumers are satisfied with their electricity bills because they have no other options or sources of information. They say service is excellent because the company offers a prepaid system with a smart card.

However, rural people still consider electricity rates to be expensive and highly value having cheaper or other resources. Since the project started, no conflicts worth mentioning have arisen between suppliers and consumers. Small and medium-sized vehicle repair shops are making profits. Students can study until midnight. The advantage of the mini-grid is that it is a hydropower plant and relies primarily on rainfall. Power generation and distribution have been on track since 2013, which is considered sustainable.

④ Town D, Eastern Shan (interview no. 5)

Community Model

Overview

Planned by the region government in 2006, the hydro-energy project was established in 2007. The government provided special loans to the residents, who had to pay them back under the management of the community. The community enjoys complete access to energy. The initial project cost was MMK210 million, including the cost of construction of the power plant and the cable lines. Eighteen community members manage the power plant.

It could generate 160 kW and supply 392 households in 2007. By 2018, it supplied about 472 households. Since 2009, production and distribution have been constrained by summer, when the water level is low.

The community charges MMK100–MMK200 per unit. During the reimbursement period, the community charged MMK200 per unit. All the beneficiaries are satisfied with the unit price. There have been no conflicts between suppliers and consumers, not even with the ethnic armed group.

⑤ Town E, Northern Shan (interview nos. 6–9)

Hybrid Operator Model

Overview

- Interview no. 6

Town E is on the border with China, on the Shweli river, and connected by road and bridge to Shweli city (Ruili in Chinese), Yunnan province. Town E has three sub-townships and a population less than 150,000.

The main source of electrical power is the Shweli hydropower plant. Power distribution is managed by a private company, Junction River, which won the tender for electrical power supply services and related processes. All the procedures, including unit price, distribution, and service system, are the same as those for government services.

No private company or local developer distributes electricity based on an agreement or business system. All ESE services and extension plans to surrounding areas and villages are based only on the budget allocated by the national government, which means the process takes time and cannot be completed in a few years. The difficulties with electrification are not limited to Town E but also afflict other rural regions. It is not only electrification that needs to be improved but also transportation, roads and bridges, telecommunication, education, health, among others.

As agreed, the ESE first extended the distribution system to villages 2 miles away from Town E. Only after doing so could the ESE deliver services to areas farther away. In some villages along the border with China, some households have no access to the national grid and get electricity from China. Such cases of infringement can be charged a royalty fee but the national grid cannot reach these places. Such villages are in restricted areas and cannot be approached, as per the township officer.

Electrification services must improve and the private and public sectors cooperate. Electrification is important for building rural infrastructure, and the government must plan and implement it carefully.

- Interview no. 7

Great Hor Kham is a big public company building basic and general infrastructure for roads, bridges, and electricity distribution, not only on its own but also as a hired contractor or subcontractor for the government or private institutions and companies.

Great Hor Kham is finalising the hydropower project on Nang Paw creek near Mane Han village, Saelant village, Town E. The project's capacity is 20 MW, to be directly connected to the national grid in Town E. A PPA was forged with the MOEE in July 2017, with the agreed price of MMK65 per unit (MMK/kW). The project's output will not be directly distributed to local households and surrounding areas where it is generated.

Mini-grids, especially off-grids, are difficult to implement on a small scale because they are not bankable and are expensive. The laws on electricity distribution state that a transmission line should be able to supply areas at least 50 km from the main power source and cost about the same as the total cost of the power source construction. The tariff rate for electricity will be proportionally high, which leads to complaints from beneficiaries.

Hydropower is the best mini-grid scheme for long-term supply to Town E compared with solar, coal, biomass, and so on, but can cost more. If villages have water sources (streams, mountain torrents, cascades), hydropower can provide sustainable electrification that will support agriculture, education, health, and the economy.

Mini-grids may be expensive and they are risky. We need to consider who will be responsible for keeping rates reasonable and identify power sources (coal, hydro, or solar). Coal-fired projects would not only be costly to monitor but also give rise to environmental concerns.

