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Shaping Energy Policies to Achieve the Sustainable Development Goals in Myanmar and the Greater Mekong Subregion

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Foreword

Global energy demand and supply have been experiencing historic changes due to new and innovative ideas in the energy sector. The energy landscape has rapidly evolved over the last 10 years, most notably in the form of drastic cost reductions in renewable energy sources such as photovoltaic solar energy and the digitalisation of electricity. The Sustainable Development Goals (SDGs) of the United Nations and the Paris Accord of 2015 are being implemented globally and materialising into actionable outcomes. For example, the SDGs created a strategic framework for companies to contribute to realising the goals. However, energy-related CO_2 emissions hit a record high in 2018, well above the optimal level dictated by the Paris Accord.

Our research emphasised rural electrification through renewable power generation, using mini-grids in Myanmar and the Greater Mekong Subregion (GMS). Given the global energy challenges, we focused on three themes: (i) electricity connectivity in the region, (ii) barrier analysis of the mini-grid business in Myanmar, and (iii) energy for sustainable development. The Government of Myanmar is attempting to fulfil its promise of 100% electrification by 2030, although developments to date do not suggest it is on target to meet this goal. People do require energy for their daily living, however, so we have attempted to provide realistic solutions to real problems. We also realised that the issue is tied to many other important national issues – conflict and peacebuilding, national unity, poverty and well-being, democracy, equality, and gender – most of which are closely aligned to the SDGs. Therefore, we came to understand that a wider and more conceptual approach was also required, particularly in a young democracy such as Myanmar, which faces ethnic and religious conflicts, particularly in rural areas. For these reasons, we have chosen the above themes for this year's research.

We do hope that this report will contribute to energy policymaking in the GMS, particularly in Myanmar. We also hope that it will stimulate a wider discussion about renewable energy sources and energy policy in the region.

We would like to extend our sincere appreciation to the Economic Research Institute for ASEAN and East Asia for its continued support of our research. We would also like to thank the Parliament and the Government of Myanmar for its invaluable advice and assistance during our research.

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List of Abbreviations

AA	Arakan Army
ACE	ASEAN Center for Energy
ADB	Asian Development Bank
AHP	analytic hierarchy process
ASEAN	Association of Southeast Asian Nations
CPB	Communist Party of Burma
CSG	China Southern Power Grid Company Ltd.
CSO	civil society organisation
DRD	Department of Rural Development
EAO	ethnic armed organisation
ERIA	Economic Research Institute for ASEAN and East Asia
ESCAP	Economic and Social Commission for Asia and the Pacific
GEIDCO	Global Energy Interconnection Development and Cooperation Organization
GMS	Greater Mekong Subregion
HVDC	high-voltage direct current
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
KIO	Kachin Independence Organization
KNU	Karen National Union
LNG	liquified natural gas
MNDAA	Myanmar National Democratic Alliance Army
MoALI	Ministry of Agriculture, Livestock and Irrigation
MOEE	Ministry of Energy and Electricity
MONREC	Ministry of Natural Resources and Environmental Conservation
MOU	memorandum of understanding
MPC	Myanmar Peace Center
MRC	Mekong River Commission
NCA	Nationwide Ceasefire Agreement

NCDDP	National Community Driven Development Project
NDA-K	New Democratic Army- Kachin
NEP	National Electrification Plan
NGO	non-governmental organisation
NLD	National League for Democracy
NRPC	National Reconciliation and Peace Center
Lao PDR	Lao People's Democratic Republic
RCSS	Restoration Council of Shan State
RESCO	Renewable Energy Service Company
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goal
SEA	strategic environmental assessment
SHS	solar home system
SSPP	Shan State Progress Party
TNLA	Ta'ang National Liberation Army
UWSA	United Wa State Army

Executive Summary

Myanmar's power sector confronts two main issues – how to satisfy the ever-rising demand of electricity on the main grid, and how to electrify rural areas, including those with prior and ongoing conflicts. Although the government has been making substantial progress is solving these problems, much remains to be done. Blackouts are not uncommon, even in big cities such as Yangon, because of the lack of power capacity. Thanks to the National Electrification Plan, more villagers are enjoying access to modern electricity services, and the electrification rate now stands at 42%. But much must be done to achieve universal access by 2030.

Energy policies cannot be tackled with engineering and economics alone as they are also entwined in societal and political problems. The literature on techno-economic assessments of the power sector has been growing and can now provide alternative policy options for Myanmar. Renewable energy sources can contribute more to power generation mix than the government currently assumes. Solar photovoltaics can significantly help to expand power-grid capacity. Renewable-based mini-grids can accelerate rural electrification. However, there is a dearth of comprehensive examination of non-economic factors and socio-political and geopolitical considerations.

This report rectifies the lack of adequate research and identifies ways to contribute to sustainable development, a notion that has received increasing attention since the adoption of the 2015 Sustainable Development Goals.

Potential Role of Renewables in Electrifying Peripheral Areas and Facilitating Peace Processes

The goal of universal electricity access by 2030 requires Myanmar to bring electricity to peripheral areas, where ethnic conflicts were rife until recently or remain ongoing. Achieving the goal is a significant challenge but also offers an opportunity to reflect on rural electrification and peace processes.

Since its independence in 1948, Myanmar, a diverse country with more than 100 ethnic-minority groups, has experienced ethnic conflicts, which continue unresolved today. Large-scale energy projects such as hydropower dams exacerbated the adversarial relationship between the central government and ethnic armed organisations (EAOs). Bringing small-scale

hydropower and solar photovoltaics to rural areas could have favourable social effects by ameliorating unequal energy access.

Semi-structured interviews were conducted with stakeholders to elicit their views on the possible role of renewables in facilitating peace processes. Many interviewees agreed that decentralised renewable energy could be an important component of cooperative projects and build trust amongst local stakeholders. However, how such projects are implemented needs to be carefully examined since they might be conducted top-down. It is crucial to foster a partnership amongst the state government and existing local service providers such as EAOs and civil society organisations (CSOs). The issues such projects will be dealing with should be less political and more practical.

Such bottom-up initiatives need many more engineers, and Myanmar should enhance training programmes for them.

In addition to the primary political process of the Nationwide Ceasefire Agreement (NCA), there have been some cooperative projects between the state and region governments and EAOs. The NCA excludes many EAOs, when such cooperation should ideally be extended to NCA non-participants.

Regional Power Connectivity for Myanmar and the GMS

The main grid's lack of power capacity persists, and the government recognises the need to double it by adding approximately 3,000 MW by 2020. Such expansion is not feasible without considering social and environmental conditions, in addition to engineering and economic constraints.

Many avenues for expanding power capacity have been explored, including constructing large-scale hydropower dams, coal-fired power plants, and natural gas–fired plants that use imported liquified natural gas, which are featured in the National Electricity Master Plan. Unfortunately, all these options would take many years to implement, either because of community opposition or technical issues. Solar farms would be able to provide desperately needed electrical access in a short period but progress has been slow.

Cheaper electricity imports from neighbouring countries have emerged as a possible solution to the electrical supply shortage. Myanmar already utilises some small-scale cross-border

exchanges to meet electricity demand in peripheral regions. In recent years, the government has conducted exploratory discussions, and in some cases signed memoranda of understanding (MOUs), with the Lao People's Democratic Republic (Lao PDR), China, and India. For example, Myanmar recently announced an agreement to import 1,000 MW from Yunnan, China.

The government has taken an important step but should consider this interdisciplinary issue strategically in terms of economics, geopolitics, and environmental sustainability, according to our thorough review of the academic and grey literature. In the short term, regional interconnections will present Myanmar with a crucial opportunity to meet the growing demand for electricity in a short time. At the same time, regional power connectivity presents numerous critical issues.

Importing affordable power could directly reduce power shortages but requires investments in energy transmission infrastructure. If well done, these infrastructure improvements could also contribute to rural electrification through benefit-sharing mechanisms.

Myanmar is at the centre of an interregional energy cooperation network between South Asia (Bangladesh, India) and Southeast Asia (Lao PDR) and China. This is a potential positive first step towards fostering economic and political cooperation with other areas in the region. It could also provide Myanmar with a strategically important regional position as a 'power' bridge between South Asia and Southeast Asia and southern China. Myanmar should exploit this strategic advantage to balance relations between itself and its neighbours rather than become increasingly dependent on them for energy.

In the GMS, international connectivity has become synonymous with large-scale hydropower development. Basin-wide planning could simultaneously bring energy and environmental benefits to the region, and a strategic environment assessment could be an important first step in that direction.

Finally, strengthening the national power grid should be considered as critical to development. Myanmar has no 500 kilovolt (kV) lines, which limits the viability of cross-border power trade. The construction of such infrastructure, already in the early planning stages, is critical for low-cost imports. The system's ageing infrastructure leads to increased technical losses, which also need to be addressed.

Barriers to Development of Renewable-based Mini-grids

Mini-grid development should be accelerated to achieve equitable growth. Decentralised approaches should be considered in addition to centralised options such as national grid extension.

Mini-grids are an effective option to fill the supply gap between solar home systems (SHSs) and national grids. In rural areas, where diesel fuel is considerably more expensive than in urban centres, mini-grids powered by renewable energy may be a cost-competitive alternative to diesel generators. However, adoption of mini-grids is slow and they continue to be subsidised.

A survey questionnaire was administered to stakeholders to analyse barriers to widespread diffusion of mini-grids. A multi-criteria decision-making method – the analytic hierarchy process (AHP) – was utilised, along with k-means clustering, to rank barriers to implementation based on stakeholder evaluations.

The inconsistency amongst clusters represents the disagreement amongst each clustered group of respondents. The results demonstrate that stakeholders were divided on mini-grid implementation, making it difficult to identify a primary or dominant barrier. This differs from other countries, where a single lead barrier to implementation can be easily identified. In the social and cultural barrier survey category, opinions were divided amongst clusters of stakeholder respondents. One cluster prioritised the perception of the inferior quality of renewable energy as the biggest barrier, whilst the other cluster prioritised the educational gaps of local mini-grid developers and operators. These results show that there is no single 'silver bullet' for implementing mini-grids and that overcoming multiple barriers requires significant effort.

Financing Mini-grids

To expand mini-grids to the entire country, significant public sector financial support is required to shoulder the costs of developing mini-grid infrastructure. Myanmar can look to neighbouring countries such as Thailand for an effective financing model based on secured revenue sources such as a petroleum tax. To pursue such large-scale energy infrastructure projects, institutional reform and integration of electrification policy will be required eventually.

To secure significant government support for developing electrical infrastructure, a public financing mechanism such as a public fund is desperately needed. In a country such as Myanmar, where the banking sector is not advanced, fund mechanisms are required to achieve multi-year targets. A law providing for a rural development fund is in the final stages of approval. As the law broadly dictates that the proposed fund can be used for rural infrastructure electrification projects, it is reasonable to interpret it as permitting the use of fund revenues to support community-based mini-grid development.

The source for a potential fund could be secured through an earmarked tax such as a gasoline tax. The initial costs of a mini-grid would have to be subsidised, especially for the proposed community-based model. Current public support for one project by the Department of Rural Development is around US$180,000. The Ministry of Energy and Electricity (MOEE) reports that 2,000 rural villages need mini-grid energy systems, so roughly US$360 million is needed to achieve mini-grid targets in rural and/or conflict-prone areas. Thailand's model (Thai Energy Conservation Fund) suggests that a petroleum tax is a feasible revenue-generating option. Assuming surging urban transportation usage, an approximately 5% tax rate increase on both regular and diesel gasoline is sufficient to fund rural mini-grid development.

Ministries need to be reformed to facilitate large-scale mini-grid development. The MOEE oversees on-grid electrification, whilst the Ministry of Agriculture and Livelihood (MoALI) conducts off-grid electrification projects such as the '60-20-20' programme. As MoALI is not an 'energy' ministry, the programme it manages remains small. To enlarge the scale of the MoALI programme and integrate off-grid systems with on-grid ones, the MOEE and MoALI need to be reformed and to coordinate with each other. Ultimately, an integrated energy policy and planning body such as the previous administration's National Energy Management Committee is required, with broad authority to enact energy projects.

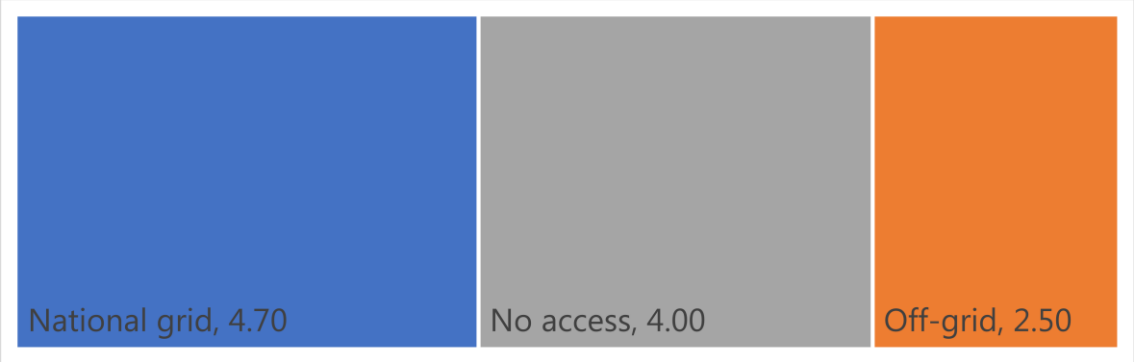
Chapter 1

Introduction and Update on Energy Policy in Myanmar

Myanmar's energy situation has not changed significantly in fiscal year 2018–19 compared with previous years. Neither have major changes been made to the institutional architecture, nor has a new energy minister been appointed. However, energy consumption continues growing, tightening supply capacity. Hydropower and gas-fired generation continue to be the national grid's major sources of electricity. In May 2019, China and Myanmar signed an agreement for Myanmar's import of 1,000 MW of electricity. Although it has not yet been implemented, the agreement represents the first major import contract for Myanmar. The government has been discussing an increase in tariffs on electricity from the national power grid. This has finally been approved and a new tariff was put in place on 1 July 2019.

The rural electrification programme is expanding rapidly but not at the desired levels. Of the country's households, 42% or 4.7 million have access to the national grid. An additional 22% or 2.5 million are served through off-grid solutions (mainly solar home systems [SHSs] and diesel mini-grids), which generally provide electricity only for limited hours but at more expensive tariffs. The remaining 36% households (4 million) do not have access to electricity (Figure 1.1) (Billen and Bianchi, 2019).

Figure 1.1: Access to Electricity in Myanmar (million households)



Source: Billen and Bianchi (2019).

Government and development partners are making great efforts to develop initiatives to diffuse mini-grid systems. However, the so-called '60-20-20' project, implemented by the Department of Rural Development (DRD) with funds provided by the World Bank's National Electrification Plan (NEP), is still the only main available mechanism. The government and parliament are also revising the electrification law to include a more robust financing scheme to scale up the implementation of mini-grids so that the government can meet its target of full electrification by 2030.

1. Generation Increases but Supply–Demand Conditions Remain Tight

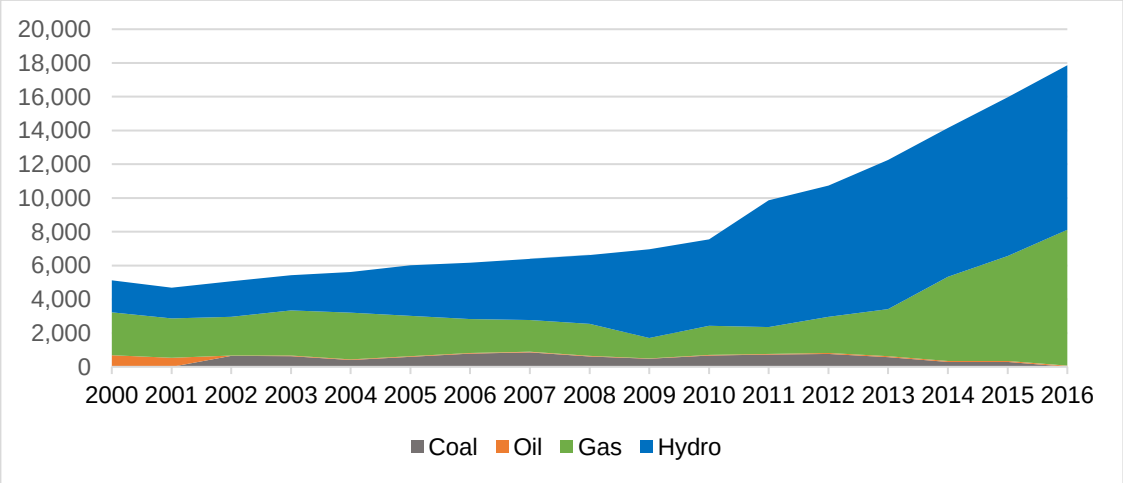
Power shortage in the national grid area continues to be one of Myanmar's gravest issues. In the 2019 dry season, power supply was cut across the country, including in the capital, Nay Pyi Taw. The shortage persists even though Myanmar has abundant endogenous energy sources that could be harnessed. The Ministry of Electricity and Energy (MOEE) has been increasing generation capacity but is facing difficulties keeping up with rapidly rising demand. The country's efforts to solve this problem are explained below.

The country has continued increasing its power generation capacity by around 300 MW per year but demand has been rising rapidly (Figure 1.2). Power is generated primarily from hydropower and natural gas. Since 2010, expansion has come mainly from gas-fired projects. Major hydropower projects have seen no progress but some construction work on new dams has occurred. The International Financing Corporation's (IFC) Strategic Environmental Assessment on hydropower, submitted to the MOEE and the Ministry of Natural Resources and Environmental Conservation (MONREC), recommends not proceeding with hydropower projects on mainstream rivers (IFC, 2018).

Renewable energy has not yet been generated despite efforts being made in that direction. Expected solar projects are still awaiting completion. The first phase of the Minbu solar project (40 MW) has witnessed several delays but is expected to supply electricity to the grid during 2019 (H. M. Htwe, 2018), with solar panels already being imported from China (Kenning, 2019). Two wind projects of 50 MW each are being planned in Chauk township (Magwe region) (N. Aung, 2018). Projects are being explored in other parts of the country (Htike, 2018), such as the Chaung Tha wind power project (30 MW) in the Ayeyarwady Region (Chau, 2019).

The government held significant discussions in 2018 on electricity imports from neighbouring countries. A memorandum of understanding (MOU) was signed with Lao People's Democratic Republic (Lao PDR) following high-level visits. Similarly, India and Myanmar have signed agreements to foster cooperation in the energy sector. However, it is the import of 1,000 MW from China that is expected to have the most significant impact on the power shortage (C. M. Htwe, 2019). The agreement with China is also of interest to Bangladesh, which could import electricity through Myanmar (Begum, 2019). Chapter 3 analyses the implications of these power import schemes for the sustainable development of Myanmar and the region.

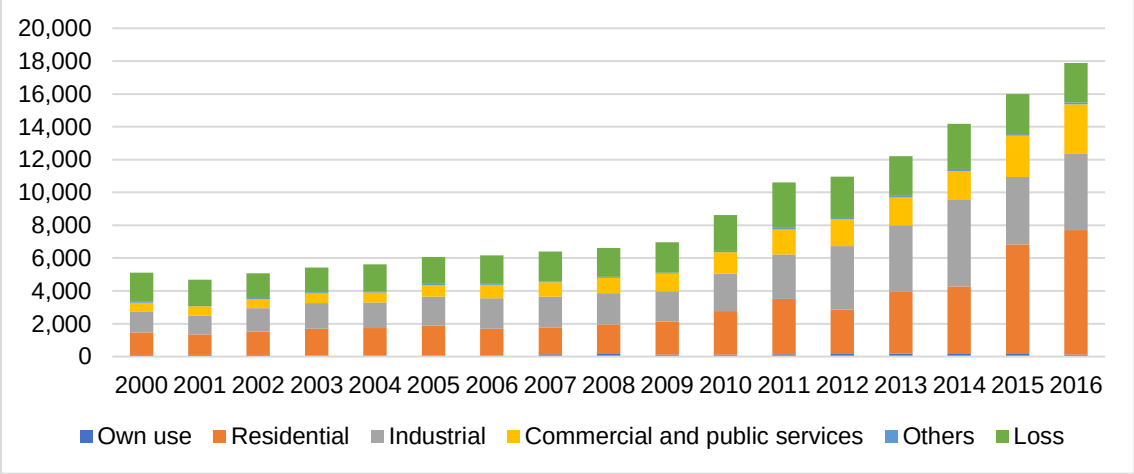
Figure 1.2: Electricity Production (GWh)



Source: IEA (2018).

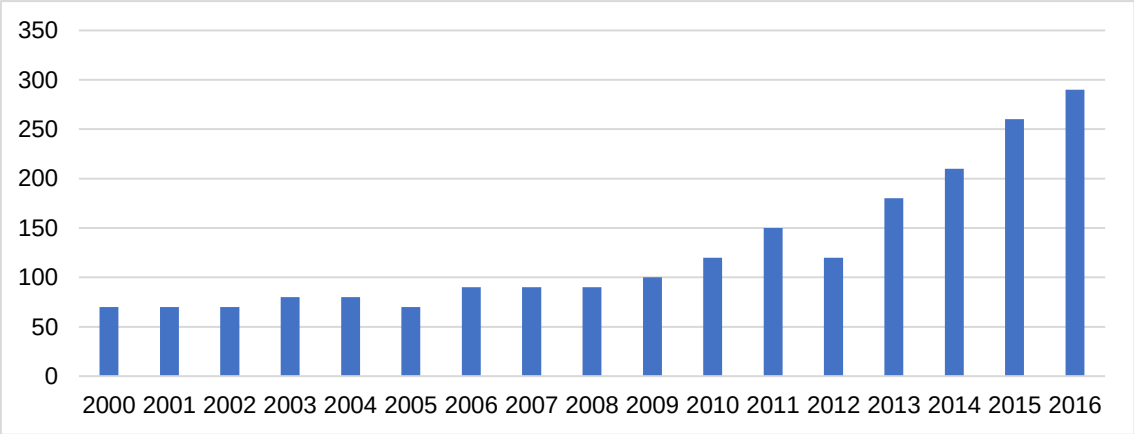
The demand for electricity continues to rise in both aggregate and per capita terms (Figure 1.3 and Figure 1.4). However, national demand is still below the average in the Association of Southeast Asian Nations (ASEAN) members, a trend expected to continue in the short and medium term and giving rise again to discussions on increasing the electricity tariff. As electrification and consumption rates increase, so do the government subsidy and consequent deficit in the sector (Thant, 2018; Thant and Htwe, 2019a), which are touching levels that challenge the MOEE's ability to finance new projects. Rural electrification needs also call for increasing funding, especially for mini-grids (chapter 5).

Figure 1.3: Electricity Consumption by End User (GWh)



Source: ERIA (2019).

Figure 1.4: Per Capita Electricity Consumption (kWh)



Source: IEA (2018).

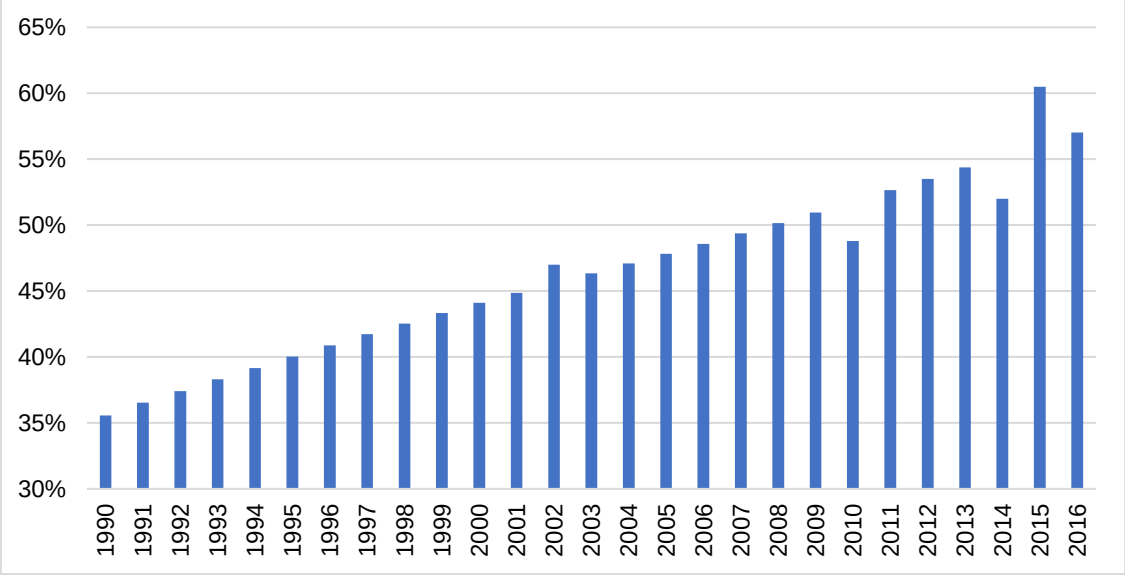
2. Rural Electrification Expands but Challenges Persist for Mini-Grids

The government is hopeful of meeting its goal of nationwide electricity access by 2030. It is committed to the World Bank–supported NEP. However, the NEP's component for expanding the national grid has not been implemented, with expansion being done by the MOEE through different funding sources. The off-grid electrification programme, however, is progressing as planned.

As a result, electrification of the country continues to progress (Figure 1.5). Although figures differ depending on their source, the national grid is estimated to reach roughly 40% of the population. SHSs are rapidly expanding in off-grid areas. An additional 20% of the population accesses electricity through isolated systems such as SHSs and/or mini-grids (diesel, solar, mini-hydro, or hybrid).

The government continues to promote mini-grid systems through the '60-20-20' programme using NEP resources. Under this scheme, the government provides a 60% grant for the project's capital expenditure, whilst the developer and the local village electrification committee provide 20% each. The NEP has allocated US$90 million out of US$400 million for off-grid electrification. Other initiatives are being launched to support those efforts. NEP data is being updated (Du Pont, 2019). The governments of Myanmar and Italy have signed a EUR30 million soft loan to support the NEP's rural electrification component (Thant and Htwe, 2019b). Nevertheless, several challenges remain (chapter 4). Chapter 2 analyses the positive impact of rural electrification on sustainable development.

Figure 1.5: Electrification Rate



Source: World Bank data (https://data.worldbank.org/).

Chapter 2

Energy for Peace and Sustainable Development

This chapter examines renewable-energy electrification and ethnic conflicts. Our point of departure is that distributed renewables can play a role in electrifying rural areas that had or have ongoing ethnic conflicts and help resolve them.

The energy situation has been analysed using a technical or economic approach, but a social approach is also needed to understand the local context in ethnic-minority areas. The energy justice theory is used as a lens for analysing the case at hand.

Since its independence in 1948, Myanmar has suffered ethnic conflicts, which have not yet been resolved. Myanmar has huge ethnic diversity, with the majority, the Bamar, accounting for about two-thirds of the population, whilst more than 100 ethnic-minority groups account for the rest. The causes of conflict date back to the colonial era and are complexly intertwined with not only ethnicity but also history, religion, politics, and interventions by neighbouring countries. The presence of natural resources such as hydropower in ethnic-minority areas is more a curse than a blessing as it sometimes exacerbates conflicts.

About 20 ethnic armed organisations (EAOs) are recognised as opponents of the Myanmar army (Tatmadaw), but they differ greatly in size, legitimacy, background, and relationship with the government. Thus far, 10 EAOs have signed the Nationwide Ceasefire Agreement, but the current peace process seems to be in a deadlock because of lack of trust.

The government prioritises economic development, believing that reducing poverty will result in decreasing conflict. However, the issue is not so simple and large-scale development programmes sometimes exacerbate conflicts, especially if they are not conflict-sensitive. A distinct example is a large-scale hydropower dam.

Semi-structured interviews with key stakeholders indicated that a cooperative programme between a state or region government and EAOs and/or local civil society organisations (CSOs) is more effective for building trust amongst local stakeholders than large-scale development programmes. To elicit smooth cooperation from both sides, such programmes

should be less political and more practical and agreeable. A good example is a health programme between a government ministry and health departments of EAOs.

Energy access has received relatively less attention than other sectors such as health care and education although it provides local benefits. To be conflict-sensitive means to implement a programme carefully. Large-scale construction is often met with scepticism, and the national grid extension would not be an exception. In contrast, decentralised power sources such as SHSs or mini-grids face smaller hurdles. SHSs are used primarily for lighting and mobile-phone charging but they are quick to deploy. Our key message is that decentralised renewable energy can be the subject of cooperative projects, which could encourage building trust amongst local stakeholders.

1. Electrification, Energy Access Injustice, and Conflicts

1.1. Energy Access

Overall Situation

The electrification rate has not yet surpassed 50%, which is low by global standards (Billen and Bianchi, 2019). The government has set a goal of 100% electrification by 2030 (Ministry of Electricity and Energy Electricity Supply Enterprise, The Republic of the Union of Myanmar, 2019). One challenge is to fully electrify peripheral regions that once had or continue to experience ethnic conflicts. Myanmar has ratified the Paris Agreement (The Republic of the Union of Myanmar, 2015), so electrification using renewable energy sources is preferable to using fossil fuels. We analysed the cost-competitiveness of renewable-energy mini-grids, which have gained attention as off-grid methods of electrification, and diesel generators (Numata, Sugiyama, Mogi, Wunna Swe, and Anbumozhi, 2018), as well as barriers and other factors unrelated to the economy (Numata, Sugiyama, and Mogi, 2018). However, '[a]ll too often, energy policy and technology discussions are limited to the domains of engineering and economics' (Sovacool, Heffron, McCauley, and Goldthau, 2016). The analysis of the energy sector has been focused on the technical side and on economic evaluations that are primarily concerned with cost, but 'social, political, and cultural domains' also need to be considered and understood (Sovacool, 2012).

As Myanmar makes progress on electrification, it increasingly faces the tough question of how to electrify peripheral regions that had and/or continue to have ethnic conflicts. Development projects in those regions, including some hydropower dams, suffered from 'energy injustice'. In recent years, the declining costs of distributed renewables began changing the energy landscape, allowing rural villages to take advantage of new technologies to gain access to modern electricity services.

This chapter examines electrification with renewables, especially in rural areas with ethnic conflicts. Our point of departure is that distributed renewables can play a role in electrifying rural areas that had and/or have ongoing ethnic conflicts, and that such a contribution could possibly help resolve them. This chapter (i) reviews the energy-justice theory; (ii) reviews the history of ethnic conflicts since the Second World War; (iii) critically appraises development and electrification projects in conflict areas; and (iv) presents the initial findings from semi-structured interviews with key stakeholders, focusing on high-level messages.

1.2. Energy Justice

Energy justice is a widely used framework for studying injustice in the energy sector (Jenkins, Mccauley, Heffron, Stephan, and Rehner, 2016; Sovacool and Dworkin, 2015). Its core tenets are distributional justice, justice as recognition, and procedural justice. Distributional justice focuses on whether public goods and public 'bads' are fairly distributed by, for example, considering whether resources and pollution are distributed fairly. Recognition-based justice focuses on who is being ignored within the decision-making process. Procedural justice is concerned with how decision-making occurs, who participates in it, and whether appropriate information and compensation are being offered to communities. Availability, affordability, due process, transparency and accountability, sustainability, intragenerational and intergenerational equity, responsibility, resistance, and intersectionality are the principles of the energy justice framework (Sovacool, Burke, Baker, Kotikalapudi, and Wlokas, 2017).

Energy and due process, energy poverty, energy resources, amongst others, have been cited as specific problems for the analytical applications of energy justice (Sovacool and Dworkin, 2015). Energy poverty is a distributive-justice problem (Sovacool et al., 2016). The effects of a decline in energy poverty include not only a decrease in health problems caused by direct indoor air pollution and a positive impact on education from access to electricity, but also a

decrease in absenteeism due to health problems and an impact on gender roles (as both cooking and gathering firewood are often considered women's roles) (Sovacool, 2012).

Hydropower dams are a topic suitable for an energy-justice framework. Internal displacement of people as a result of dam construction represents a violation of procedural justice (Sovacool et al., 2016). Siciliano, Urban, Tan-Mullins, and Mohan (2018) have analysed decision-making processes surrounding the construction of large-scale dams in Cambodia, Malaysia, Ghana, and Nigeria using an energy-justice framework. However, the framework has been used only in a study of coal-fired power plants in post-conflict Kosovo (Lappe-Osthege and Andreas, 2017).

Sovacool (2013) summarises the challenges of reviewing the literature on energy poverty in Myanmar: poverty and subsistence needs, conflicting priorities, lack of resources, and policy fragmentation. Few studies, however, consider the problem of minorities in analysing energy poverty in Myanmar. The majority Bamar also experience energy poverty, but as electrification proceeds from areas that the government can easily engage with, delays are, unsurprisingly, in minority areas, where substantial coordination is necessary to conduct electrification. Energy poverty and ethnicity are, therefore, not unrelated. Energy infrastructure and services should be distributed to all members of society regardless of 'income, race, etc.', and 'the divergent perspectives rooted in social, cultural, ethnic, racial and gender differences' should be recognised, whilst marginalised groups should be allowed to participate in decision-making and its attendant processes (McCauley, Heffron, Stephan, and Jenkins, 2013; Jenkins, Sovacool, and Mccauley, 2018). These recommendations apply to minorities, and energy injustice should be promptly corrected.

Although this chapter does not attempt to contribute to the energy-justice theory, it uses energy justice as a lens for analysing the case at hand.

2. Brief Overview of Conflicts

2.1. Ethnic Groups

Since gaining independence in 1948, Myanmar has witnessed a series of primarily ethnic conflicts in what may be described as one of the world's longest-running civil wars. The population is approximately two-thirds Bamar, with the remainder made up of various ethnic

minorities; 135 ethnic groups are recognised by the government (Central Intelligence Agency, 2019; Lall and South, 2018). Table 2.1 the major national ethnic races and their constituent subgroups.

Table2.1: Ethnic Groups[1]

Major National Ethnic Races	Number of Subgroups	Subgroups
Kachin	12	Kachin, Trone, Dalaung, Jinghpaw, Guari, Hkahku, Duleng, Maru (Lawgore), Rawang, Lashi (La Chit), Atsi, Lisu
Kayah (Karenni)	9	Kayah, Zayein, Ka-Yun (Padaung), Gheko, Kebar, Bre (Ka-Yaw), Manu Manaw, Yin Talai, Yin Baw
Kayin (Karen)	11	Kayin, Kayinpyu, Pa-Le-Chi, Mon Kayin (Sarpyu), Sgaw, Ta-Lay-Pwa, Paku, Bwe, Monnepwa, Monpwa, Shu (Pwo)
Chin	53	Chin, Meithei (Kathe), Saline, Ka-Lin -Kaw (Lushay), Khami, Awa Khami, Khawno, Kaungso, Kaung Saing Chin, Kwelshin, Kwangli (Sim), Gunte(Lyente), Gwete, Ngorn, Zizan, Sentang, Saing Zan, Za-How, Zotung, Zo-Pe, Zo, Zah nyet (Zanniet), Tapong, Tiddim (Hai-Dim), Tay-Zan, Taishon, Thado, Torr, Dim, Dai (Yindu), Naga, Tangh kul, Malin, Panun, Magun, Matu, Miram (Mara), Mi-er, Mgan, Lushei (Lushay), Laymyo, Lyente, Lawhtu, Lai, Lai zao, Wakim (Mro), Haulngo, Anu, Anu n, Oo-Pu, Lhinbu, Asho (Plain), Rongtu
Bamar	9	Bamar, Dawei, Beik, Yaw, Yabein, Kadu, Ganan, Salon, Hpon
Mon	1	Mon
Rakhine	7	Rakhine, Kamein, Kwe Myi, Daingnet, Marama gyi, Mro, Thet
Shan	33	Shan, Yun (Lao), Kwi, Pyin, Yao, Danaw, Pale, En, Son, Khamu, Kaw (Akha-E-Kaw), Kokang, Khamti Shan, Hkun, Taung yo, Danu, Palaung, Man Zi, Yin Kya, Yin Net, Shan Gale, Shan Gyi, Lahu, Intha, Eik-swair, Pa-O, Tai-Loi, Tai-Lem, Tai-Lon, Tai-Lay, Maingtha, Maw Shan, Wa

Source: Smith (1994), Embassy of the Union of Myanmar Brussels (n.d.).

Although data related to religion and ethnicity was not collected in the 2014 census, religious data was published in 2016 (Department of Population Ministry of Immigration and Population, 2015). Data on ethnicity, however, has not been published (Tun, 2017; S. Y. Aung, 2018). Roughly 100 languages are spoken within Myanmar, sometimes synonymous with ethnicity and sometimes not (Ethnologue, n.d.). Some languages have their own alphabets and some do not (Everson and Hosken, 2006). Chin state has so many languages that the

[1] The Rohingya are not included in the list of 135 ethnicities recognized by the government. As a discussion of the Rohingya would be extensive and complex, it has been excluded from this chapter.

villages on the other side of the valley may speak a different dialect (Takahashi, 2018). The official language is Burmese, the language of the Bamar (Smith, 1994).

The administrative districts are made up of seven states and seven regions, as well as self-administered zones and divisions. Most of the population in the seven regions is Bamar. The seven states are Chin, Kachin, Kayin, Kayah, Mon, Rakhine, and Shan – named for the ethnic group that makes up most of each state's population. However, the distribution of ethnicities within each state is diverse and does not necessarily coincide with the ethnolinguistic boundaries of states and regions or townships. For example, a number of Kayin (Karen) and Rakhine people reside in the Ayeyarwady region, and the ministers of Kayin ethnic affairs and Rakhine ethnic affairs both belong to the Ayeyarwady region government.

The 2008 Constitution provides for six self-administered zones (Danu, Kokang, Pa'O, and Pa Laung) and divisions (Wa in Shan state, and Naga in Sagaing region) (Office of the Civil Service Commission, n.d.).

2.2. Ethnic Armed Organisations

Myanmar has one of the longest-running conflicts in the world. The war has become entangled with the history of neighbouring countries, greatly complicating it. About 20 ethnic armed organisations (EAOs) of various sizes, degrees of sophistication, and origin operate in the country. The more influential ones have organised initiatives for education, health, and so on, and directly provide social services to the areas they control independently or through coordination with CSOs (Christophersen and Stave, 2018). For example, the leadership of an influential EAO, the Karen National Union (KNU), is determined by formal election (S. Y. Naing, 2017). Table 2.2 lists the names and acronyms of the major EAOs alphabetically.

Table 2.2: Names and Abbreviations of Active Ethnic Armed Organisations

Political Organisation	Armed Wing
ULA/**AA**	United League of Arakan/Arakan Army
ABSDF	All Burma Students' Democratic Front
ALP/ALA	Arakan Liberation Party/Arakan Liberation Army
CNF/CNA	Chin National Front/Chin National Army
DKBA (formerly DKBA-5)	Democratic Karen Benevolent (Buddhist) Army
KIO/KIA	Kachin Independence Organization/Army
KNPP/KA	Karenni National Progressive Party/Karenni Army
KNU/KNLA	Karen National Union/Karen National Liberation Army
KNU/KNLA-PC (not related to KNU or KNLA)	Karen Nation Union/Karen National Liberation Army Peace Council
KUKI	Kuki National Organisation/Kuki National Army
LDU	Lahu Democratic Union
MNDAA	Myanmar National Democratic Alliance Army
PSC/**NDAA**(-ESS)	Peace and Solidarity Committee (Mongla)/National Democratic Alliance Association–East Shan State
NMSP/NMLA	New Mon State Party/Mon National Liberation Army
NSCN-K	National Socialist Council of Nagaland–Khaplang
PNLO/PNLA	Pa-O National Liberation Organization/Army
RCSS/SSA(-S)	Restoration Council of Shan State/Shan State Army(–South)
SSPP/SSA(-N)	Shan State Progress Party/Shan State Army(–North)
PSLF/**TNLA**	Palaung State Liberation Front/Ta'ang National Liberation Army
UWSP/**UWSA**	United Wa State Party/Army

Note: Many organisations have a political wing and an armed wing but, for ease of comprehension, this chapter makes no distinction between them and uses the boldface acronym.
Sources: Tønnesson, Aung, and Nilsen (2019); Myanmar Peace Monitor (2016).

Table 2.3 summarises the modern history of Myanmar.

Table 2.3: Brief History of Myanmar

1886–1947	Britain uses two methods for colonial administration. Direct governance for Burma proper area – what is now Tanintharyi region, Rakhine state, Bago region, and Ayeyarwady region. Indirect governance in autonomous in peripheral areas. Appointment of more ethnic minorities than Bamar to the military and police, leading to ethnic divisiveness.
1943	Myanmar becomes independent with Japanese military support.
1945	Coup d'état led by Aung San overthrows the Japanese puppet state. British colonial rule is restored.
1947	First Panglong Agreement is concluded. Signatory General Aung San is assassinated.
	KNU is formed in Kayin state, southeast Myanmar.
1948	Myanmar becomes independent under its first prime minister, U Nu. Uprisings by minority peoples and the Communist Party of Burma (CPB) cause instability.
	Kachin Independence Organization (KIO) is formed in Kachin state. Shan State Army[2] is formed in Shan state, north Myanmar.
1962	Coup d'état by General Ne Win establishes a military regime, which continues until 1988 even after Ne Win retires as president in 1981. 'Burmese Socialism' is promoted.
	Tatmadaw (the military) adopts the infamous 'four cuts' strategy to deprive ethnic armed organisations (EAOs) of food, funds, intelligence, and recruits from villages. Villagers are unable to farm, are forcibly relocated and internally displaced.
1988	'8888 uprising' takes place. Demonstrations demanding democracy bring down the socialist administration after 26 years. The military seizes power under General Saw Maung.
	CPB collapses and each ethnic group forms its own EAO. In north-east Shan state: Myanmar National Democratic Alliance Army (MNDAA) of the Kokang, United Wa State Army (UWSA) of the Wa, and National Democratic Alliance Association (NDAA)

[2] This became the base of the armed wings of the SSPP and RCSS, the Shan State Army–North and Shan State Army–South.

	of the Mong La Shan and the Aka. In north-east Kachin state: New Democratic Army–Kachin (NDA-K) of the Kachin. Future prime minister Khin Nyunt concludes a ceasefire agreement allowing these four EAOs to turn their areas of control into special administrative districts.
1990	National League for Democracy (NLD) wins general elections by a landslide, but the military ignores the results and suppresses dissent. Aung San Suu Kyi is put under house arrest (three times until 2010 for a total of 15 years).
1992	Than Shwe becomes head of state and is commander-in-chief until 2011, ranking fourth on the 'World's Worst Dictators' list in 2009.
	Under pressure from the Thailand government to send back 10,000 internally displaced Mon, the New Mon State Party (NMSP) and the government of Prime Minister Khin Nyunt conclude a bilateral ceasefire. The movement for peace wanes with his overthrow in 2004.
2006	The capital is moved to Nay Pyi Taw.
2007/9	The Saffron Revolution – demonstrations by monks – sweeps the nation.
2007/10	Thein Sein becomes Prime Minister.
2008	Cyclone Nargis kills 85,000 people.
2010	NLD boycotts general elections. Union Solidarity and Development Party wins.
2011	Thein Sein administration begins.
2011	Conflicts restart between the national military and KIO. Armed organisations continue to clash in north-east Myanmar.
2012	Conflicts occur between Buddhists and Muslims in Rakhine.
2015/10	The government and eight EAOs agree to a nationwide ceasefire.
2015/11	NLD wins general elections by a landslide.
2016	NLD administration begins.
	Northern Alliance is established by four EAOs that did not agree to the ceasefire: KIO, Arakan Army (AA), Ta'ang National Liberation Army (TNLA), and MNDAA.
	UWSA (which is the largest non-state army in the world and has close relations with China), Shan State Progress Party (SSPP), NDAA, and Northern Alliance form the

	Federal Political Negotiation and Consultative Committee. UWSA takes the initiative and influences non-signatory EAOs.
	AA moves its activities from Kachin state to Rakhine state, and the southern part of Chin state then becomes very active.
2018/2	NMSP and Lahu Democratic Union sign the Nationwide Ceasefire Agreement.
2018/12	Tatmadaw announces a 4-month unilateral ceasefire covering Shan and Kachin in the north-east, where Northern Alliance is active. The ceasefire does not cover AA in Rakhine state.