- Interview no. 8

The main electricity source in Town E is Shwe Li Hydropower but it covers only the town and not the villages. Although the township ESE manages distribution of electricity and related services, its scope and budget are limited. Grid extension and upgrade are funded only by a government-allocated budget. The ESE plan prioritises only villages within 2 miles from Town E. Areas farther than 2 miles are difficult to access because of the strong animosity between the Tatmadaw and some ethnic armed groups in Shan. Some villages do not allow strangers to pass through without liaising with the village heads.

Town E has three sub-townships, all of which are electrified by China Hydropower for CNY2/kW. Until 1999, CNY1 was equivalent to MMK50, which was not expensive. The Chinese yuan is higher now so the tariff per unit is more than MMK450/kW.

Solar power would be useful and effective in hilly areas, but these are restricted conflict sites so local governments and developers cannot operate there. The NEP, started by the previous government, benefitted the local people, but the present government is shouldering the project by offering some percentage to local beneficiaries.

Nang Paw creek, where Great Hor Kham is implementing a hydropower project with the ESE and MOEE, is of the highest interest for Chinese private developers, who are running hydropower projects in border areas of Town E.

Town E's main source of electricity is Shwe Li Hydropower, which charges according to government regulations. Coverage is limited, however, and some villages at the border buy Chinese electricity at a higher price. The government is planning to extend the grid but the process is slow, the areas are not accessible, and the budget is limited. Electrification projects should be well planned by closely collaborating private, public, and government sectors.

- Interview no. 9

Shwe Li Hydropower provides electricity to Town E but does not cover the whole township. All villages close to China get electricity from China. It would be better if the government could provide electrification but it remains a dream. One cannot say how long it will take the government to provide such services. It would be highly appreciated if some organisation could implement electrification projects only in the hilly areas and areas bordering China, where people have no option but to use power from China. Electrification is very important for developing all sectors.

⑥ Town F, Northern Shan (interview nos. 10–12)

Hybrid Operator Model

<u>Overview</u>

- Interview no. 10

The main source of electricity for Town F is Shweli Hydropower although the transmission line is far from the main source. The distribution area is very small and covers only three-quarters (more or less 570 households) of Town F. The distribution system is not regular and power breakdowns are frequent not only due to distant transmission lines but also insufficient electricity. Power breakdowns occur during the rainy season and in abnormal weather conditions such as high winds. Due to such breakdowns, there is power for only 10 days a month.

Not only is the capacity for electricity transmission not enough but the transmission line system is also wrong. First, the transmission line is far from the hydropower source and the supports used for cables are just short concrete lamp posts. As a result, the lines disappeared in the forests and cables, frequently intertwined amongst tree branches, causing power breakdowns. Second, the power transmission branch for Town F is in Nanmatu town, where the controlling system is located. In any system upgrade or casual breakdown of lamp posts or cable replacement works, Town F suffers power breakdowns without any notice. Therefore, it is crucial to develop, subsidise, and electrify Town F.

- Interview no. 11

National grid extension and electricity distribution services were implemented and monitored by departments (Department of Electrical Power Planning, the ESE) under the MOEE. It is not clear who the energy policy makers are. Perhaps energy policy is also under the ESE. In any case, the policy for grid extension and for distribution is not acceptable or understandable.

Based on its history, grid extension may be prioritised based on population and number of households or distance of the existing grid to the new extended areas (villages). Areas far from existing grid lines are not always considered for grid-line extension. Areas with only a few households and low population have no chance to get access to the grid. This is not acceptable. In most rural areas, especially hilly regions with minorities, almost every village has only a few households and a low population. They will never have the number of people required to be covered by the current policy. If private organisations could support or improve such areas, it would be highly appreciated.

The main source of electricity in Town F is Shweli Hydropower, which is very far from the power station. Although Town F has access to the national grid, capacity is not enough to cover the whole town. Only three-quarters (about 550 households) are connected to the national grid and they have frequent power breakdowns due to heavy rains or winds. The main source is far from Town F and it comes from Nanmatu town (grid sub-station for Town F), about 35 miles from Town F through meandering hills and forests.

The DRD is planning to implement mini-grid projects for rural electrification, but they have not yet been started. The electrification projects and plans are under the MoALI, which may confuse the residents. Electrification and its related services should be under the same department and ministry so that operations and monitoring are systematic and functional.