Sources: Myint-U (2011); Kramer (2012); Bi (2012); Ministry of Foreign Affairs of Japan (2017); Burke, Williams, Barron, Jolliffe, and Carr (2017); Tønnesson et al. (2019); Nyein (2018b); Wallechinsky (2009); Nemoto (2014); and Kubo (2014).

Areas where minorities live are often designated as black, brown (or grey), and white. Areas controlled by the state or region government or by the Tatmadaw are white, those controlled by EAOs black, and mixed-control areas brown or grey. Access to black areas is restricted for foreigners, and no maps show detailed locations of villages. Access to brown or grey areas must also be arranged in advance by foreign visitors. As they are controlled by two forces, these areas are said to be the hardest to live in even for the villagers, as taxes are collected by both the government and the EAOs, forcing residents to work for one side or the other (Jolliffe, 2014).

Nationwide Ceasefire Agreement

The central framework for the current Myanmar peace process is the Nationwide Ceasefire Agreement (NCA). In October 2015, it was signed by the Thein Sein administration and with the agreement of eight EAOs. Since 2016, when the National League for Democracy (NLD) won the November 2015 election in a landslide, the NCA has remained in place and even gained two more EAO signatories in February 2018. EAOs differ considerably in size and legitimacy, and in whether they signed the NCA or not. Amongst non-signatory EAOs, some have agreed to bilateral ceasefires with the government and some have not. Table 2.4 shows the participation status of EAOs in the NCA. Of the approximately 20 major EAOs, roughly half are signatories. However, a total of 66,000 soldiers serve in non-signatory EAOs, including the United Wa State Army (UWSA), which is thought to have a force upwards of

30,000, whilst only 17,000, or one fourth of total EAO forces, serve in signatory EAOs (Myanmar Peace Monitor, 2016). Generally, EAOs from south-east Myanmar on the border with Thailand are signatories, whilst those in the north-east along the border with China are not (Burma News International, 2017; United States Institute of Peace, 2018). Prior to and following the enactment of the NCA, internally displaced people shifted from the southern states of Shan, Kayah, and Kayin, and the south-east region of Tanintharyi in 2006, and regrouped in the states of Kachin, Shan, Rakhine, and a portion of Mon in 2016 (Burke et al., 2017). Unfortunately, the number of battles fought within EAO states has not decreased since the signing of the NCA (Bynum, 2018).

Table 2.4: Nationwide Ceasefire Agreement and Ethnic Armed Organisations: Participation Status

NCA Signatories	**NCA Non-signatories**	
	Bilateral Ceasefire	**No Ceasefire**
RCSS	UWSA	KIO
KNU	SSPP	TNLA
DKBA	NDAA	AA
ABSDF	KNPP	MNDAA
PNLO	NSCN-K	KUKI
CNF		
KNU/KNLA-PC		
ALP		
NMSP (signed in 2018 Feb.)		
LDU (signed in 2018 Feb.)		

NCA = National Ceasefire Agreement, RCSS = Restoration Council of Shan State, UWSA = United Wa State Army, KIO = Kachin Independence Organization, KNU = Karen National Union, SSPP = Shan State Progress Party, TNLA = Ta'ang National Liberation Army, DKBA = Democratic Karen Benevolent (Buddhist) Army, NDAA = National Democratic Alliance Association-East Shan State, AA = Arakan Army, ABSDF = All Burma Students' Democratic Front, KNPP = Karenni National Progressive Party, MNDAA = Myanmar National Democratic Alliance Army, PNLO = Pa-O National Liberation Organization, NSCN-K = NSCN-K: National Socialist Council of Nagaland-Khaplang, KUKI = Kuki National Organisation/Kuki National Army, CNF = Chin National Front, KNU/KNLA-PC = Karen National Union/Karen National Liberation Army Peace Council, ALP = Arakan Liberation Party,
NMSP = New Mon State Party, LDU = Lahu Democratic Union.
Source: Myanmar Peace Monitor (n.d.-b).

NCA Signatories

The main NCA signatories are the KNU, the Restoration Council of Shan State (RCSS) , and the New Mon State Party (NMSP), which became a signatory EAO in 2018 (Tønnesson et al., 2019). The origins of the All Burma Students' Democratic Front, which began as a student movement, have indirectly had an impact on higher education in Myanmar.

The origins of the main EAOs, divided into NCA signatories and non-signatories, are described in Appendix 1.

Conflicts Between EAOs

Each EAO's relationship with the government or Tatmadaw has been different, and relations between EAOs are certainly not limited to their alliances. EAOs are often one another's enemies. The RCSS, an NCA signatory, and the Shan State Progress Party (SSPP), an NCA non-signatory, are both active in Shan. Although the RCSS is active in southern Shan, whilst the SSPP is active in northern Shan, they do not keep entirely to themselves. Since the end of 2018, combat has frequently broken out in northern Shan, displacing more than 2,000 people (Weng, 2018; Weng, 2019b). As the Shan did not welcome this conflict (Tønnesson et al., 2019), peace talks finally began between the two rival EAOs in 2019 (Asianews.it, 2019). However, the Ta'ang National Liberation Army (TNLA), which allied with the SSPP against the RCSS, has not been included in the peace talks (Weng, 2019b). Conflicts between other groups have occurred, such as between the RCSS and Pa-O National Liberation Organization and between the KNU and NMSP from 2018 to April 2019 (Bynum, 2019), and between the TNLA and the RCSS, between the UWSA and National Democratic Alliance Association (NDAA), between the Arakan Army (AA) and Arakan Liberation Party in 2015–2016 (Burma News International, 2017).

2.3. Issues with the Current Peace Process

When the NLD took power, led by current State Counsellor Daw Aung San Suu Kyi, the de facto leader of the government, people hoped that the peace process would make further progress. However, it has stalled, as evidenced by the agreement of only two EAO signatories since the NLD took over.

The NCA is not a merely an agreement to cease armed conflict but is also 'a curiously half-baked seven-chapter draft road map for arriving at a comprehensive political agreement' (Tønnesson and Nilsen, 2018). It is a road map towards national reconciliation and provides for the following:

(a) signing the NCA,

(b) drafting and adopting political dialogue,

(c) holding political dialogue and negotiating security reintegration,

(d) holding a Union peace conference,

(e) signing a Union accord,

(f) ratifying the accord by the Union parliament, and

(g) implementing provisions in the accord (The Nationwide Ceasefire Agreement Between the Government of the Republic of the Union of Myanmar and the Ethnic Armed Organisations, 2015; Institute for Security & Development Policy, 2015).

Therefore, signing the NCA also means agreeing to the road map — which provides for negotiations for security reintegration — making signing even more difficult for EAOs (Jolliffe, Bainbridge, and Campbell, 2017). There is no other official way to participate in the peace process outside of signing the NCA (Tønnesson and Nilsen, 2018). The exclusion of non-signatories has allowed the Northern Alliance to emerge and the Arakan Army, a Rakhine insurgent group, to expand (Johnson [anonym], personal communication, 12 February 2019).

Distrust between EAOs and the central government runs deep. EAOs are concerned that the Tatmadaw may use the ceasefire to prepare for action (Davis [anonym], member of an international CSO, personal communication, 5 December 2018). Regions that have signed the NCA cannot be considered to be in a 'post-conflict' state and are instead considered 'fragile' (Saferworld and Karen Peace Support Network, 2019; South et al., 2018).

Myanmar has become democratic under the NLD but the Tatmadaw continues to hold significant power. It appoints the ministers of defense, home affairs, and border affairs (Republic of the Union of Myanmar, 2008) and reserves for itself 25% of seats in parliament (Republic of the Union of Myanmar, 2008; Batcheler, 2018). The Thein Sein regime was

dominated by a large pro-military party established under the previous military administration (Kudo, 2010), and the government and the military coordinated well. However, coordination between the NLD administration and the Tatmadaw is poor, and the government is 'two-headed' (Tønnesson and Nilsen, 2018) – led by de facto political leader Aung Sun Suu Kyi and the Myanmar army commander. Before it became the ruling party, the NLD had confronted the military to demand democratisation, so it is not hard to imagine that close coordination between the formerly warring factions would be difficult. As a result, ethnic minorities are forced to negotiate with both the military and the NLD administration, which increases the difficulty of negotiations (Tønnesson and Nilsen, 2018). Compared with the previous regime, which tried to gain the trust of the EAOs, including by investing in human resources, the NLD administration, some believe, is not doing enough to foster a trusting relationship with them (South et al., 2018).

Others observe that the NLD administration is more focused than previous administrations on placing CSOs under government control (Lall and South, 2018). Environmental non-governmental organisations (NGOs) generally had 'good' access under the Thein Sein administration but only 'moderate' access under the NLD administration (Simpson and Smits, 2018).

The NLD administration replaced the Myanmar Peace Center (MPC), established under the Thein Sein administration, with the National Reconciliation and Peace Center (NRPC). The MPC had sufficient human resources, received financial aid from foreign donors, and functioned well as a platform for the peace process. EAOs and military personnel were able to converse directly in the MPC. State Counsellor Daw Aung San Suu Kyi chaired the NRPC, which has been accused of failing to serve as coordinator, a role the MPC was able to fulfil (Smith [anonym], personal communication, 12 February 2019).

The NLD government is sometimes accused of being 'Burmese-centred' (Shida, 2017). Under the constitution, the chief minister of a state can be appointed by the central government from members of the state parliament and need not be a member of the majority party (Batcheler, 2018). In Rakhine, the parliament majority is held by the Arakan National Party, but the chief minister is appointed from the NLD. Such actions are seen as marginalising ethnic minorities and encourage support for the AA in Rakhine state (Weng, 2019a). Whilst General Aung San is widely respected as the hero of independence, the government is

erecting statues of him and naming bridges after him where ethnic minorities do not have any particular connection to him, causing a backlash from these communities (Lynn, 2019; K. H. Aung, 2019).

Trust has not been fostered between the military and EAOs or between the civilian government and EAOs. The government claims that poverty reduction through economic development leads to peace but some doubt that it is that simple.

3. Development and Electrification Programmes in Conflict Areas

3.1. Sensitivity to Development Programmes in Ethnic-minority Areas, Due to Past Conflict

The narrative that raising the standard of living through economic development and prosperity discourages young people from becoming radicalised and leads to regional stability and large-scale development projects is widely celebrated. However, no clear correlation has been observed between development and subnational conflicts, even in countries that have developed rapidly, such as Indonesia, the Philippines, and Thailand (Parks, Colletta, and Oppenheim, 2013). The government touts economic development as leading to peace, but its relationship to peace building is complex and has not necessarily led to its intended results (Christophersen and Stave, 2018). Economic development can even encourage conflict in some cases (Burke et al., 2017), and implementing development programmes that ignore social and political contexts can trigger adverse impacts (South et al., 2018). For ethnic minorities, 'development' often has a negative connotation or association with the government, the military, corruption amongst EAO leaders, collusion between the government and businesses, corrupt politics, and bribery (Burke et al., 2017). Therefore, development programmes led by the government are often viewed with distrust (Christophersen and Stave, 2018; South et al., 2018).

<u>Large-scale Hydropower</u>

Large-scale hydropower generation is often the first image evoked by the words 'development' and 'energy'. Myanmar has rich hydropower resources (ADB, 2016) and the country depends on them for 56% of its generated electricity (Du Pont, 2019). Since the United Nations announced the SDGs, sustainability has been emphasised in development

projects, and hydropower generation projects often require an assessment of environmental and social impacts on the river basin, along with a conventional assessment of individual projects, to ensure that hydropower development is sustainable. The International Finance Corporation (2018) released a strategic environmental assessment of the Myanmar hydropower sector , but the MOEE logo that was in the draft was deleted in the final report. The MONREC is the only Burmese ministry listed in the report, whilst the MOEE is reported to be working on a white paper on hydroelectric policy with the Government of China (Kean, 2019). It cannot be said that the idea of sustainable development of hydropower generation is widely accepted in Myanmar. Kittner and Yamaguchi (2017) note the need for greater transparency and local engagement in large-scale dam development in Myanmar, as well as for international technical assistance.

Hydropower resources are unevenly distributed in ethnic-minority areas. Amongst the 104 dams (including those suspended and identified) listed in the hydropower database (IFC, 2017), 28 are in seven regions where the Bamar ethnic group is the majority, whilst the other 76 are in seven states. For this reason, large-scale dam development has come to symbolise the exploitation of ethnic-minority resources, which makes it difficult to build dams. Development of large-scale dams with large environmental and social impacts on local communities, such as the Myitsone Dam, was decided under the military regime without any communication with the local community and completely without transparency. Some EAOs are concerned that dam development may progress further as a result of a ceasefire agreement, as development work has become easier to conduct in areas with peace agreements (Christophersen and Stave, 2018).

The Baluchaung No. 2 Hydropower Plant (also known as the Lawpita Hydropower Station) was constructed in Kayah state as part of the first post-war compensation project conducted by Japan. After the plant began operating in 1960, it was expanded to a total capacity of 168 MW, generating 1,200 GWh of electricity annually. It generated about 14% of total power in Myanmar in 2010 (Japan International Cooperation Agency, Nippon Koei Co. Ltd., and Tokyo Electric Power Company, 2012). The Baluchaung No. 1 Hydropower Plant provides 28 MW and began operating in 1992. The two plants have undoubtedly been vital in providing electric power. In 2014, the independent power producer began operating the Baluchaung No. 3 Hydropower Plant, which had 52 MW of capacity (H. T. Lwin, 2014). The three plants are of

the cascade type, allowing them to use hydropower resources efficiently (Japan International Cooperation Agency, Nippon Koei Co. Ltd., and Tokyo Electric Power Company, 2013).

In the 1960s, however, when operations began under the military regime, the Baluchaung No. 2 plant was located in Kayah state where the Karenni National Progressive Party is active. Initially, the plant did not transmit power locally but only to the cities of Yangon and Mandalay, bringing no benefits to the area. (Since 2015, the plant has provided power to Loikaw in Kayah and Mobye and Phekon in Shan). To build the plant, 1,740 people were forcibly relocated from the site (Kramer, Russell, and Smith, 2018) and received no compensation for the seizure of their land. Residents suffered damage to agriculture and fisheries due to changes in the river basin, were forced to work as security forces for the transmission towers, and suffered injuries from landmines buried around the power plants and transmission towers (Burke et al., 2017). Not only did some residents die or become disabled as the result of stepping on landmines, but if one of their livestock stepped on a landmine and was injured, they were forced to pay the military for damage to the mines (Kubo, 2014; Pyi Pyi Thant, interview, 18 February 2019).

In recent years, more power has been provided within the state and the electrification ratio has exceeded the national average at 77% (Du Pont, 2019). Provision of electric power to nearby villages has become more stable. Wooden utility poles have been replaced with concrete ones. Blackouts caused by strong winds are nearly non-existent and any outages are planned to conduct repairs (Village development committee members, interview, 21 March 2019).

Roads and Bridges

Road construction is highly sensitive and can easily worsen conflict. The military can access an area more easily via the new road, so suspicion of bases built by the Tatmadaw for military use runs deep in EAO-controlled areas. Some are concerned over forced appropriation (without compensation) and forced emigration. On a new stretch of the Asia Highway, which connects Thailand and Myanmar and was built in 2015, a fight broke out between the Democratic Karen Benevolent (Buddhist) Army and the Tatmadaw, resulting in two casualties among the villagers and displacement of over 1,000 people (Downing, 2016; Karen Human Rights Group, THWEE Community Development Network, and Karen Environmental and

Social Action Network, 2016). In the area controlled by the KNU, which signed the NCA in 2018, 2,300 people were displaced as a result of the road upgrade by the Tatmadaw (South et al., 2018). This led to greater distrust on the KNU side (Anderson, 2018). The KNU even left the NCA temporarily in 2018 (Nyein, 2018a). Taking a conflict-sensitive approach and understanding local circumstances is important in road construction.

3.2. Trust Building Through Cooperative Projects

What triggers progress, however incremental, in a peace process? Trust between stakeholders is, no doubt, essential (Johnson and Lidauer, 2014).

Burke et al. (2017) summarise what contributes to the peace process without entrenching conflict:

- Ensure returns for the local people.
- Sufficiently consult local stakeholders, including organizations in conflict with each other.
- Plan in a bottom-up manner and leave decision making to the locals, or enhance local authority and develop capacities so that decision making can be entrusted to them.
- Ensure that the standard of living is improved.
- Ensure that the scheme aligns with the framework for the peace process.[3]
- Prevent aggravation of points of dispute (e.g. language education for the ethnic minority).
- Ensure that one side is not gaining any military benefits (e.g. by constructing roads to conflict areas).

[3] The NCA states in Chapter 6, Article 25 that a signatory EAO has responsibilities related to (i) health, education, socio-economic development; (ii) environmental conservation; (iii) efforts to preserve and promote ethnic culture, language, and literature; (iv) peace and stability, maintenance of rule; (v) receipt of aid from donors for regional development and capacity building; and (vi) permission for the execution of a project related to eradication of illicit drugs (The Nationwide Ceasefire Agreement Between the Government of the Republic of the Union of Myanmar and the Ethnic Armed Organisations, 2015).

- Accept a diverse system, respect existing service providers, and consider collaboration.

Through aid, local people can experience the dividends of a peaceful relationship between the state, EAOs, and ethnic communities, and may improve grassroots collaboration. A project managed with the cooperation of all will prevent resentment that may result from some parties benefiting at the expense of others (Jolliffe, 2014). A health sector initiative has been successful, whilst efforts are also under way for education.

Health

Cooperation in the healthcare sector between the government and healthcare providers in rural or ethnic-minority areas would improve standards of care and lead to increasing trust amongst stakeholders, which, in turn, would promote peace (Tang and Zhao, 2017). Specifically, with coordination assistance from the United Nations Children's Fund (UNICEF), the government cooperates to provide vaccination services with CSOs that are also fully supported by EAOs and local communities in EAO-controlled areas (United Nations, 2016).

Education

Some fear that education efforts will encourage conflict (Christophersen and Stave, 2018). In particular, education in ethnic minorities' own language is a critical problem. The government has approved education in ethnic languages, if needed, in Article 43 of a 2015 amendment to the National Education Law (Union of the Republic of Myanmar, 2014), starting from the primary level (Article 44). Before this law, primary education was officially conducted entirely in Burmese. Formal teaching staff in official schools continue to be predominately Bamar and the government sends them to ethnic-minority areas. However, ethnic-minority areas have a chronic shortage of teaching staff, and villagers, at their own expense, may hire staff to fill vacancies with people of the same ethnic group (Johnson [anonym], member of an international CSO, personal communication, 12 February 2019). Since 2018, five of the seven state governments have been developing a curriculum for teaching ethnic-minority languages in school (Salem-Gervais and Raynaud, 2019). Education in ethnic-minority languages is in

high demand amongst EAOs, and the discussion to coordinate government systems and existing ethnic-minority schools has just begun (Hirschi, 2019).

3.3. Energy-access Projects

Distributed Renewable Energy Sources

Distributed power generation is expanding because prices of solar panels and batteries are falling. The International Renewable Energy Agency (IRENA) reports that 63% of the generated electricity needed to achieve universal electricity access by 2030 is being supplied by off-grid electrical sources (mini-grid, 44%; stand-alone system such as SHSs, 19%) (IRENA, 2017).

- Solar Home Systems

An SHS combines a solar panel, a battery, and a controller, and has a battery charge port for mobile phones. A solar panel is installed on the roof of a residence for uses such as lighting by wiring the panel to the indoors. A particularly small system called a solar lantern features a light and consists of a charge port, a small solar panel, and a battery. More expensive models include larger-capacity solar panels and batteries and can power radios, small televisions, and DVD players.

- Mini-grid

A mini-grid is a system in which small-scale power stations such as solar, small hydropower, and biomass are connected to one or several villages by a grid. In rural areas with sparse populations, the extension of bulk transmission networks is often cost- and time-inefficient. A mini-grid can be an effective solution in such cases. Whilst it depends on the capacity of a power plant and its backup (battery and diesel generator), a mini-grid allows the use of equipment that consumes more electricity than an SHS, thus enabling productive use in addition to household uses.

Electrification by Distributed Power Sources

Distributed power generation is an effective approach to electrification and has fewer elements that might encourage conflict than the extension of a bulk transmission network in ethnic-minority areas.

The main grid is under the government's jurisdiction. Power generation that connects to the main grid is under the MOEE's jurisdiction. Transmission of over 33 kV is managed by the MOEE, whilst 11 kV distribution lines are managed by the state and region governments. The 400 V distribution line is managed by the communities themselves (Du Pont, 2019). Urban residents who live close to a distribution line are required to pay only a connection fee, whilst villagers need to bear the cost of the transformers, as well (Aung Myint, interview, 21 February 2019). The cable fee for a single village to connect to a grid is $20,000/mile, a medium-voltage cable through which several villages can connect to a grid costs $35,000/mile, a transformer for a single village costs over $10,000, and the connection fee for a household is $150–$800 (Langre, 2018). The current main grid extension worsens inequality.

In main grid extension, large-scale work cannot be avoided. It tends to be viewed with suspicion: it is perceived as seeking to expand the central government's authority. Connection to a grid can benefit the local people directly but it is inevitably seen as a government-led project. An extension of the grid to an EAO-controlled area requires sensitive adjustment and the project may become a long-term initiative. Distributed power generation, however, can be introduced independently of the central government. In reality, however, and particularly when foreign institutions are involved in implementing the project, adjustment and coordination with the state government and the EAO are done in advance (Jones and Young [anonym], members of an international CSO, personal communication, 13 November 2018).

Given that villages in ethnic-minority areas are often in mountainous areas where houses are sparse, SHSs may be more appropriate than a mini-grid for initial electrification (Young [anonym], member of an international CSO, personal communication, 13 November 2018). In contrast to rural villages in Bamar, which are in the central dry zone, ethnic-minority villages are often in high altitudes. This is in part because states where ethnic minorities live are in peripheral mountainous areas, and in part because the Tatmadaw burned down the villages when the villagers were thought, wrongly or rightly, to be cooperating with the EAO

during a conflict, and houses were more easily burned down if they were concentrated in one location (Jackson [anonym], member of an international CSO, personal communication, 10 December 2018). Ethnic minorities then moved to more inaccessible areas in the mountains. Installing a distribution line to these homes would be expensive.

National Programmes Related to Energy Access

Table 2.5 shows projects related to energy access in ethnic-minority areas.

Table 2.5: Energy-Access Projects in Ethnic-Minority Areas

	Period	Total Amount	Notes	Donor
NEP	2015–2021	USD$527 million	Grid extension: US$321.25 million Off-grid electrification: US$172.00 million Technical assistance: US$20.00 million Contingent emergency response: US$13.75 million	World Bank
NCDDP	2012–2021	US$535.5 million[4]	Transport: 53% Education: 14% Water and sanitation: 12% **Electrification: 9%** (by cumulative number of sub-projects by the end of FY 2018/19)	World Bank, Italy
Electrification project in Kayin state and eastern Mon state	2016–2019	US$4.5 million[5] (JPY495 million[6])	SHS installation, technical assistance to operators and villagers	Japan
Smart Power Myanmar	2018–		The facility was established in 2018. It is managed by Pact, a CSO.	The Rockefeller Foundation, World Bank, United States Agency for International Development (USAID), and Yoma Strategic Holdings
The Barefoot Project	2017–2019	US$400,000		Denmark, India, Finland, Energy and

[4] Total of community block grants (US$356.55 million), facilitation and capacity development (US$100.00 million), knowledge and learning (US$6.00 million), implementation support (US$54.00 million), emergency contingency response (US$18.95 million) (Bradley, 2019).

[5] US$1 = JPY110.201 (XE.com, 2019).

[6] Total of four projects.

				Environment Partnership
Renewable energy support in Kayin state	2018–2019	US$100,000		Denmark, Sweden, European Climate Foundation

Sources: World Bank (2019), NCDDP (2017), , NCDDP (2018a); NCDDP (2018b), Ministry of Foreign Affairs of Japan (2018), Pact (2018), WWF (2018), Myanmar Energy Monitor (2018), and Thit (2018).

- National Electrification Project

The NEP aims to achieve universal access by 2030 through on- and off-grid electrification (World Bank, 2019). For off-grid efforts, subsidies are provided to implement mini-grids, and SHSs are distributed. On-grid efforts are handled by the MOEE, whilst off-grid efforts are managed by the DRD. As of September 2018, mini-grids were implemented only in Burmese areas (Rodriguez and Lewis [anonym], ministry official, personal communication, 13 September 2018). SHSs are limited to regions controlled by the government (Young and Jones [anonym], member of an international CSO, personal communication, 13 November 2018).

- National Community Driven Development Project

The National Community Driven Development Project (NCDDP) aims to improve rural communities' access to small-scale basic infrastructure and services. The community itself decides what is implemented or rehabilitated and decides how the funds are used (NCDDP, 2017). The NCDDP states that it targets conflict-affected townships and considers villages that are not registered with the government as ideal sites for its projects (World Bank, 2016). However, out of approximately 40,000 total sub-projects in the 6 years leading up to FY 2018/19, transportation-related infrastructure such as roads, bridges, footpaths, and jetties accounted for over half of the projects, but electrification projects for less than 10% of the total (NCDDP, 2018b). Details such as whether the electrification project is on- or off-grid are not shown (Bradley, 2019; NCDDP, 2018a; NCDDP, 2018b). Table 2.6 shows the number of electrification sub-projects in ethnic-minority areas.

The NCDDP has a favourable reputation because of its community-oriented approach, whilst some are concerned about the quality of the infrastructure projects because Myanmar has an insufficient number of engineers (Tsuji, interview, 16 February 2019).

Table 2.6: Electrification Sub-project in Ethnic-minority Areas (number)

State	Number of electrification sub-projects (township)
Kayin	2 (Kyerinseikgyi)
Chin	1 (Tonzan) 12 (Matupi)
Mon	3 (Bilin) 6 (Chaungzon) 6 (Paung)
Rakhine	4 (Ann)
Shan	13 (Namhsan) 5 (Mabein)
Tanintharyi region	2 (Tanintharyi)
Kachin	0
Kayah	0

Source: Lee [anonym], ministry official, email (2 November 2018).

Electrification Projects in South-east Myanmar

The BHN Association, an international NGO, installs SHSs in parts of KNU-controlled areas in Kayin and Mon states. The project is funded through the Grant Aid Project of the Government of Japan in partnership with the Nippon Foundation, and manages the selection of contractors through a bidding process, arrangement, and monitoring after completion, whilst villagers are trained in the basics of using electricity. Volunteers are solicited from amongst the villagers to operate and maintain SHSs in current and future target villages and dispatched to installation work (Ministry of Foreign Affairs of Japan, 2018).

- Smart Power Myanmar

The facility, established by Pact and The Rockefeller Foundation, aims to mobilise funds to support the rollout of mini-grids and other solutions through public–private partnerships for rural electrification. Other founding members of the facility are the World Bank, the United States Agency for International Development (USAID), and Yoma Strategic Holdings (Pact, 2018).

- The Barefoot Project

SHSs are provided to rural households, and women in villages are trained to install and maintain them. The project aims to empower women, as well (WWF, 2018). The project is for 2 years (2017–2019), with a budget of around US$400,000 (Manandhar, email, 6 June 2019).

- Renewable Energy Support in Kayin State

WWF and the Kayin state government signed an MOU for advisory assistance on renewable energy planning (Myanmar Energy Monitor, 2018; Thit, 2018). The term is for 1 year, during 2018 and 2019, and the budget is around US$100,000 (Manandhar, email, 6 June 2019).

4. Stakeholder Perspectives

This study relied on semi-structured interviews, which are open frameworks that enable communication in both directions through conversations. Unlike questionnaires, detailed questions do not need to be prepared if mutual associations between topics are clearly identified before the interview. Questions can be added during the interview and flexibility is afforded to both the interviewer and interviewee (Food and Agriculture Organization of the United Nations, 1990).

Given that the study involved sensitive matters such as peace processes and conflict, the authors conducted open interviews or engaged in conversation when the semi-structured form was difficult to follow or when topics were too difficult for the interviewee. Table 2.7 shows the list of interviewees. Open and semi-structured interviews were conducted on 10–14 September and 3–13 December 2018, 10–23 February and 19–23 March 2019, in Yangon; Nay Pyi Taw; Hpa-an (the capital of Kayin state); Ah Lel Chaung village tract, PhoungPyar village, Lawksawk township (Burmese: Yatsauk) township, Taunggyi district, Shan state; and Ngwe Taung village, Ngwe Taung village tract, Demoso township, Loikaw district, Kayah state. Additional interviews were conducted in person and via Skype in Tokyo, Japan, during the same period. Interviewees from local CSOs were active primarily in Kayin state and south-east Myanmar. In Kayin, the dominant EAO was the KNU, which was a leading EAO amongst the NCA signatories. International CSOs have been more active in Kayin than in other areas

and were able to conduct interviews with multiple stakeholders there. The interviewees include those in charge of the overall peace process.

Table 2.7: Interviewees

	Semi-structured	**Unofficial/Open**
Myanmar government officials	1	3
Foreign government officials		2
International CSO members	8	11
Local CSO members	6	1
International organisation members	1	1
Academia members	2	
Village committee members		6
Total	18	24

5. Findings and Conclusions

Energy access is the key issue to be resolved. To achieve universal access, peripheral areas with ethnic conflicts need to be electrified. Ethnic-minority and rural Bamar areas have endured unequal energy access, which has not been discussed widely. National programmes such as NEP off-grid electrification can reach government-controlled areas but may have difficulty going into EAO-controlled areas, where ethnic-minority CSOs have worked to improve villagers' livelihoods. Some local CSOs have provided social services but not energy and electricity.

Regrettably, energy has often been associated with resource exploitation because of experiences with large-scale hydropower development in conflict contexts. However, technological innovations make off-grid renewable power sources more affordable. SHSs are easy to deploy and not politically divisive. They are used mainly for lighting and mobile-phone charging, which greatly improve people's livelihoods. Mobile phones and social networking services have spread rapidly all over the world, including rural Myanmar. SHSs suit local needs.

The peace process has reached a stalemate and trust amongst stakeholders has not been built. The framework takes a top-down approach, such as the Union Peace Conference and large-scale economic development. A bottom-up approach is necessary. Both sides – the government and Tatmadaw, and EAOs – agree that improving the standard of living of villagers in conflict areas is a matter of great urgency. Livelihood projects not only provide returns to local villagers but also create opportunities to build trust at the grassroots. Collaboration amongst state and region governments, EAOs and ethnic-minority groups, and CSOs is necessary to ensure the success of energy projects. All stakeholders must meet often and remain in constant contact. Frequent meetings are important to build relationships. Stakeholders collaborate in the health sector and they could also develop off-grid renewables. Overall, having multiple connections amongst stakeholders in different sectors is desirable.

The following are our findings from the interviews.

Aid must meet the community's needs.

Aid programmes must understand local needs (South, interview (Skype), 27 March 2019; Williams, interview, 22 February 2019). Local stakeholders need to be engaged and community needs understood thoroughly. Otherwise, a minor malfunction will lead to the project being abandoned.

Trust can be built through bottom-up cooperative projects.

Collaboration between the state government and EAO or ethnic-minority CSO is effective in building trust from the bottom up. Cooperating on 'low-hanging fruit' or areas on which stakeholders can easily agree will foster trust from the bottom up. Initiatives are already under way in health and education, and distributed energy can be another area of cooperation.

Frequent exchange and contact are important.

Cooperative projects create opportunities to meet stakeholders. In Myanmar, frequent face-to-face meetings are important to build and sustain relationships. Relationships based on personal networks are vital for relationships amongst organisations. In addition to the Union Peace Conference, the 21st Century Panglong conference occasionally takes place at top levels. Bilateral meetings that take place frequently at the grassroots are meaningful (Takahashi, interview, 11 March 2019).

Further diffusion of mobile phones assisted by SHSs may reduce the digital divide.

Mobile phones are a necessity, and they need electricity. When asked how widespread mobile-phone use is in rural areas, the interviewees had varied answers. Some said that almost everyone had mobile phones, even in rural areas (Takahashi, interview, 11 March 2019; Tsuji, interview, 16 February 2019; Aung Myint, interview, 21 February 2019; Anderson [anonym], member of a local CSO, personal communication, 9 December 2018). Others pointed out that many people in ethnic-minority villages still did not own phones, and some of those who did had connectivity problems (Allen [anonym], member of a local CSO, interview (Skype), 28 February 2019; Smith [anonym], member of an international CSO, personal communication, 12 February 2019; Young [anonym], member of an international CSO, personal communication, 13 November 2018). In 2017, the overall mobile-phone penetration rate was 81.5%, with an average of 76.6% in rural areas. The gap in ownership rates was likely because of the difference in purchasing power rather than underdeveloped infrastructure (Central Statistical Organization, UNDP, and World Bank, 2018). There were cases where a powerful figure in the village gave away a used mobile phone to a villager (Takahashi, interview, 11 March 2019). Throughout the interviews, the need for mobile phones was pointed out strongly, especially by younger people (Aung Myint, interview, 21 February 2019; Anderson [anonym], member of a local CSO, personal communication, 9 December 2018). Mobile phones and lighting can be charged using solar lanterns. If mobile-phone batteries can be charged using distributed power generation, villagers will no longer need to pay shops the relatively high prices to charge their phones. In line with the global trend, social networks have spread tremendously. Connecting to a social network is not only strongly desired but also believed to help reduce the rural digital divide.

Many SHSs do not last long and need to be improved.

Some interviewees thought that the lifespan of an SHS was approximately 2 years (Tsuji, interview, 16 February 2019; Aung Myint, interview, 21 February 2019; Williams, interview, 22 February 2019). The SHS battery lasts 1.5–2 years (Manhar, Latt, and Hilbert, 2018).

A solar panel battery lasts 25 years or more, lithium 10 years, and lead 4–5 years. However, 2 years is realistic for products available on the market. Since SHSs are affordable, many buyers tend to check whether the light turns on or not at the time of purchase, and believe

they can simply buy a replacement if the product breaks (Aung Myint, interview, 21 February 2019).

Roads must be constructed in consultation with local communities.

Many interviewees pointed out how crucial roads are to village development (Zar Ni, interview, 11 February 2019; Tsuji, interview, 16 February 2019; Takahashi, interview, 11 March 2019; Anderson [anonym], member of a local CSO, personal communication, 9 December 2018). When roads are built and people move in and out of villages, products from the village can be sold in markets and an industry can be created. Social services can be accessed more easily. Some in ethnic-minority areas become isolated during the rainy season. Many communities welcome the construction and upgrades of roads and bridges (South et al., 2018). However, roads can exacerbate a fragile situation. It is important to consider the local context and to facilitate the appropriate consultation process.

Chapter 3

Interconnection and Sustainable Development in the Greater Mekong Subregion

Myanmar needs to increase its generation capacity in the short and medium term to meet rapidly growing demand. Blackouts are not uncommon even in big cities such as Yangon. In the short term, the government expects to double supply by 2020 by adding about 3,000 MW. Although different options are available, social, economic, and environmental constraints hinder efforts to secure steady, undisrupted power supply.

Hydropower is dominant in the energy mix, and although the potential for expansion is vast, major projects are not progressing as planned. Coal is expected to make up over one-third of the total power mix, according to the National Electricity Master Plan. However, social protests and national government policy guidelines indicate the difficulties in realising it. Solar energy has been proposed and projects are in the pipeline, but with little progress in implementation. Wind power has not moved beyond the pilot phase. Liquified natural gas (LNG) projects are expected to meet demand, but concerns still exist about financial viability, the price tag, the remaining time until the projects start, and the options after that.

Cheaper electricity imports from neighbouring countries have emerged as a possible alternative. Myanmar already has some small cross-border exchanges to meet its own demand. Recently, the government held exploratory discussions; signed MOUs with Lao PDR, China, and India; and announced an agreement to import 1,000 MW from Yunnan, China.

In this chapter, we analyse the possibilities for Myanmar to benefit from regional power trading, and the overall geopolitical consequences of regional power transfers. We thoroughly review academic and grey studies. Our analysis finds that power imports can have a direct positive impact on Myanmar's ability to reduce its power shortages. Nonetheless, investments in transmission infrastructure are needed to decongest the system. If done well, they can contribute to electrification of the periphery through benefit-sharing mechanisms. These interconnections (with China, Lao PDR, Bangladesh, and possibly India) can position

Myanmar at the centre of interregional energy cooperation between South Asia and Southeast Asia and China, which would foster economic and political cooperation elsewhere in the region.

Asia is gradually increasing interconnectivity. Sub-regions are integrating their electricity systems. Energy ministers have agreed to prepare a road map under UN-ESCAP's leadership. Myanmar is part of several regional initiatives and a neighbour to two sub-regions active in power interconnectivity – South Asia and Southeast Asia. Myanmar can become a 'power' bridge between South Asia and Southeast Asia and southern China. Myanmar should strategically balance its relationships with its neighbours and not become overdependent on any of them.

1. Introduction

1.1. Background

Myanmar needs to generate more electricity. The country suffers frequent blackouts and brownouts even in major cities such as Yangon and Mandalay. Regional power connectivity has been one of the hottest topics on Southeast Asia's energy agenda for the last 30 years. Regional economic cooperation was launched to promote peace after the end of the Cold War. Energy was a front runner in showing the benefits of regional cooperation. Since then, regional power trade has grown dramatically due to successful agreements and institutions. Integration, however, has not deepened, although it is fair to say that it has expanded. This has created new challenges. As Lao PDR has increased its hydro generation in the Mekong and its tributaries, for example, CSOs have stepped up their opposition to it.

Myanmar has been considered an important potential source of hydro-based power generation in the regional mix, but the situation is shifting. Hydropower generation has not been realised and the government has initiated negotiations for the possible importing of electricity from neighbouring countries.

1.2. Objective and Methods

This paper aims to understand the implications of developing the infrastructure required to import power for sustainable development.

So far, Myanmar has been considered only a potential exporter of electricity to the region based on its hydropower potential. It exports to China and has signed an MOU with Thailand (although no project has been realised yet). Myanmar also imports small amounts of electricity from its neighbours to electrify the border areas: from China for Muse, from India for Tamu, and from Lao PDR for Shan state. The government is in talks with neighbouring countries to import electricity to secure the national grid supply in the short and medium terms. The implications for sustainable development in Myanmar and the region need to be understood further.

Myanmar's interconnections with its neighbours are linked to geopolitical factors such as the rapidly increasing penetration of variable renewable energy, which drives the development of transboundary power trade or 'super-grids'. Research is being conducted to explain the drivers and consequences of super-grids (Overland, 2019; Scholten and Bosman, 2016), as well as particular case studies (Escribano, 2018). International initiatives are paying attention to the potential of transboundary power trade, such as the Regional and Global Energy Interconnection Initiative by the Clean Energy Ministry and IRENA's Clean Energy Corridors.

Regional research has focused on power connectivity in the GMS (ADB, 2008; Krongkaew, 2004; Yu, 2003). Formerly known as the Indochina Peninsula, the GMS covers all the countries crossed by the Mekong. Upstream countries (China, Myanmar, and Lao PDR) are endowed with high potential for hydropower generation, which can be used to export low-carbon generation to downstream countries (Thailand, Viet Nam, and Cambodia). However, developing power plants in the mainstream of the Mekong can have severe ecological and socio-economic effects across the basin.

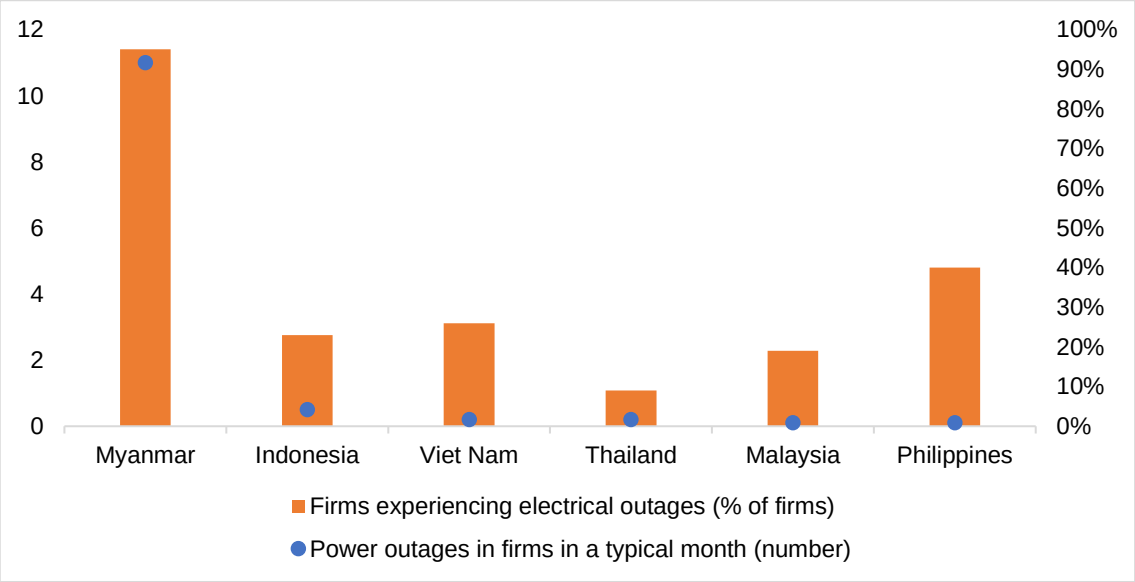
1.3. Structure

This chapter begins with an overview of the rationale for Myanmar's efforts to look for import opportunities and describes the possibilities being explored. The second part analyses the implications of regional power trade for the GMS's sustainable development. The next part explores how Myanmar can link South Asia and Southeast Asia and southern China. Finally, the chapter recommends policies for the country and international community to link new energy and revenue alternatives for sustainable development.