The residents believe that gaining access to electricity would improve education, health, and small businesses. We hope private telecommunication system developers will also enter these areas and keep the local people updated about the world. Some households in Town F use SHSs but capacity is hardly enough. The locals are eager to get access to electricity.

- Interview no. 12

The mini-grid hydropower system in Town F belongs to a local powerful figure. This project was initiated and completed in 2005. It is led by U Eike Mone, the chairman of the Ta Aung National Party and a town elder. The mini-grid's capacity is 75 kW in the day and 60 kW at night. Two dynamos are used alternately and the three branch transformers can cover 300 households.

The project's main objective is to supply power to the business of the ethnic armed group that lives in this area. Eventually, power output was more than enough for the group and it shared it with neighbouring households to use for lighting.

At the time of running this hydropower system, there were seven volunteers – two for the power station generator, three linemen to check cables and posts, one meter reader, and one for finance and administration. Most were group members. The system took fees for regular maintenance and service.

Now, there is only one volunteer (the operator), who regularly checks the power station and alternates the dynamos. There is no special maintenance work and the operator checks the gear oil, ball, oil seals, and carbon daily.

The system is simple now. The charge is MMK1,500 per household. Initially, the charge was based on MMK500 per lightbulb.

<u>Advantages and Disadvantages</u>

Advantages. The water source is sufficient. A dam or reservoir to supply water in summer would ensure sufficient hydroelectric power all year round. When hydropower is sufficient, output is stable for current per capita demand. The transmission line is not far from the main power station and there is less power loss. Maintenance poses no special difficulties. The system can be improved. The grid line can be extended to surrounding villages 2 miles from Town F and the electrification area can be increased, improving other sectors.

Disadvantages. Power output is limited and so, therefore, are the areas reached. To upgrade the system, a water reservoir should be considered, which will entail additional costs for compensation for land and construction. Covering the costs through tariffs could be a problem because most people in Town F are poor. They do not have the technical knowledge and operation experience to maintain the project, much less upgrade it. As the community has been hooked up to the national grid, the community's cooperation for this mini-grid operation may be lacking.

Conclusion

Electrification in Town F, including its downtown area, is a necessity. Current capacity cannot meet demand. The transmission line was not constructed correctly, which results in frequent breakdowns. Extending or upgrading electrification areas or the system requires not only a power source but also coordination with the local people. The water source for hydropower is in good condition and it can be upgraded. Most local people are interested in gaining access to electricity. It would be appreciated if some organisations (government and private) could implement electrification projects besides providing support for local communities.

2.3. Summary of Stakeholder Interviews

The mini-grid business is operated and implemented in various forms in Shan. Table 5.8 classifies the mini-grids by operator model.

Table 5.8: Mini-grid in Shan State, Myanmar

Model		Place	Scale	Tariff	Operator	Owner	Maintenance
Private	Private enterprise	Town B	6,300 kW	Illumination: MMK100/kWh Industry: MMK160/kWh	Private enterprise	Four stockholders	Private enterprise
		Town E	20 MW	MMK65/kWh	Private enterprise	Private enterprise, government	Private enterprise, ESE
	Local leader	Town C	640 kW	MMK35/kWh	Private enterprise	Armed ethnic group	Private enterprise

		Town F	75 and 65 kW	MMK500/bulb	Private enterprise	Local leader	Private enterprise, ESE
Community	Transfer	Town A	5 kW	MMK1000 /month	From DRD to Community	Community	Community
	Burden	Town D	160 kW	MMK100–200/kWh	Community (government loan)	Community	Community

DRD = Department of Rural Development, ESE = Electricity Supply Enterprise.
Source: Based on interviews conducted by authors.
The models are described below.

- Private operator model: Private enterprise

In Town B and Town E, a private company enters into a contract where the government owns the property but the company invests and manages the business. In Town B, private companies and residents communicate and both parties are satisfied. In rural areas, however, residents are dissatisfied with the electricity charges because they are unaware of the pricing system.

- Private operator model: Local leaders and armed ethnic groups

In Town C and Town F, armed forces are involved in electricity distribution. As company shareholders, armed groups invest in power supply. The private companies that set up the system are given overall control by the local government and tax is paid to the federal government. In some cases, the community is involved in system management.