2. Myanmar's Tightening Power Supply and the Emergence of Imported Alternatives

Myanmar's State Counsellor has committed to increase the government's efforts to expand generation capacity to avoid shortages (Xinhua, 2019). The MOEE's new objective is to double generation capacity by 2021 (S. Naing and Lee, 2018). Myanmar suffers frequent power blackouts and brownouts (Phone Kyaw, 2017; Shin, 2014, 2016). The tightening between peak demand and installed capacity is strongly linked to dependency on hydropower generation, which is down during the dry season. Power shortages have a great impact on people's lives and businesses (Peel, 2017), especially in Myanmar (Figure 3.1). Studies and analyses have evaluated the economic impact of power outages in Cambodia (Hoekstra, 2019) and South Asia (4%–7% of GDP a year) (Zhang, 2019).

Figure 3.1: Power Outages Affecting Firms (per month and share of firms affected)



Source: World Bank data (https://data.worldbank.org/), IEA (2017).

Myanmar has various endogenous energy resources: vast hydropower potential, natural-gas fields, and a large potential for solar energy (Table 3.1). But social, environmental, economic, and political considerations have prevented their further development. Hydropower capacity remains constrained because of opposition to the construction of large-scale dams and the complexities of implementing projects in some areas where EAOs and the national government are in conflict (del Barrio Álvarez, Numata, Yamaguchi, and Yoshikawa, 2018). Solar projects have been delayed

or terminated, so that the first phase was connected in the summer of 2019 (Eleven Myanmar, 2019). While solar projects are not included in official capacity expansion plans (del Barrio Álvarez and Sugiyama, 2018), recent changes indicate renewed interest in promoting new solar projects (Lynn and Kean, 2019).

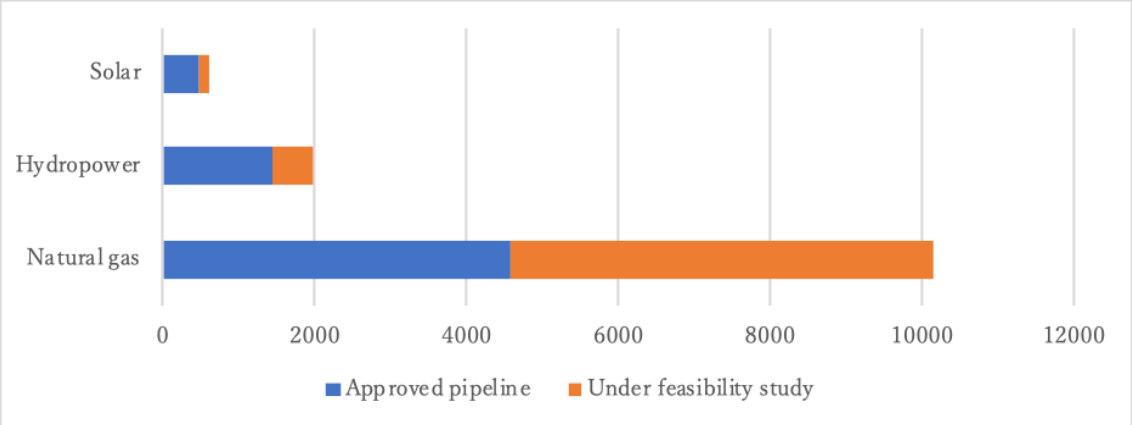
Table 3.1: Endogenous Energy Resources in Myanmar

Resource		Reserve
Hydropower		> 100 GW (estimate)
Crude oil	Onshore	102 MMbbl (proven)
	Offshore	43 MMbbl (proven)
Natural gas	Onshore	5.6 TCF (proven)
	Offshore	11 TCF (proven)
Coal		540 million tons (estimate)
Wind		365.1 TWh/year
Solar		52,000 TWh/year

MMbbl = million barrels, TCF = trillion cubic feet.
Source: MOEE (2018).

The pipeline of power generation projects is dominated by gas-fired plants, followed by hydropower and some solar energy plants (Table 3.2). In 2018, the MOEE signed four power purchase agreements (PPAs) for gas-fired power plants using imported LNG (Figure 3.2), which should allow doubling power generation by adding 3,100 MW in 2021 (S. Naing and Lee, 2018).

Figure 3.2: Ministry of Energy and Electricity's Pending Power Generation Projects (MW)



Source: Du Pont (2019).

Table 3.2: Approved LNG Projects

Project	Region	Power (MW)	Companies	Project Duration (months)
Mee Laung Gyaing	Ayeyawady Division	1,350	Zhofy (China), Supreme (Myanmar)	36 (first phase), 42 (completion)
Ahlone	Yangon Division	356	TTCL (Thailand)	28
Kanbauk	Dawei District	1,230	Total (France), Siemens (Germany)	36 (first phase), 48 (completion)
Kyaukphyu	Rakhine State	135	Sinohydro (China), Supreme (Myanmar)	28

Source: Kean (2018a, 2018b); Khidir (2019).

3. Emergence of the Regional Power-trade Option

Importing electricity from neighbouring countries has raised the idea that an alternative could be cost- and time-effective. Although the cases are not directly comparable, Thailand is importing electricity from Lao PDR at less than US$0.04/kWh, whilst Cambodia imports from Lao PDR at a rate of about US$0.09–US$0.10/kWh (Ministry of Energy and Mines, Lao PDR, 2015). Yunnan accounts for a large surplus of hydropower generation and Bangladesh benefits from imports of electricity from India. Table 3.3 summarises Myanmar's current and future power cooperation with its neighbours.

Table 3.3: Power Cooperation Between Myanmar and Its Neighbours

Thailand	MOUs signed. Thai companies have been seeking hydropower projects in Myanmar but plans are not progressing.
Lao PDR	MOU signed to explore further trade. Exports 3 MW for border electrification.
India	Bilateral cooperation at different levels, including on energy, is a priority. Exports power to electrify border towns.
China	Jointly developed hydropower in Shweli. Myanmar exports and imports small amounts for border electrification in Muse. Yunnan province has a large hydropower surplus, which sometimes needs to be curtailed. Three options for power trade are being explored. An agreement for the import of 1,000 MW has been announced.
Bangladesh	Its government has shown interest in importing electricity from China through Myanmar.

Source: Authors.

3.1. Thailand

Thailand imports natural gas from Myanmar and has been seeking to import electricity as well. Electricity would come from hydropower projects to be developed under schemes similar to those in Lao PDR. In 1997, an MOU was signed for Thailand to import up to 1,500 MW from Myanmar. The MOU expired in 2010 and, since then, new projects have been explored (EPPO, 2016).

Thailand could also provide valuable exports to south-east Mynamar, parts of which are still not connected to the national grid. Tanintharyi region depends on fuel oil generators, resulting in higher tariffs than those subsidised through the national grid (N. L. Aung, 2018).

3.2. Lao People's Democratic Republic

Lao PDR is often called the 'battery of Southeast Asia' because of its large hydropower potential and low internal electricity demand. It is the largest power exporter in the region and has been exporting electricity, including to Thailand, since the 1970s, after the construction of the Nam Ngum Dam. The construction of export-oriented dams restarted in the 1990s with the Xe Set hydropower dam, a front runner of the GMS programme. Since then, Lao PDR's hydropower export potential has continued to grow with the construction of additional dams. Electricity is mostly exported to Thailand and Cambodia. Studies are being conducted with Viet Nam for power trade (ANN, 2018). Lao PDR imports electricity mostly for areas bordering Thailand, China, and Viet Nam.

On 16 January 2018, Myanmar and Lao PDR signed an MOU for the export of 300 MW (Xinhua, 2018b), a qualitative upgrade from the current 5 MW that Myanmar imports from Lao PDR (Xinhua, 2018a) for its border areas. A joint working committee was formed to implement the MOU and held its first meeting in June 2018 (Pongkhao, 2018). The energy ministers of both countries met in February 2019 (Myanmar News Agency, 2019).

3.3. China

Myanmar and China have developed several joint energy projects. The gas and oil pipelines and the Shwelli power plant are the most representative of these efforts. Soon, one of four LNG power plants proposed in Myanmar will be built by a Chinese company. The China-

backed Asian Infrastructure Investment Bank contributed to the Mingyan gas-fired power plant. Cooperation has continued even after the paralysis of the Mytsone dam, which caused economic damage to Chinese developers, whose future remains unclear.

The large-scale expansion of hydropower capacity in Yunnan has triggered interest from China's government in exporting power to its southern neighbours, including Myanmar. Lao PDR imports energy from China at about US$0.08/kWh. Curtailment of hydropower in Yunnan opens an opportunity to optimise existing resources through transboundary power trade (Liu, Liao, Cheng, Chen, and Li, 2018; Magee and Hennig, 2017), which is part of China's foreign policy and international expansion efforts. Power interconnection is a pillar of the Belt and Road Initiative (Cohen, 2015; Duan, Ji, Liu, and Fan, 2018; Mathews and Huang, 2018; Hurley, Morris, and Portelance, 2018; Karim and Islam, 2018). China is becoming increasingly active in dam building abroad (Siciliano, Del Bene, Scheidel, Liu, and Urban, 2019).

In 2018, three projects for Myanmar to import energy from Kunming, China, were proposed. China Electric Power Equipment and Technology and the state-run China Southern Power Grid (CSG) will construct a high-voltage line to carry the imports. Yunnan International (a subsidiary of CSG) will utilise an existing transmission line. The projects can be completed in up to 5 years, sooner than the construction and connection of new hydropower plants (KDNG, 2017). The MOEE recently announced the decision to import up to 1,000 MW from China (N. Lwin, 2019).

3.4. India and South Asia

India once sought to increase its electricity supply by developing hydropower dams in Myanmar but abandoned the idea. Relations between the countries were suspended because of international sanctions imposed on the Myanmar military regime beginning in 1988. The political situation has evolved dramatically since sanctions ended and both governments are seeking increasing cooperation.

In 2016, the Ministry of Education of Myanmar and the Ministry of Renewable Energy of India signed an MOU to collaborate on capacity building in renewable energy. In December 2018, during a state visit of the President of Myanmar to India, the India–Myanmar Joint Statement was issued, signifying the deepening of relations between both nations (Government of India,

2018). The Myanmar–India Joint Steering Committee coordinates the promotion of cross-border electric power trade. Myanmar has joined the International Solar Alliance promoted by India. Both countries have agreed to increase cooperation through the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC). India is also a dominant actor in the South Asian regional power trade through the South Asian Association for Regional Cooperation (SAARC).[7] Although Myanmar is not a member of SAARC, the SAARC countries are members of a major regional initiative – the South Asia Subregional Economic Cooperation (SASEC).[8]

Hydropower Trade Between Bhutan and India

The Government of India and the Royal Government of Bhutan have signed an agreement to further develop hydropower through the public and private sectors. India's government agreed to import a minimum of 10,000 MW hydropower from Bhutan by 2020 to develop projects under the clean development mechanism, using India's carbon emission baseline. There are three projects running in Bhutan – Chukha (336 MW), Kurichu (60 MW), and Tala (1020 MW) (P. Wijayatunga and Fernando, 2013). India will provide electricity to Bhutan in winter.

Hydropower Trade Between India and Nepal

The exchange between India and Nepal has not grown in recent years because of the lack of commercial initiatives (P. Wijayatunga and Fernando, 2013). Nepal cannot meet its own demand. Two venture capital firms are constructing a 400 kW, 126 km transmission line between Dhalkebar and Muzaffarpur as part of a project that commenced in 2015.

India–Bangladesh Cross-Border Electricity Trade

Bangladesh is facing power shortages because of low generation capacity, insufficient energy resources, and inefficient turbines. Natural gas serves about 90% of total electricity generation. Trade in power between India and Bangladesh is in the planning stage. Two projects with a total capacity of 600 MW coal-based plants were built in 2015. The first HVDC of 500 MW between Berhampur (east India) and Bheramara (west Bangladesh) was

[7] Afghanistan, Bangladesh, Bhutan, India, Nepal, the Maldives, Pakistan, and Sri Lanka.
[8] Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, and Sri Lanka. ADB is the secretariat.

completed in 2013. India's part was supported by local funding and Bangladesh's by the Asian Development Bank (ADB).

India–Pakistan Electricity Trade

Pakistan is facing an approximately 30% shortage of peak demand. Since 2005, energy demand has been rising, and about 9,000 MW are needed in the next 3–4 years. There are no transmission lines between India and Pakistan, but they have been discussing electricity imports from India to meet Pakistan's energy requirements.

Central Asia–Afghanistan Power Transfer and Central Asia–South Asia (CASA-1000)

Afghanistan's power system is supported by 500 GWh from Turkmenistan, Uzbekistan, Tajikistan, and Iran. The project was motivated by the abundant hydropower in Tajikistan and the Kyrgyz Republic, and will benefit Pakistan and Afghanistan. Pakistan will be able to import 1,300 MW of electricity at $15 per MWh, down from $132 per MWh.

India has traditionally been an energy importer (Rahman, Wijayatunga, Gunatilake, and Fernando, 2011). Since 2017, however, it has been looking at possibilities to export electricity to its neighbour. Recently, it opened a short-term market to facilitate electricity exports (FE Bureau, 2019; IANS, 2019)

4. Regional Power Trade and Sustainable Development in the GMS

4.1. The GMS Energy Cooperation Programme

The GMS is home to one of the most advanced regional power-trade programmes in Asia. Since 1992, the six members countries – Cambodia, Yunnan and Guanxi provinces of China, Lao PDR, Myanmar, Thailand, and Viet Nam – have been developing numerous initiatives on infrastructure for regional cooperation and integration. Energy has been a key area of cooperation since the programme's inception. The development of the 45 MW Xeset hydropower plant in Lao PDR and an associated PPA with Thailand can be considered the forerunner projects of the programme.

On 21–22 October 1992, the First GMS Ministerial Conference was held at ADB's headquarters in Manila, Philippines, initiating a process to identify a priority energy project, evaluate potential impacts, and conduct feasibility studies and assessments of the barriers to

developing a regional electricity market in the GMS. In 1995, the first ADB-funded sub-regional energy sector study was commissioned. In 1999, the World Bank prepared the Power Trade Strategy for the GMS. In 2002, during the First GMS Summit of Leaders in Phnom Penh, Cambodia, the Intergovernmental Agreement on Regional Power Trade was signed by all member countries. The Regional Power Trade Coordination Committee (RPTCC) was created to supervise further developments. The design of the Regional Power Trade Operating Agreement, whose final report was submitted in 2004 at the third RPTCC meeting, includes a gradual process comprising the following (ADB, 2008; Alexander, 2018):

- Stage 1: One-way power sales under a PPA from an independent power producer in one country to a power utility in a second country, using established dedicated transmission lines
- Stage 2: Trading between two countries, initially using spare capacity in dedicated stage-1 transmission lines, and eventually using a third country's transmission facilities
- Stage 3: All countries interconnected with 230–500 kilovolt lines will introduce centralised operations with a regional system operator that will facilitate third-party participation in trading (entities other than generators, sellers and utilities, and purchasers)
- Stage 4: All countries accept legal and regulatory changes to enable a free and competitive electricity market with independent third-party participation

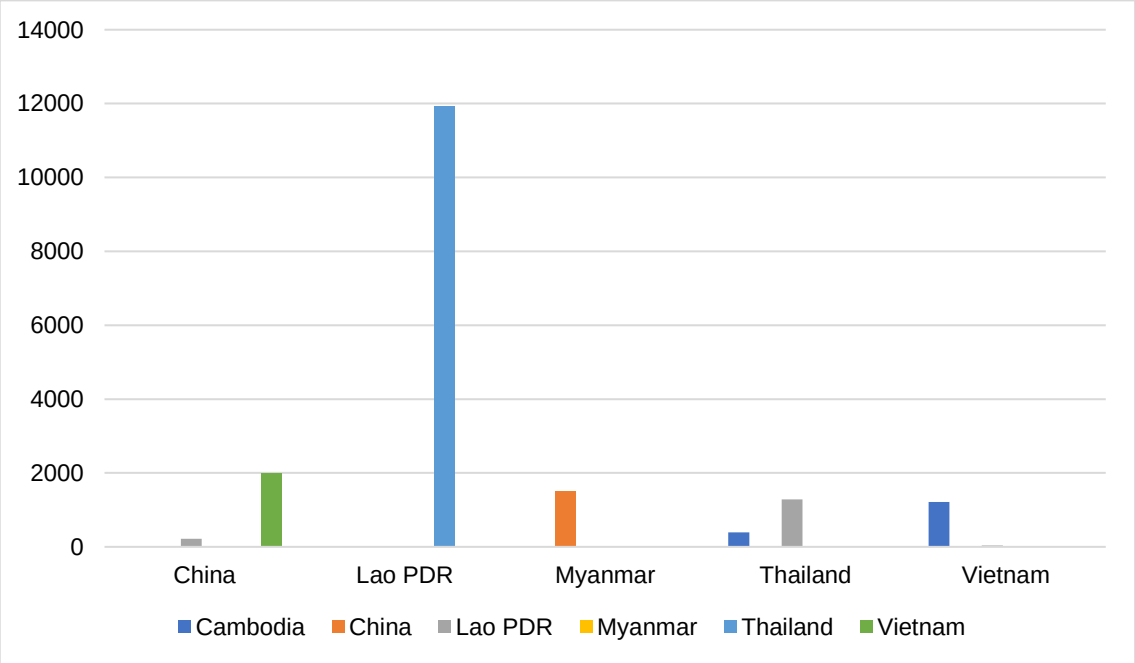
Since then, power exchanges in the region have kept growing (Table 3.4, Figure 3.3, and Figure 3.4).

Table 3.4: GMS Power Trade and Net Imports, 2010 (GWh)

Country	Imports	Exports	Total Trade	Net Imports
Cambodia	1,546	-	1,546	1,546
Lao PDR	1,265	6,944	8,210	(5,679)
Myanmar	-	1,720	1,720	(1,720)
Thailand	6,938	1,427	8,366	5,511
Viet Nam	5,599	1,318	6,917	4,281
China	1,720	5,659	7,379	(3,939)
Total	17,069	17,069	34,139	

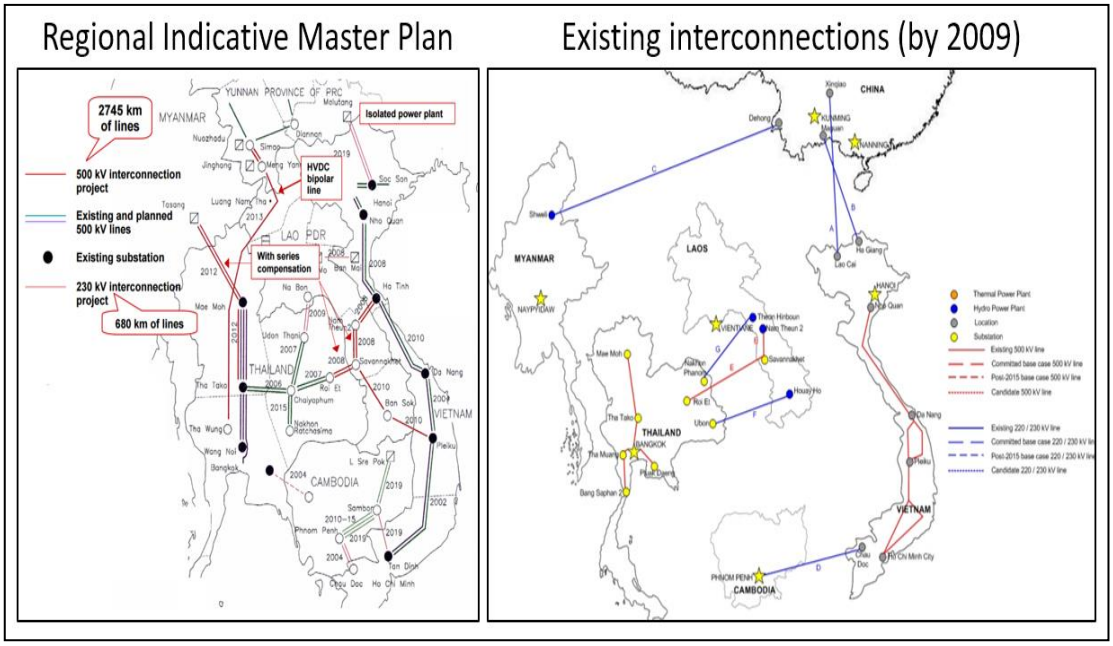
Source: Chi Nai (2015).

Figure 3.3: Power Exports in the GMS, 2014 (GWh)



Source: ADB (2016).

Figure 3.4: Planned and Existing Interconnections in the GMS



Source: ADB (2012), UNDESA (2005).

Similar progress has not yet been achieved in developing the institutional capacity to move beyond stage 1. For example, the constraints on third-party access to dedicated transmission lines developed for PPAs is a challenge for new projects (Antikainen, Gebert, and Møller, 2011). Agreement on wheeling charges for the use of a third-country transmission network appears to be impossible in the MOU signed by China and Thailand for the export of electricity from Yunnan. The imbalance between the development of physical infrastructure (hardware) and institutional aspects (software) has been pointed out by studies such as the 2013 ADB Assessment of the GMS Energy Sector Development:

> There has been remarkable progress in the GMS energy sector over the past 2 decades. Considerable success was also achieved in rolling out rural electrification in member countries. Rapid provision of large-scale, high-volume national grid systems; successful mobilization of indigenous resources; and the beginnings of cross-country trade also took place. These successes have been achieved mainly at the national level. Despite considerable political pronouncements that recognize the imperatives of regional cooperation, progress has not matched national achievements. The high-volume trans-boundary connections that have been made

to date within the GMS do not achieve a true interconnection of systems with synchronous operations, but are simply an extension of the national grids of the large- consuming countries into the territories of producers of (mainly) hydropower (ADB, 2013).

Recent developments are bringing a new impulse to the regional power cooperation programme. The power-trade agreement between Lao PDR and Singapore, with power going through Thailand and Malaysia, is promising and can have implications for third-country access agreements. The updating of the regional master plan and the negotiations to establish the Regional Power Coordination Center indicate a renewed effort to strengthen the programme's institutional structure. Projects including neighbouring countries, such as the ASEAN Power Grid and the China-supported Global Energy Interconnection project, can facilitate negotiation between member countries.

4.2. Sustainability of Regional Power Trade in the GMS

Several studies have been conducted in the GMS and ASEAN to evaluate the benefits of greater interconnectivity. The Energy Sector Strategy Study published in 2009 is one of the most referenced studies (ADB, 2013). Conducted by the ADB over 3 years, it contrasts integrated and non-integrated scenarios, providing the first proper quantification of the benefits:

- 19% reduction in overall energy costs up to 2030 (US$200 billion)
- 5.5% of total energy consumption reduction in overall dependence on imported resources
- 40% lower coal-based power generation capacity
- Greater integration of renewable energy sources and other off-grid solutions

Although this exercise was not conducted regularly (ADB, 2013), other studies have evaluated the implications of greater interconnectivity and different alternatives in the region.

Hydropower has commonly been considered a key factor in promoting greater interconnectivity, with several benefits for member countries (Piseth and Sophearin, 2014) (Table 3.5). Large-scale hydropower generation is found to be the main mechanism for power trade in the GMS. To attract more investors and to reduce investment risks in hydropower development, countries need to refine investment costs, acquire hydrological data, and mitigate social and environmental impacts. Intergovernmental joint investments and the involvement of international financial institutions can foster the necessary legal and legislative frameworks and enhance investment flow into an energy-export market. The Regional Power Coordination Center will play an important role in coordinating and accelerating regional power trade for regional market regulations, comprising agreed rules and the indicative planning priorities of interconnection.

Table 3.5: Expected Net Benefits of Hydropower-based Regional Connectivity in the GMS

Scenario year	Power Supply	Power Export	Capital Investment	Net Benefit	Distribution of Net Benefits (%)			
	(GWh)	(GWh)	(US$ million)	(US$ million)	LAO	THAI	CAM	VIE
2015	26,991	11,321	6,262	16,454	69	10	1	21
2030	110,898	74,320	23,081	40,431	76	13	1	11

Source: Piseth and Sophearin (2014).

The link between regional power trade in the GMS and the development of large hydropower dams in the Mekong's vulnerable ecosystems is a common concern. The use of hydropower resources in Lao PDR and Myanmar to export electricity to countries with more energy demand, such as Thailand and Viet Nam, has been advocated to reduce the need for thermal power generation in downstream countries and to attract foreign direct investment to upstream ones. Some have severely criticised the implications for the region's ecosystems and the reluctance to distribute economic gains. The Mekong River Commission (MRC) Secretariat commissioned the International Centre for Environmental Management to 'provide a broader understanding of the opportunities and risks' of developing hydropower dams in the Lower Mekong Basin. The strategic environmental assessment (SEA) is expected

to help countries better analyse the development impacts of more than a single project (unlike environmental impact assessments, which examine one project at a time).

The GMS SEA analyses the 11 dams planned in the Lower Mekong countries (Lao PDR, Thailand, Viet Nam, and Cambodia). MRC member countries committed, in the 1995 Mekong Agreement, to notify other riparian countries and aimed to reach an agreement whilst building mainstream dams. The procedure for notification, prior consultation, and agreement was first implemented for the Xayaburi dam in 2010 and Don Sahong in 2014, and it is in progress for Pak Beng and Pak Lay. All the projects are dams in Lao PDR. The experience with the first two was unsuccessful, with Lao PDR deciding to proceed with construction even though no agreement had been reached on either project (International Rivers, 2016). China has been working on several dams in Yunnan. China is not a member of the MRC and therefore not subject to the same requirements. The dams constructed or planned for each country are the following (Cronin and Hamlin, 2010; ICEM, 2010):

- China (Yunnan). Gonguoqiao (750 MW), Xiaowan (4,200 MW), Manwan (1,500 MW), Dachaosha (1,350 MW), Naozhadu (5,500 MW), Jinghong (1,500 MW), Galanba (250 MW), and Mengsong (600 MW)
- Lao PDR. Pak Beng (1,230 MW), Luang Prabang (1,410 MW), Xayaburi (1,260 MW), Pak Lay (1,320 MW), Sanakram (570 MW), Pak Chom (1,079 MW), Ban Khoum (2,000 MW), Lat Sua (800 MW), and Don Sahong (360 MW)
- Cambodia. Stung Treng (980 MW) and Sambor (2,600 MW)

The SEA team recommended, among others, (i) to defer the decisions of mainstream dams for 10 years, and (ii) to prevent the use of the Mekong mainstream as a test case for full-dam technologies. The MRC member countries have not reached a compromise. Lao PDR decided to proceed with the construction of Xayaburi in 2012 (Thien, 2017).

The International Energy Agency (IEA) published a special report, *World Energy Outlook*, focusing on Southeast Asia (IEA, 2015b), and prepared a study on developing transboundary energy markets in the region (IEA, 2015a), particularly in the ASEAN Power Grid. The study built upon previous IEA studies on regional electricity markets (IEA, 2014, 2016a, 2016b; Wittenstein, Scott, and Miza, 2016) and emphasised the regulatory aspects and the elements

required to develop regional electricity markets. Regional regulation's main responsibilities include (i) electricity security regulations, (ii) coordinated planning, (iii) cost allocation of transmission development, (iv) revision of network codes, and (v) system monitoring (IEA, 2015a). The study uses research on European integration to describe the benefits and challenges of the process and presents integrated resource planning as an alternative to power development plans.

Sponsored by the Konrad-Adenauer-Stifung, the National University of Singapore (NUS) analysed three international experiences with transboundary power trade, considering the GMS and ASEAN (Owen, Finenko, and Tao, 2015). Experiences in southern Africa, Europe, and the Nordic countries are contrasted to reveal the key drivers, challenges, and options to promote regional power trade. Four elements are necessary to integrate the electricity market: (i) coordinated physical infrastructure development, (ii) standardised and harmonised rules of operation, (iii) some form of market competition, and (iv) empowered governing or coordinating institutions (Finenko, Owen, and Tao, 2017).

Several important challenges lie ahead for the further integration of electricity markets in ASEAN. Several financial and technical issues remain unsolved in regional power transfers. Even if these barriers can be overcome, there are institutional concerns pertaining to the operation of a complex set of international interconnected grids. The social and environmental impacts of dams in the shared rivers should be further researched (Owen et al., 2015). The NUS authors propose three options: (i) multilateral trade of excess power via long-term contracts, (ii) multilateral trade with spot exchange, and (iii) fully competitive power markets.

Hydropower will face increasing competition from alternative power generation options (Boyle, 2018). The summer of 2018 saw two dam-related accidents, increasing cause for concern about the Swa Chaung Dam (Myanmar), which displaced 63,000 people, and Saddle Dam D of the Xe-Pian Xe-Namnoy hydropower project (Lao PDR) (Eyler, 2018; Kyaw, 2018; Son, 2019). Because of the accidents, Thailand has delayed the decision to purchase electricity from the Pak Beng Dam (International Rivers, 2018). Hydropower's role in a regional low-carbon energy system cannot be underestimated, but projects with large environmental and social impacts will be less attractive in the medium term. Basin-wide

planning and the development of more upstream dams with minor impact, along with transboundary power cooperation, are a more suitable solution (Chhengpor, 2018).

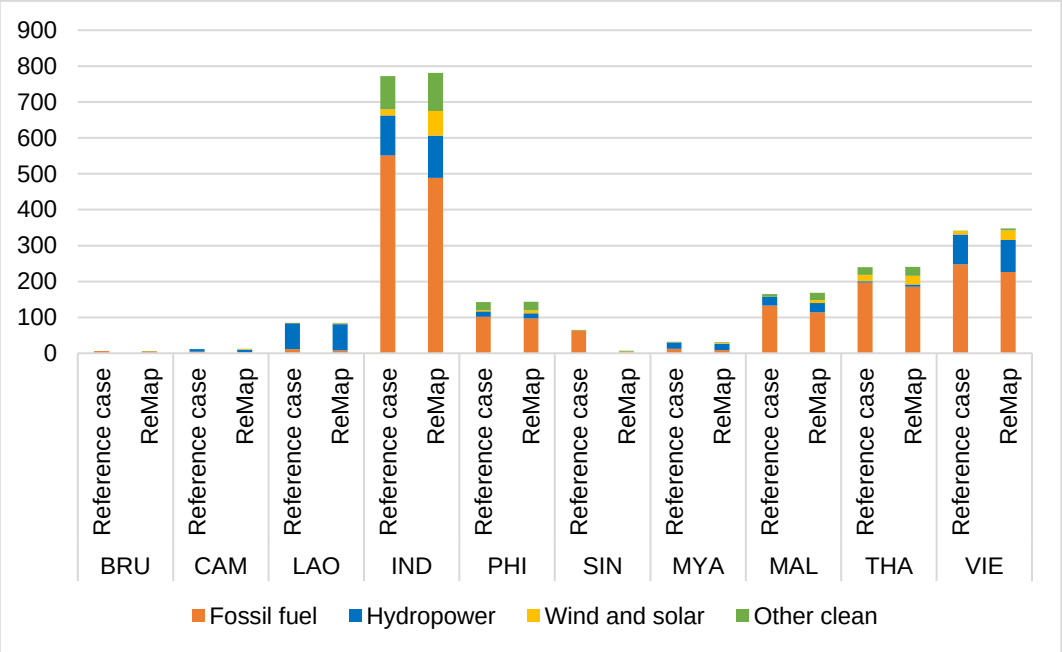
Recent studies consider broadly incorporating variable renewable generation as part of the regional strategy for power trade. The Renewable Energy Outlook was jointly developed by the IRENA and the ASEAN Center for Energy (ACE) (IRENA and ACE, 2016). Another joint study was done by the ACE, the Global Energy Interconnection Development and Cooperation Organization (GEIDCO), and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) (ACE, GEIDCO, and ESCAP, 2018). Both studies show that increasing the use of variable renewables is linked to higher levels of interconnectivity. The studies' details and results are in Table 3.6 and Figure 3.5 to Figure 3.8.

Table 3.6: Scenarios Analysed in ReMap and the ACE–GEIDCO–ESCAP Joint Study

Study	Scenario	Detail
ReMap	Reference case	A business-as-usual scenario but including accelerated commitments already made by member countries
	ReMap	A scenario that allows realising ASEAN's goal of achieving a 23% share for renewable energy by 2025
ACE, GEIDCO, and ESCAP joint study	Accelerated development scenario	Maximisation of clean-power share in generation mix (62%) Transboundary power transaction required to be 10%
	Progressive development scenario	Moderated use of clean power (42%) Transboundary power transaction required to be 7%
	Low development scenario	Lowest share of clean energy (25%) Transboundary power transaction required to be 3%

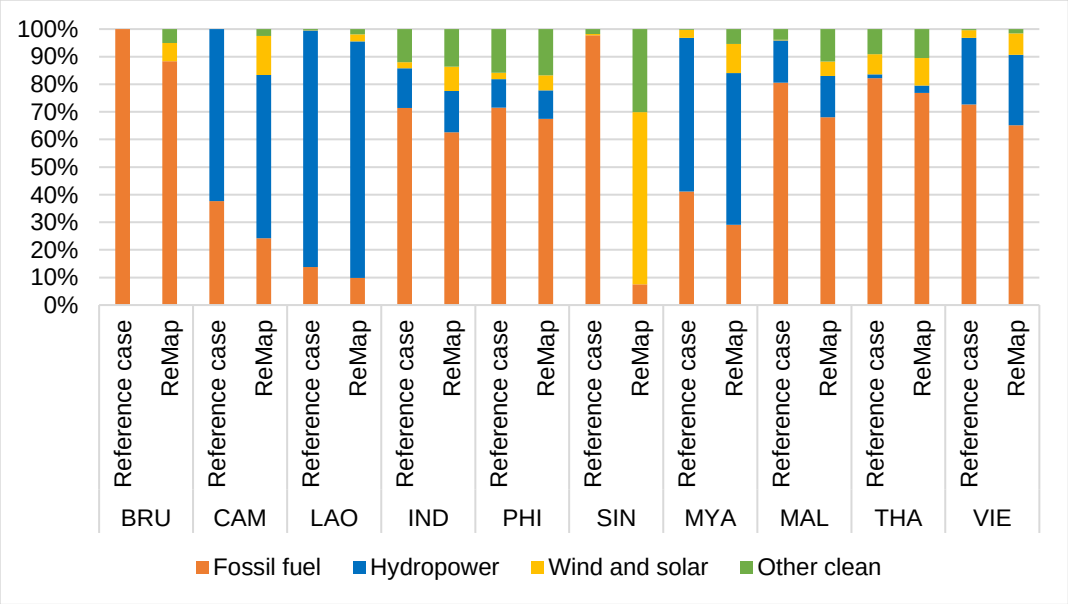
Source: Authors, from ACE et al. (2018); IRENA and ACE (2016).

Figure 3.5: ASEAN Countries' Overview for Reference Case and ReMap Scenarios (MW)



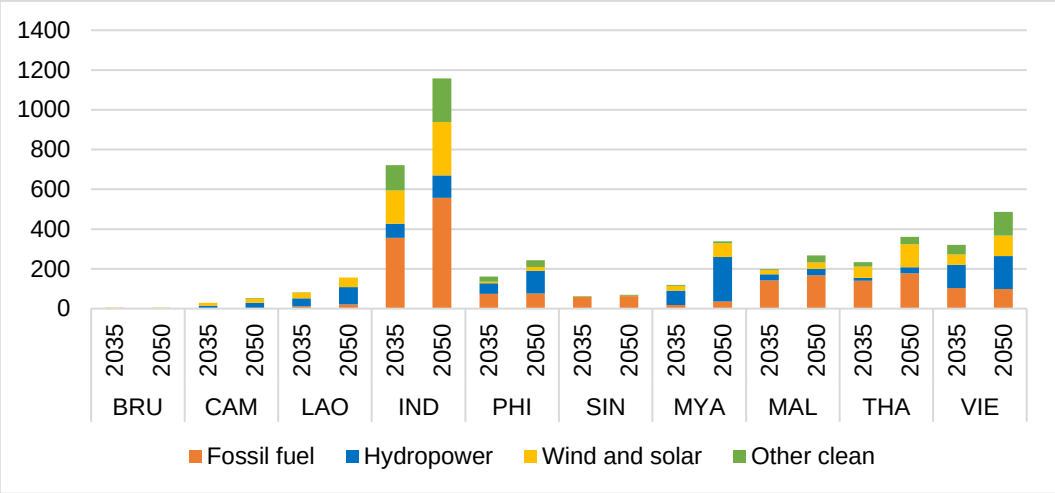
BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: IRENA and ACE (2016).

Figure 3.6: ASEAN Countries' Overview for Reference Case and ReMap Scenarios (share)



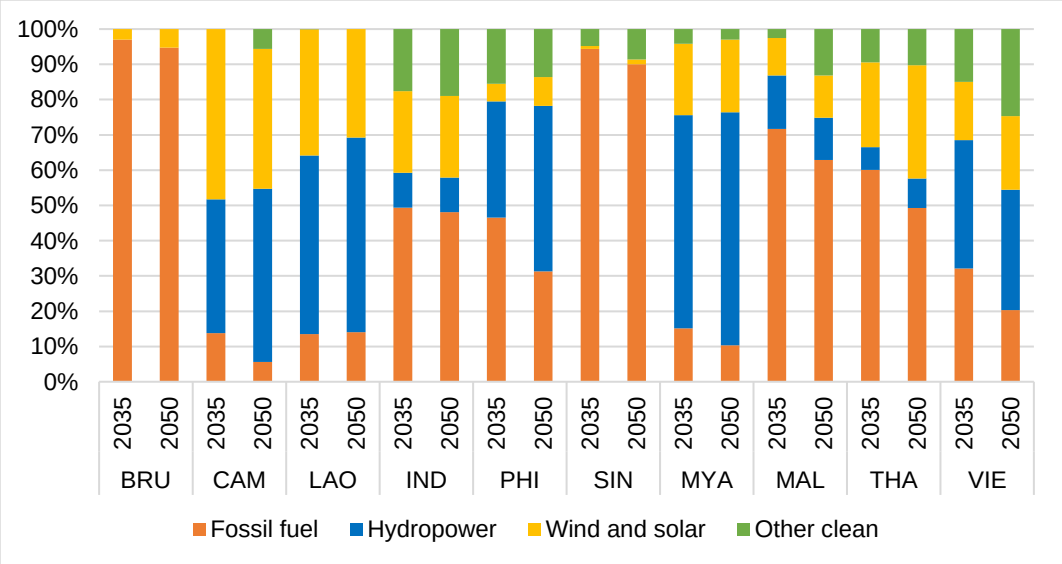
BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: IRENA and ACE (2016).

Figure 3.7: ASEAN Countries' overview for Accelerated Development Scenario, 2035 & 2050 (MW)



BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: ACE et al. (2018).

Figure 3.8: ASEAN Countries' overview for Accelerated Development Scenario, 2035 & 2050 (share)



BRU = Brunei Darussalam; CAM = Cambodia; LAO = Lao PDR; IND = Indonesia; PHI = Philippines; SIN = Singapore; Mya = Myanmar; MAL = Malaysia; THA = Thailand; VIE = Viet Nam
Source: ACE et al. (2018).

5. Conclusion

Importing power from neighbouring countries is an alternative for Myanmar to increase its electricity supply. Myanmar is exploring the possibility of importing energy from China and Lao PDR but does not yet have projects with them. Different options' techno-economic, socio-political, and environmental costs must be analysed. The social implications for communities living in the periphery should be evaluated so they can benefit from the power transmitted near them. The potential for power imports to foster sustainable development is critical.

The approach is in line with global energy trends, where the emphasis of regional power trade is shifting from energy security to energy sustainability. Initial studies focused on the regional use of hydropower resources in upstream countries. More recent analyses aim to minimise the socio-economic and environmental impacts caused by building dams on main rivers. The Mekong has attracted most of the attention. Projects being developed and their transnational impact should be re-evaluated. Myanmar has put all its large-scale hydropower projects on hold.

Southeast Asian countries are also looking to diversify their mix of variable renewable energy sources. The ability to increase generation capacity to keep pace with growing demand is essential for sustainable development. The IEA has prevented Southeast Asian countries from planning capacity additions well over their long-term needs to avoid economically burdening their governments and citizens (IEA, 2018).

This chapter reviews studies that assess the medium- to long-term impacts on Myanmar of regional power connectivity in the GMS. There is general agreement on the potential of renewable energy power trading to reduce the penetration of fossil-based fuels, but the use of fossil fuels will continue to grow in absolute terms for the foreseeable future. The power trade has been made possible mostly through point-to-point interconnections linked to large-scale hydropower dams. A basin-wide hydropower planning method is necessary to minimise negative externalities. The rise of solar and wind power in the region can become a positive driver in that direction, offering an even more economical alternative.

Myanmar is considered to be a large regional exporter of electricity because of its vast hydropower potential, which remains undeveloped. Regional studies analysing the benefits for Myanmar of importing electricity are scarce. Myanmar's links with China and Lao PDR are the most advanced amongst its connections. A Yunnan–Myanmar–Bangladesh transmission

power line is gaining a lot of attention. If realised, it would be the first formal power interconnection between South Asia and Southeast Asia and China. Lao PDR has also expressed its readiness to export electricity as demanded by Myanmar. For either option, however, new transmission capacity is needed, highlighting the importance of strengthening national power transmission and developing high-voltage lines in the country. Improving transmission infrastructure would also trigger the integration of endogenous variable renewables.

Myanmar is set to become a building block for interregional power trade. Its location between South Asia and Southeast Asia enables it to position itself as an important actor in spurring cooperation. It is a member of several regional economic cooperation initiatives in both sub-regions (Table 3.3, Table 3.7 and Figure 3.9). If Myanmar imports power, it can become the first building block for interregional connectivity between both sub-regions and southern China. The geopolitical implications of such cooperation are gaining attention (Parks, Maramis, Sunchindah, and Wongwatanakul, 2018; USAID, 2018).

Table 3.7: Myanmar's Participation in Regional Cooperation Programmes

	ACMECS	ASEAN	BCIM	BIMSTEC	GMS	LMC	SAARC	SASEC
Afghanistan							○	
Bangladesh			○	○			○	○
Bhutan				○			○	○
Brunei		○						
Cambodia	○	○			○	○		
China			○		○	○		
India			○	○			○	○
Indonesia		○						
Lao PDR	○	○			○	○		
Malaysia		○						
Maldives							○	○
Myanmar	○	○	○	○	○	○	○*	○

Nepal				○			○	○
Pakistan							○	
Philippines		○						
Singapore		○						
Sri Lanka				○			○	○
Thailand	○	○		○	○	○		
Viet Nam	○	○			○	○		

ACMECS = Ayeyawady-Chao Phraya-Mekong Economic Cooperation Strategy; ASEAN = Association of Southeast Asian Nations; BCIM = Bangladesh-China-India-Myanmar Forum; BIMSTEC = Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation; GMS = Greater Mekong Subregion Economic Cooperation Program; LMC = Lancang-Mekong Cooperation; SAARC = South Asian Association for Regional Cooperation; SASEC = South Asia Subregional Economic Cooperation.
*Myanmar holds observer member status in SAARC.
Source: Authors.

Establishing a solid interconnection between China and Myanmar will have important consequences for the region's energy landscape. China has an abundant surplus of hydropower generation in Yunnan and has been keen to export it to GMS countries at prices competitive with those of Lao PDR – about US$0.08/kWh (Eyler and Weatherby, 2017). The interconnection between China, Myanmar, and Bangladesh will allow the first interregional power exchanges to take place.