- Community model: Community transfer

Town A is an example of this model, which enables low-cost operation by the community. The initial cost of the mini-grid is borne by government agencies and foreign funds, and the running of it is handed over to the community. The JICS transfers human resources to the community through the DRD. The community owns and manages the mini-grid. The system supposedly reduces electricity charges because it recovers only the minimum operation cost. However, electricity in this area costs MMK1,000; whether the price is lower than in other areas should be investigated.

- Community model: Community burden

Town D is an example of this model, where the government gives the residents a loan for the initial investment. The mini-grid is owned by the community, and several residents manage it. Unlike in the community transfer model, the initial cost is shouldered by the residents.

3. Operation of Mini-grids in Conflict-prone Regions

3.1. Implications of the Interview Data

First, the **private enterprise** model is larger than other models. For example, Town B produces 6,300 kW and Town E 20 MW (20,000 kW), much more than other towns (Table 5.8). As the model easily achieves economies of scale, it tends to be economically sustainable without government support. In conflict-prone regions, demand on such a scale is difficult to identify, especially in peripheral areas far from national main grid. It is difficult for private enterprises to take project risks in conflict-prone regions.

Second, the **local leader** model can provide electricity at low tariff rates. For example, the rate of MMK35/kWh in Town C is lower than in other models. This is typical of patron–client relationships. Local leaders secure the basic needs of the people, who pledge their loyalty to the leaders. This model partly sustains local politics where anti-government armed ethnic groups operate.

Third, the **community transfer** model in Town A is one where the DRD transfers the system to the community. As 60% of the system's initial cost is subsidised by the DRD, the tariff is lowered to the minimum operation cost (MMK1,000/month). As the community operates the system on its own, any profit returns to the community, improving livelihoods. Only 5 kW is generated, however. If energy were produced on a larger scale, the tariff could be cheaper.

Fourth, in the **community burden** model, the community shoulders capital and operation costs. As the model uses a government loan for the initial cost, operation cost increases, leading to higher tariff rates (MMK100–200/kWh). This model is applicable only in wealthy communities such as Town D. The beneficiaries of this model are the rich villagers who can bear the project burden. Although this model has merit in that it does not require the involvement of any party other than community members, which keeps them independent, it also preserves or widens inequity.

The **community transfer** model is most suitable for conflict-prone regions. Town A generates power on a small scale but the model can be applied on a larger scale if energy is used productively. A larger-scale mini-grid can provide cheaper electricity, which contributes to the inclusive development of smallholders, who can then detach themselves from armed ethnic groups in local patronage systems. In the Energy for Peace context, a mini-grid should be operated using the community transfer model.

3.2. Scaling Up the Community Transfer Model

The community transfer model is most appropriate when the business environment does not favour mini-grids. To what extent should we diffuse this model? A target is 50% electrification by 2020 and universal access by 2030. A feasible combination of off- and on-grid measures is required to achieve the goal.

In 2018 and 2019, a series of stakeholder workshops discussed the feasibility of attaining 50% electrification by 2020 (Table 5.9). They found that 2,000 mini-grids should be diffused by 2020, requiring 1,000 mini-grids annually, a number far larger than the one currently projected. The DRD has planned for only 100 mini-grids annually, based on the MOEE's ambitious on-grid target, which anonymous stakeholders say is not realistic.

Some of the 2,000 mini-grids will be built through a private funding model, whilst others will be provided through a community model. Between improving energy access to build peace and reducing inequality between Burmese and non-Burmese, the government should prioritise the latter, as conflict discourages mini-grid developers. The grid will eventually cover Burmese regions, but off-grid solutions delivered through community transfer are applicable to non-Burmese regions.

Table 5.9: Feasible Combinations of On-grid and Off-grid Measures to Achieve Targeted Electrification Rates (number of villages)

	Electrification Rate	Electrified Village	Non-Electrified Village	No of villages (To be electrified)	Solar Home System	Grid Expansion	Mini-Grid
Current	39%	25,000	38,899				
2020 (50%)	50%	32,000	31,899	7,000	3,000	2,000	2,000
2025 (75%)	76%	48,500	15,399	16,500	7,500	4,000	5,000
2030 (100%)	100%	64,000	-101	15,500	7,500	6,000	2,000

Source: Estimates from stakeholder meetings.