Chapter 4

Barrier Analysis of Mini-grid Diffusion in Myanmar

Energy access is still a challenge for many countries, as demonstrated by SDG 7, which '[e]nsure[s] access to affordable, reliable, sustainable, and modern energy for all' (United Nations, 2015). The government has set a target of 100% electrification by 2030. However, only 42% of households are connected to national grids, and only 22% are using off-grid solutions such as SHSs and mini-grids. To accelerate electrification, decentralised approaches should be considered in addition to the centralised option (national grid extension). Mini-grids can fill the gap between SHSs and national grids. In rural areas, where diesel fuel is considerably more expensive than in urban areas, mini-grids powered by renewable energy are more cost-competitive than diesel generators. However, diesel is still dominant as a source of power for mini-grids. In a previous study, we developed a typology of barriers to developing renewable energy–based mini-grids in Myanmar (Yoshikawa and Anbumozhi [eds.], 2018). This chapter analyses the barriers that are prioritised in each category. We conducted a questionnaire survey with stakeholders using a multi-criteria decision-making method called the analytic hierarchy process (AHP) to identify the prioritisation of each barrier factor based on stakeholders' evaluation, represented as a score of each factor by each respondent. The results of the prioritisation for each respondent were analysed with clustering by k-means to identify the tendency amongst respondents. Each cluster group includes a similar evaluation by the respondents. The mean value of the results in each cluster shows the evaluation of that group. The inconsistency amongst the clusters represents the disagreement amongst the clustered group of respondents. The results demonstrate that opinions were divided amongst stakeholders for some categories and that it was difficult to identify an indisputable main barrier, unlike in other countries. In the social and cultural barrier category, opinions were divided amongst clusters. One cluster prioritised the perception of inferior quality of renewable energy as the biggest barrier whilst the other cluster prioritised the gap in education of the local mini-grid developers and operators. There is no single 'silver bullet' for implementing mini-grids and overcoming the barriers needs steady work.

1. Introduction

1.1. Background

SDG 7 (affordable and clean energy) states that access to electricity is still a global issue (United Nations, 2015). The global population without access to electricity finally dropped to 840 million in 2017 (IEA, IRENA, UNSD, WB, and WHO, 2019). Access to power should be provided by expanding renewable energy instead of using fossil fuels. Sub-Saharan Africa attracts the most attention because of the large population that lives without access to electricity. In Asia, Myanmar has a similar electrification rate (Climatescope, 2019). The share of households connected to the national grid has grown from 34% in 2016 (Myanmar Energy Monitor, 2019) to 42% in 2018 (Billen and Bianchi, 2019), and 36 million people (70% of the population) live in rural areas (Myanmar Ministry of Immigration and Population Department of Population, 2014). The government has set a target of 100% electrification by 2030 (Ministry of Electricity and Energy Myanmar, 2018). The national grid accounts for over 80% of electrification in urban areas but for less than 13% in rural areas. Electrification by mini-grids represents approximately 13% (Ministry of Planning and Finance Myanmar and World Bank, 2017). The IRENA (2017) estimates that main grids and mini-grids need 37% and 44% more, respectively, to achieve universal energy access in developing Asian countries, suggesting that actions should not be focused on extending the national grids alone.

Mini-grids have recently begun to attract attention as a bridge between household electrification methods such as solar lanterns and home systems and large-scale national grids (Schnitzer et al., 2014; BNEF, 2017). In rural areas, which are not connected to the grid, roads are often not developed and fuel prices are higher because of transportation costs. In areas where diesel fuel is expensive, renewable energy is cost-competitive with diesel generators as a power source for mini-grids (Numata, Sugiyama, Mogi et al., 2018). In Myanmar, diesel is still used in most villages: 13,000 use diesel-powered mini-grids, 2,400 hydropower, 1,200 biomass, and 150 solar energy (Greacen, 2017). Various international aid agencies promote the introduction of mini-grids combining solar power and storage batteries (ADB, 2018; Frontier Myanmar Research Ltd., 2018) but mini-grids are still not expanding rapidly enough.

Myanmar has an abundance of renewable energy resources. The potential capacity of solar power is estimated as 27 GW, small and medium-sized hydropower 0.23 GW, and large-scale

hydropower 100 GW (ADB, 2016; ADB, 2015). Myanmar's Intended Nationally Determined Contribution to the Paris Agreement establishes that the country will 'implement mitigation actions in line with sustainable development needs' (The Republic of the Union of Myanmar, 2015). Therefore, the country should use its abundant resources not only for large-scale power generation but also as a power source for mini-grids (del Barrio Álvarez and Sugiyama, 2018).

1.2. Previous Study

In a prior study (Yoshikawa and Anbumozhi [eds.], 2018), we conducted a bibliographic survey of the barriers to disseminating mini-grids associated with renewable energy sources in Myanmar (Table 4.1). Based on current conditions, we constructed a barrier typology through discussions with stakeholders (international organisations, private companies, NGOs, and field researchers). For the present study, we conducted a questionnaire survey of stakeholders based on an AHP and analysed the priority of each barrier.

Barrier Typology

Table 4.1: Barrier Typology

Category	Sub-categories	Description	Sources
Financial	Access to financing	Due to their lack of familiarity with project financing through a financial institution, developers find it difficult to obtain loans. Immature stock and debt markets limit financing options.	Gershenson et al. (2015); Greacen (2017b); Ahlborg and Hammar (2014); T. S. Schmidt, Blum, and Wakeling (2013); Luthra, Kumar, Garg, and Haleem (2015); UNCDF/UNDP (2012)
	High cost of capital	Even if funds are arranged, financing costs are high. Interest rates are high and loan fees costly.	Painuly (2001), Greacen (2017b), Gershenson et al. (2015), Comello et al. (2017), Luthra et al. (2015), UNCDF/UNDP (2012)
	Customers' insufficient capital	Customers' financing methods are limited. Microfinance is relatively new and unofficial money lenders are expensive.	Painuly (2001), Gershenson et al. (2015), Comello et al. (2017)
	Currency risk	If financing is based on a foreign currency, companies are exposed to exchange rate risks because their revenue and expenses are in different currencies.	Gershenson et al. (2015), BloombergNEF (2018)
Economic	Small market	The energy market in Myanmar is in its initial stage despite the rapid development of the international market.	Painuly (2001), Palit and Chaurey (2011), Bhattacharyya (2013), Luthra et al. (2015)
	Low demand	Creating demand in addition to basic use, such as for lighting, is still a challenge for operators.	Painuly (2001), Palit and Chaurey (2011), Bhattacharyya (2013), Ahlborg and Hammar (2014)
	Tariff structure: cost–revenue gap	Tariff revenue should cover costs but tariffs should be affordable, which is sometimes difficult to balance.	Bhattacharyya (2013); T. S. Schmidt et al. (2013); Comello et al. (2017); Ahlborg and Hammar (2014); Hasan (2018); Tenenbaum, Greacen, Siyambalapitiya, and Knuckles (2014)
	Uncertain fee collection	Operators must ensure that customers pay for the electricity, sometimes using new technology such as Pay As You Go.	Franz, Peterschmidt, Rohrer, and Kondev (2014); Bhattacharyya (2013); Ulsrud et al. (2011); Blum, Sryantoro Wakeling, and Schmidt (2013); Hasan (2018)
Social/ Cultural	Negative externalities caused by international organisations	Existing local mini-grid businesses were mostly for non-commercial and social welfare purposes, but the introduction of business models has changed the mindsets of operators and/or customers, breaking the trust between them.	Interviews with stakeholders

	Education	The educational gap hinders financing of local companies by international organisations, which provide lower capital costs. The language barrier (non-English speakers) is part of the reason.	Interview with stakeholders
	Ethnic or language differences	Residential areas with ethnic-minority groups overlap with off-grid areas. Language and cultural differences hinder project implementation.	Interview with stakeholders
	Perception of inferior quality	Especially in the early stages, it is difficult to offer 24/7 service.	Bhattacharyya (2014); Franz, Peterschmidt, Rohrer, and Kondev (2014); Comello et al. (2017)
Technical	Technology gap	Indigenous technology is different from international standards in many aspects but should not be flatly dismissed.	Interview with stakeholders
	Operation and maintenance	Operation and maintenance are often not appropriate or continued.	Gershenson et al. (2015); Comello et al. (2017); Ahlborg and Hammar (2014)
	Intermittency	The energy supply fluctuates over the day or season, which is typical for intermittent renewable energy sources.	T. S. Schmidt et al. (2013); Comello et al. (2017); Luthra et al. (2015)
	Lack of interoperability with national grid	Mini-grids might be designed without connections to the national grid due to the absence of technical rules.	Comello et al. (2017)
Regulatory	Lack of regulatory framework	There are no regulations for mini-grids.	Greacen (2017b); Painuly (2001); Luthra et al. (2015)
	Institutional capacity	Institutions are focused on their regular job, and it is difficult to coordinate between ministries beyond their current work.	Ahlborg and Hammar (2014); Bhattacharyya (2013); Comello et al. (2017); del Barrio Álvarez and Sugiyama (2018); Luthra et al. (2015)
	Lack of technical standards	Without technical standards or codes, it is difficult to maintain a certain level of quality for mini-grids. Rules for industrial waste, tar, and lead acid should be established.	Painuly (2001); T. S. Schmidt et al. (2013) ; Comello et al. (2017); UNCDF/UNDP (2012)
	Threat of grid extension	Mini-grid operators do not know what will happen to them after the national grid reaches their customers' villages.	Bhattacharyya (2013); Kobayakawa and Kandpal (2014); Comello et al. (2017); Hasan (2018); Tenenbaum, Greacen, Siyambalapitiya, and Knuckles (2014)

Source: Yoshikawa and Anbumozhi (eds.) (2018), modified by the authors.

2. Methodology

2.1. Analytic Hierarchy Process

The AHP is a decision-making method developed by T. L. Saaty in the 1970s and has been widely used since then (Saaty, 1987, 1990, 2003). A problem is hierarchically structured and a paired comparison for each factor is defined to rank their importance. The procedure is as follows (Saaty, 1994):

(i) Model the problem considering the hierarchy of the key factors.

(ii) Determine the importance of the elements by comparing pairs based on knowledge and emotion and score them (Table 4.2)

(iii) Calculate the priority of each factor based on the scores.

The result obtained is a square matrix (we chose 4 factors so here 4 × 4) with a diagonal component of 1. The obtained results are checked for consistency using the random index in Table 4.3 (0.89 for a matrix of n = 4) created by Saaty (2013). The consistency ratio is set to 0.1 as suggested in many papers (Saaty, 1994; Soma, 2003; Aras, Erdoğmuş, and Koç, 2004) and only answers whose consistency score is lower than 0.1 are used for the analysis.

Table 4.2: Fundamental Scale

1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Extreme importance

Source: Saaty (2013).

Table 4.3: Random Index

Matrix order	1	2	3	4	5	6	7	8	9	10
Random index	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Source: Saaty (2013).

Various multi-criteria decision-making methods can be applied to energy planning (Bhattacharyya and Palit [eds.], 2014; Kumara, 2015), but we chose AHP because it is widely

used and easy to understand. AHP has been applied to prioritise decentralised power in Iran (Zangeneh, Jadid, and Rahimi-Kian, 2009) and Jordan (Kablan, 1997); develop energy in rural China (Xiaohua and Zhenmin, 2002); and select suitable locations for wind power generation (Aras et al., 2004) and research long-term energy resources as well as development planning in the Republic of Korea (Lee, Yoon, and Kim, 2007).

Barrier analysis has been applied to small-scale power sources in Sri Lanka (P. D. C. Wijayatunga, Siriwardena, Fernando, Shrestha, and Attalage, 2006), the adaptation of renewable energy in India (Luthra et al., 2015), cooking stoves and biogas fermenters in rural Thailand (Limmeechokchai and Chawana, 2007), energy efficiency in small-scale industries in India (Nagesha and Balachandra, 2006), and cleaner production by small and medium-sized enterprises in China (Shi, Peng, Liu, and Zhong, 2008). In this study, we applied AHP to analyse the barrier to dissemination of mini-grids powered by renewable energy in Myanmar. A questionnaire survey was conducted from September 2018 to February 2019. Table 4.4 lists the respondents. Energy-related stakeholders were selected from amongst various occupations. We sent out about 50 questionnaires and received 42 answers.

Table 4.4: Details of Questionnaire Survey

No. of respondents (individuals)	**Sent**	**Answered**
NGO (international, local)	8	8
Government	8	7
Private company	25	15
Media	2	2
Academia	6	6
International organisation	4	4
Total	53	42

2.2. K-means

K-means is a non-hierarchical clustering algorithm. The values are partitioned to the nearest cluster that has the nearest mean value within the cluster. The number of clusters k is given. The classification is based on the following process:

(i) Allocate each unit of data to a cluster at random. Set the number of clusters.

(ii) Calculate the centroid (arithmetic mean) of each cluster.

(iii) Calculate the square of the distance (difference) between each unit of data and the centroid of the cluster.

(iv) Reassign each unit of data to the centroid cluster with the closest distance (for which the difference square is minimum).

(v) Recalculate until the allocation of each unit of data in the cluster does not change.

The elbow method was used to investigate the number of clusters (Raschka, 2017): the sum of squared errors for each cluster number is calculated and a line graph is plotted. The number of clusters in the elbow-like bend is the reference with which to determine the lack of effect in increasing the number of clusters. This happens when the number of clusters increases and is subdivided but the decrease in the sum of the squared errors is not significant. Nevertheless, it is rare for a dataset to have a clear elbow-like bend.

3. Results

In AHP, a problem is hierarchised. Figure 4.1 shows the hierarchised barriers. The number of factors in each category was arranged in order based on a prior study (Yoshikawa and Anbumozhi [eds.], 2018). There are four factors in a category for which a pair comparison is performed. Whilst conducting the questionnaire survey based on the AHP, the subjects answered 30 questions with 6 sets of paired comparisons × 5 barrier categories. Four factors were to be compared in each category. If the number of factors was 5, there would be 10 × 5 = 50 questions, and 15 × 5 = 75 questions for 6 factors. It was assumed that an excessive number of questions would impact the response rate. The questionnaire is in Appendix 3.

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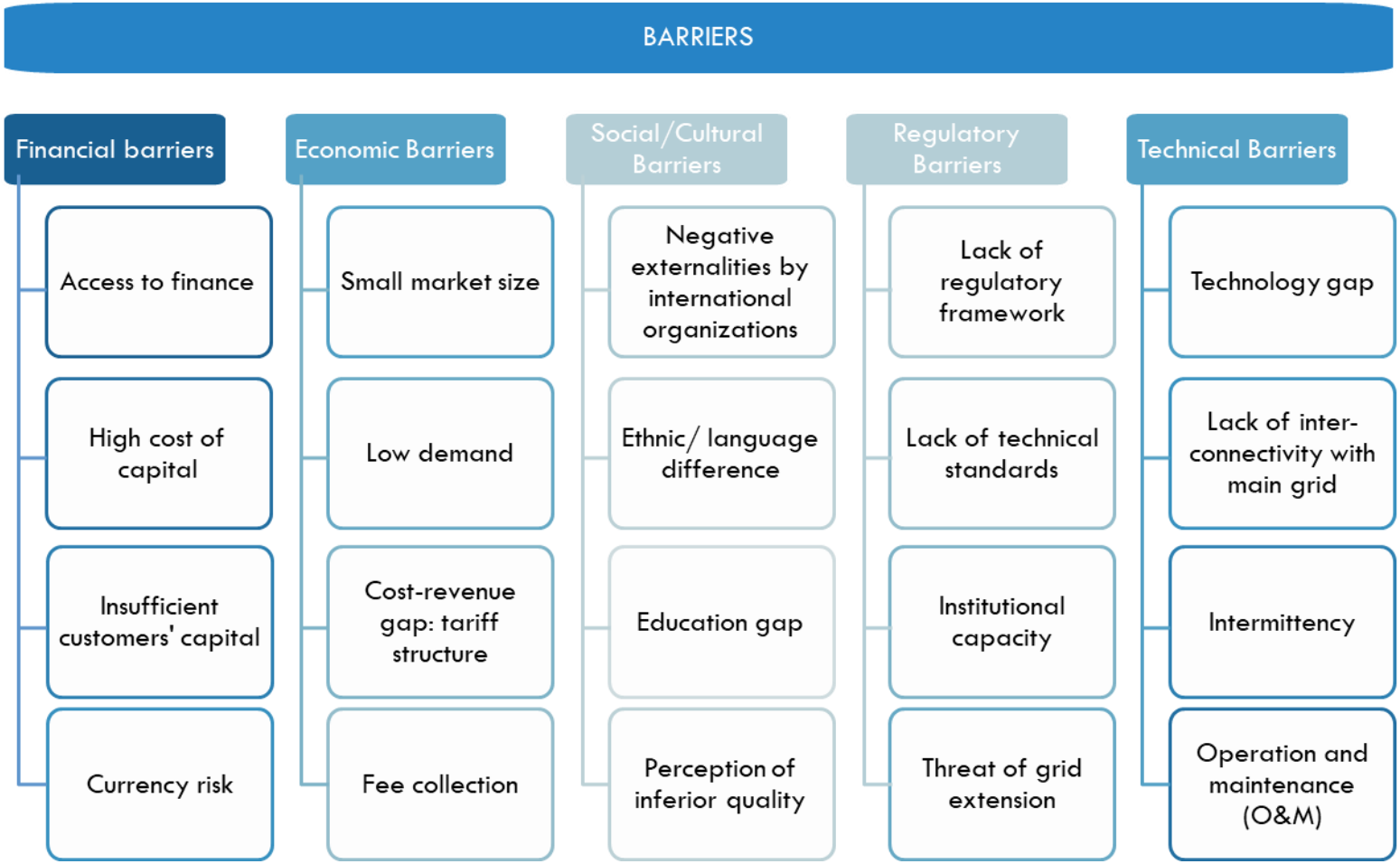
Figure 4.1: Hierarchy of Barriers Based on Previous Study



Source: Yoshikawa and Anbumozhi (eds.), (2018).

Table 4.5 shows an example of the answers obtained using the questionnaire. The score for each factor (financial barrier 1, financial barrier 2,..., technical barrier 4) is calculated from the score that the subject provided. The total score is 1. The consistency ratio of each category was calculated, and only those with a consistency ratio lower than 0.1 were considered valid answers. The results obtained were analysed by category.

Table 4.5: Example of Answers

Financial	Barrier 1	Barrier 2	Barrier 3	Barrier 4	Consistency Ratio
Respondent 1	0.059	0.191	0.647	0.103	0.084
Respondent 2	0.433	0.085	0.048	0.433	0.057
...					

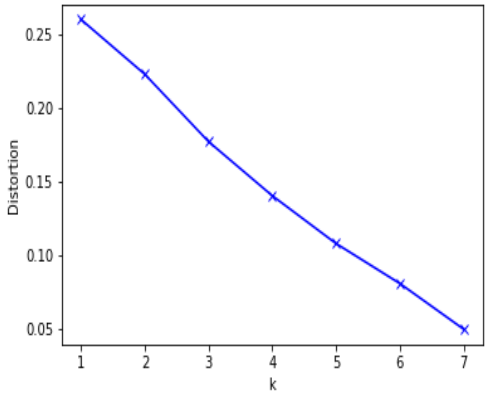
Economic	Barrier 1	Barrier 2	Barrier 3	Barrier 4	Consistency Ratio
Respondent 1	0.059	0.191	0.647	0.103	0.084
Respondent 2	0.25	0.25	0.25	0.25	0
...					

The number of clusters was examined using the elbow method (Figure 4.2). However, since most of the barrier categories did not display a clear elbow shape, the number of clusters was set to three based on the balance with the number of valid answers. For all barrier categories, the number of clusters was set as the same in a way that was easy to understand. Within each category, the scoring results obtained from the respondents were clustered into three groups and analysed. The numbers of valid answers for each category are in Table 4.6. The consistency ratio was set to 0.1, which led to less than half of the answers being classified as valid.

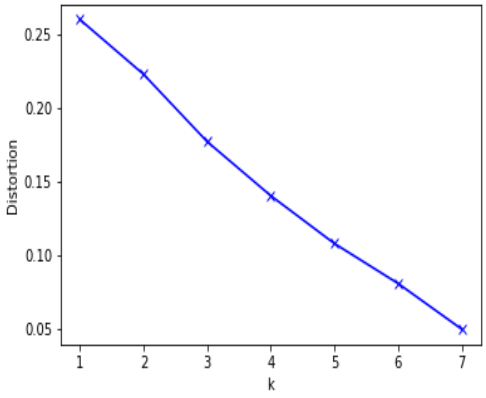
Table 4.6: Number of Valid Answers

	Number of Valid Answers / Total Number of Answers
Regulatory barriers	17/42
Social or cultural barriers	13/42
Economic barriers	12/42
Technical barriers	12/42
Financial barriers	8/42

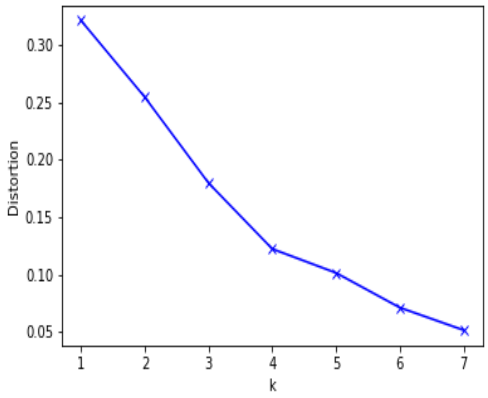
Figure 4.2: Elbow Plot of Each Barrier Category



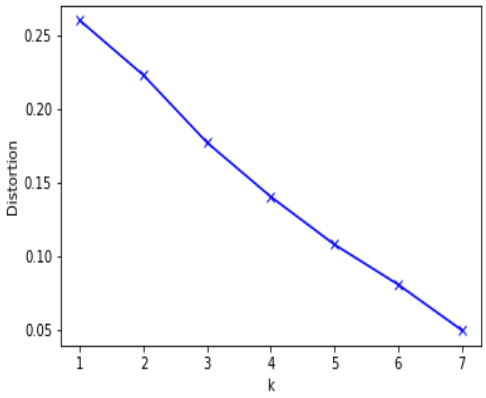
(a) Social and cultural barriers



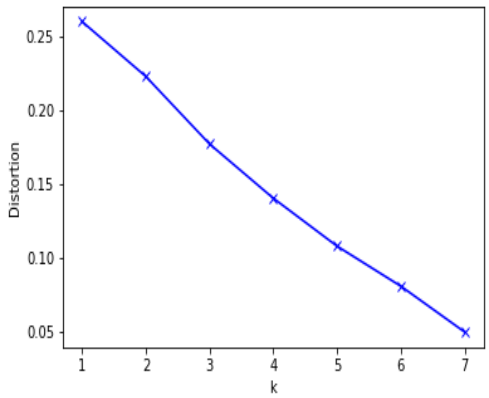
(b) Regulatory barriers



(c) Technical barriers



(d) Economic barriers



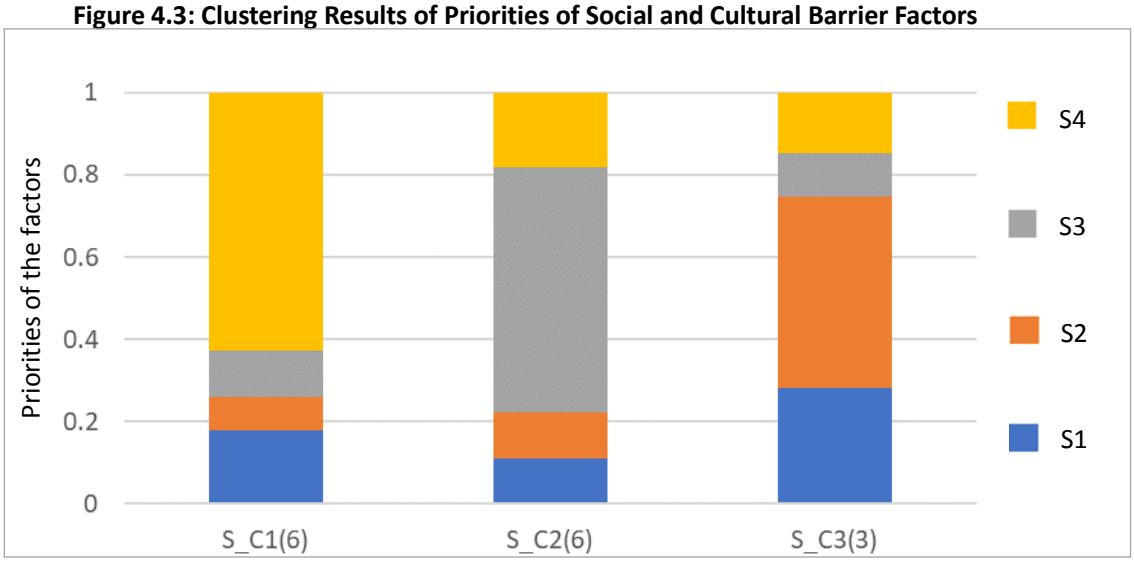
(e) Financial barriers

3.1. Social and Cultural Barriers

Figure 4.3 shows the results of the social and cultural barriers. The valid responses were divided into three clusters, and the weight of each barrier factor was averaged considering the responses in the cluster. Results are shown in the graphs, where the vertical axes show the weight value.

In the social and cultural category, clusters 1 and 2 have six valid responses each. 'S4: Perception of inferior quality' was considered the most important factor in cluster 1, and 'S3: Education gap' the most important in cluster 2. These factors are the most important by far in their clusters (S4 has a weight of 0.63 in cluster 1 and S3 has a weight of 0.60 in cluster 2).

Figure 4.3: Clustering Results of Priorities of Social and Cultural Barrier Factors



Note: S_C1 (6) indicates that cluster 1 of the social category contains six valid responses. The legend indicates each barrier factor (S1 to S4) in Table 4.7.

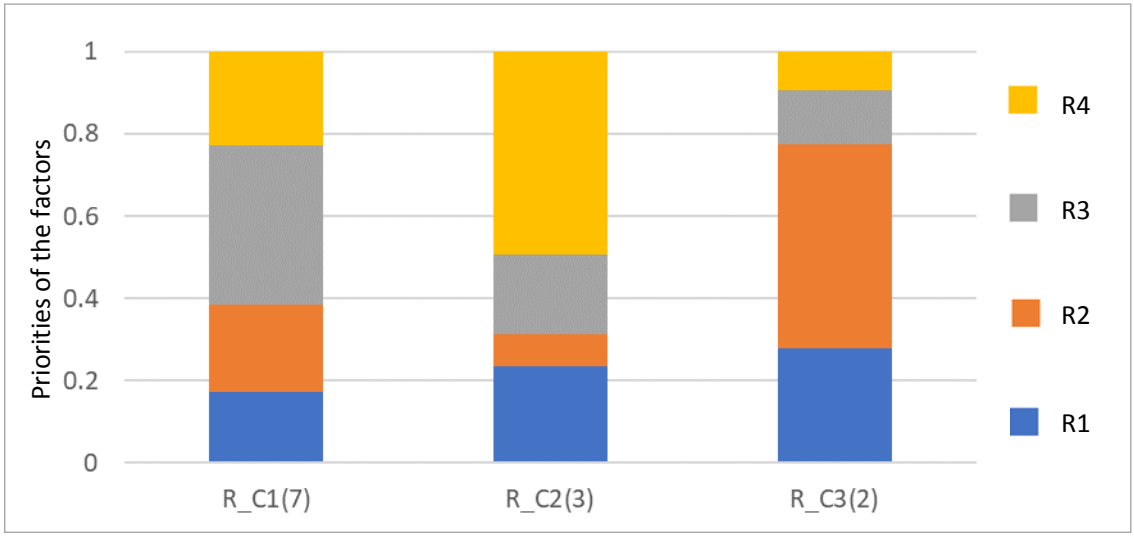
Table 4.7: Numbering of Social and Cultural Barrier Factors

S1	Negative externalities caused by international organisations	Existing local mini-grid businesses were almost all non-commercial, but the introduction of business models has changed the mindsets of operators and/or customers.
S2	Ethnic or language difference	Residential areas with ethnic-minority groups overlap with off-grid areas. Language and cultural differences hinder project implementation.
S3	Education gap	The educational gap hinders financing of local companies by international organisations, which provide lower capital costs. The language barrier (non-English speakers) is part of the reason.
S4	Perception of inferior quality	Especially in the early stages, it is difficult to offer 24/7 service.

3.2. Regulatory Barriers

Figure 4.4 shows the results of the regulatory barriers. Cluster 1 has 7 valid responses (out of 12), and the tendency of the respondents was consistent with the other categories. In cluster 1, 'R3: Institutional capacity' was the most important factor. In Myanmar, the extension of the national grid and the mini-grids connected to it are under MOEE jurisdiction, but off-grid electrification is under DRD jurisdiction. However, if mini-grids are constructed in areas where there is no national grid, the involvement of the MOEE, which is the governing authority in the electric power sector, is essential to develop legal systems and technical standards. However, the respondents believe that the ministries do not cooperate.

Figure 4.4: Clustering Results of Priorities of Regulatory Barrier Factors



Note: R_C1 (7) indicates that cluster 1 of the regulatory category contains seven valid responses regarding regulatory barriers. The legend indicates each barrier factor (R1 to R4) in Table 4.8.

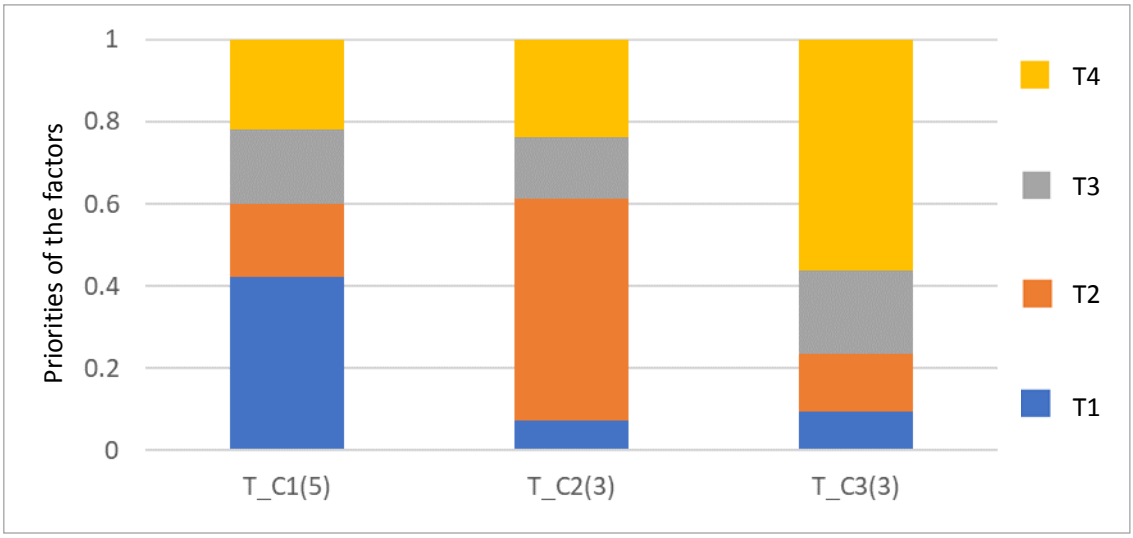
Table 4.8: Numbering of Regulatory Barrier Factors

R1	Lack of regulatory framework	There are no regulations for mini-grids.
R2	Lack of technical standards	Without technical standards or codes, it is difficult to maintain a certain level of quality for mini-grids. Rules for industrial waste, tar, and lead acid should be established.
R3	Institutional capacity	Institutions are attached to their current work, and it is difficult to coordinate priorities between ministries and/or other institutions.
R4	Threat of grid extension	Mini-grid operators do not know what will happen to them after the national grid reaches their customers' villages.

3.3. Technical Barriers

Figure 4.5 shows the results of the technical barriers. Cluster 1 has five valid answers, slightly more than other clusters. For Cluster 1, 'T1: Technology gap' is the most important factor. Local technology is often deemed inferior by international experts, but domestic technology has developed alongside local needs and often is affordable.

Figure 4.5: Clustering Results of Priorities of Technical Barrier Factors



Note: T_C1 (5) indicates that cluster 1 of the technical category contains five valid responses. The legend indicates each barrier factor (T1 to T4) in Table 4.9.

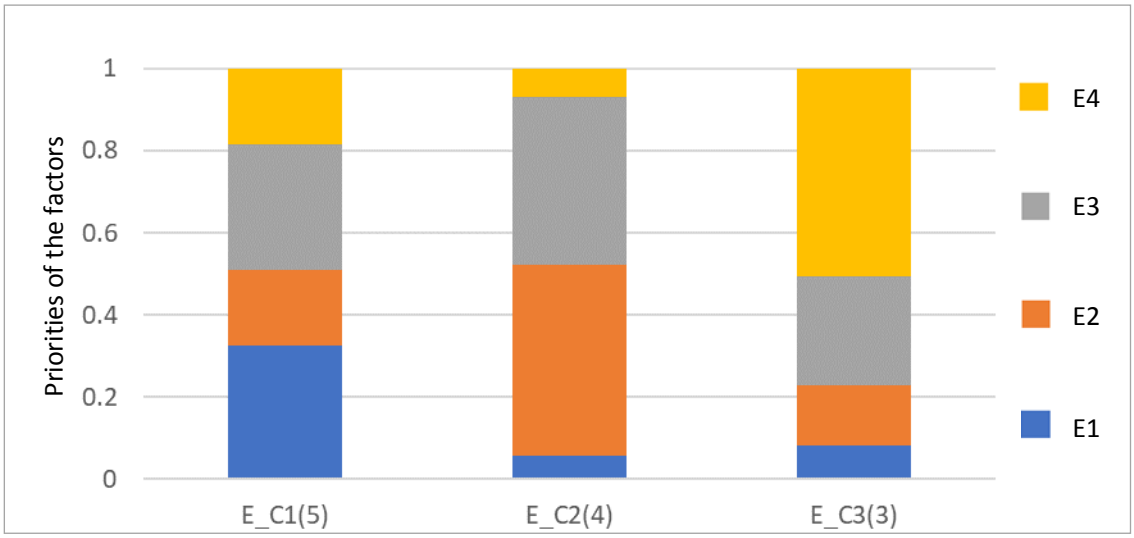
Table 4.9: Numbering of Technical Barrier Factors

T1	Technology gap	Indigenous technology is different from international standards in
T2	Lack of	Mini-grids might be designed without connections to the national
T3	Intermittency	The energy supply fluctuates over the day or season, which is
T4	Operation and	Operation and maintenance are often not appropriate or

3.4. Economic Barriers

Figure 4.6 shows the results of the economic barriers. 'E1: Small market size' (weight of 0.33) and 'E3: Cost-revenue gap' (weight of 0.31) are important in cluster 1, with the highest number of valid responses. 'E2: Low demand' (weight of 0.46) and 'E3: Cost-revenue gap' (weight of 0.41) are important in cluster 2, with the highest number of valid responses. E3 was evaluated as relatively important considering the top two clusters. In this context, solar power generation is particularly capital-intensive and has a business model that recovers the initial costs through electricity charges. However, if a high tariff is set for recovery, the costs might exceed the consumers' ability to pay for electricity, and consumers will likely refrain from using it. Therefore, the consumers' ability to pay should be balanced against recovery of cost.

Figure 4.6: Clustering Results of Priorities of Economic Barrier Factors



Note: E_C1 (5) indicates that cluster 1 of the economic category contains five valid responses. The legend indicates each barrier factor (E1 to E4) in Table 4.10.

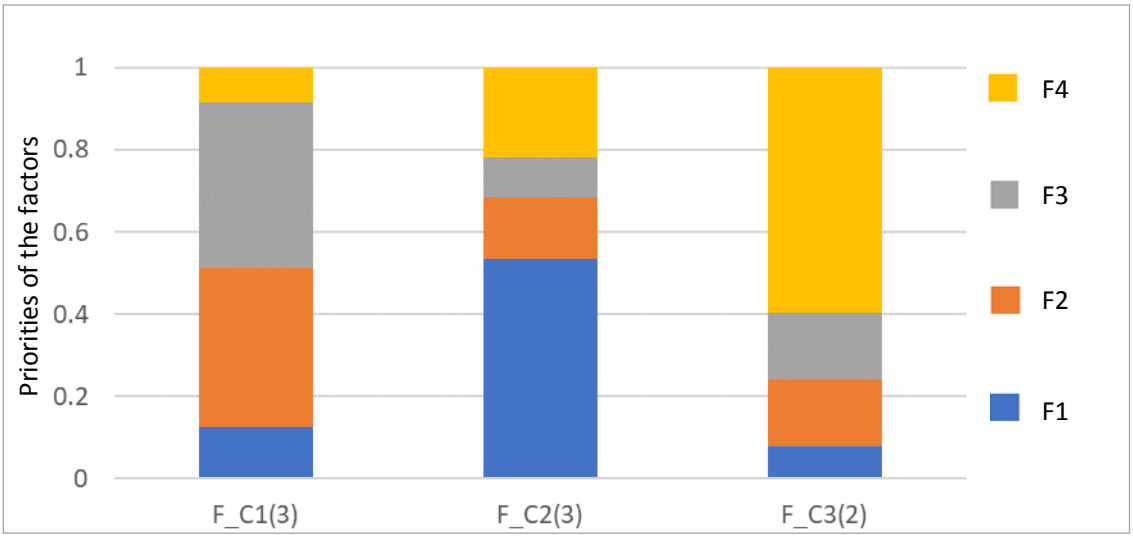
Table 4.10: Numbering of Economic Barrier Factors

E1	Small market	The Myanmar market is in its initial stage, despite the rapid development of the international market.
E2	Low demand	Creating demand in addition to basic use, such as for lighting, is still a challenge for operators.
E3	Cost–revenue gap	The design of the tariff structure affects the business model.
E4	Fee collection	Operators must ensure that customers pay for the electricity, sometimes using new technologies such as Pay As You Go.

3.5. Financial Barriers

Figure 4.7 shows the results of the financial barriers. As a result of the consistency analysis, the financial category presented many inconsistent answers with the smallest number of valid answers. The weighting tendency also varied according to each cluster. It was concluded that the evaluation of each factor varied according to personal perspectives.

Figure 4.7: Clustering Results of Priorities of Financial Barrier Factors



Note: F_C1 (3) indicates that cluster 1 of the financial category contains three valid responses. The legend indicates each barrier factor (F1 to F4) in Table 4.11.

Table 4.11: Numbering of Financial Barrier Factors

F1	Access to financing	Due to local banks' lack of familiarity with project financing through a financial institution, obtaining loans is difficult. Immature stock and debt markets limit the options for financing arrangements.
F2	High cost of capital	Even if funds are arranged, financing costs are high. Interest rates are high and loan fees are costly.
F3	Customers' insufficient capital	Customers' financing methods are limited. Microfinance is relatively new and unofficial money lenders are expensive.
F4	Currency risk	If financing is based on a foreign currency, companies are exposed to exchange rate risks because their revenue and expenses are in different currencies.

4. Discussion and Conclusions

In some categories, high agreement amongst respondents was observed. In other categories, opinions were divided. Clear findings, such as the greatest barrier for mini-grid development being the threat of national grid extension in India (Comello et al., 2017), were not observed. We investigated whether the respondent's occupation had an impact but did not observe any particular trends related to occupation in any category. The results indicate that there are various barriers to disseminating mini-grids based on renewable energy in Myanmar, and there is no consensus yet on what the greatest barriers are.

In the social and cultural category, respondents' opinions were divided. In the top two clusters, 'S4: Perception of inferior quality' and 'S3: Education gap' were evaluated as important. The output of mini-grids that use solar, hydropower, and other renewable energy may be affected by weather conditions, which hinders securing quality. Securing enough power generation and transmission requires an increase in installation capacity and in the capacity of backup power supply. However, the extra facilities would lead to increasing costs. System capacity is normally set according to the village's demand, and power generation may not be available because of the weather. It should be noted that explaining appropriate measures to the residents would facilitate business.

The gap in education is significant for businesses developing mini-grids in rural areas. Mini-grid developers from overseas entering the market can speak English and operate tools such as computers and Microsoft Office. However, existing operators are often based in rural areas where the net high school enrolment was 39% in 2017 (Central Statistical Organization et al., 2018). It is challenging for them to prepare the required documentation for low-interest financing from international donor organisations, such as the Excel-based finance model required for '60/20/20' under the NEP. This limits their access to favourable finance.

In the regulatory category, there is a considerable degree of agreement that institutional capacity is important. The Electricity Law 2014 (Pyidaungsu Hluttaw, 2014) established that sources generating 30 MW or more and any power generation connected to the national grid come under MOEE jurisdiction. Power generation under 30 MW that is not connected to the national grid is under the jurisdiction of the state and region governments. However, under the NEP, which is funded by the World Bank, electrification of off-grid areas is being promoted by the DRD. The off-grid mini-grid legal system has been developed under the DRD and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and submitted to the MOEE (Du Pont, 2019). By accelerating the development of legislation, business risks surrounding mini-grids will be reduced (e.g. handling of the mini-grid when the national grid reaches the mini-grid business area) and investments are likely to accelerate.

The technology gap was considered relatively important under the technical category. Despite the differences between native Myanmar technology and foreign standards, domestic technology has not been entirely rejected. Indigenous technology refers to technology independently developed in Myanmar before the country became democratic and the market was opened. Stakeholders identified technologies for small hydropower and biomass power generation, which allow operation and maintenance to be performed easily in off-grid rural areas. Practical issues occur often, such as the difficulty of obtaining repair parts in rural areas, too-high technology installed by international organisations, and the lack of engineers who can conduct repairs. In the future, it will be important to select affordable technologies and introduce power plants using more advanced technology, which will lead to improving engineers' skills.

In the economic category, the cost–revenue gap was relatively important in the top two clusters. The cost–revenue gap can be considered a problem of tariff setting. Solar power generation is particularly capital-intensive, and it is a business model that recovers the initial costs incurred through electricity charges. However, consumers' ability to pay is limited and a high tariff to recover costs will cause consumers to refrain from using electricity. Consumers' ability to pay should be balanced against recovery of cost. The acceptance of the tariff by residents depends largely on the reference price. Myanmar has subsidised its residential prices for the national grid and set them very low. The price of mini-grids will likely seem high if the residents reference the price of the national grid. Therefore, implementing mini-grids depends on the economic equilibrium of price and convenience of electricity. In villages that originally relied on diesel power, electricity from solar-powered mini-grids is cheaper than electricity generated from diesel, which is more expensive in rural than in urban areas. Villagers in those areas are more willing to pay tariffs for mini-grids, which shows that the reference price is important and can deeply affect customer behaviour.

This study has some limitations. For the AHP, prioritisation was first performed between factors of the lowest hierarchy. Subsequently, prioritisation was performed at a hierarchy that was one level higher. However, since the paper-based questionnaire survey was conducted, immediate prioritisation results could not be presented and superior prioritisation based on the results could not be investigated further. For future research, we would like to use a survey method that allows for ease in obtaining answers, which can then lead to a deeper analysis. We also had inconsistent answers. We used the consistency ratio of 0.1 as suggested in most of the extant literature, but some studies have a consistency ratio of 0.2 (Cox, Alwang, and Johnson, 2000). The consistency ratio should be examined in more detail.

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

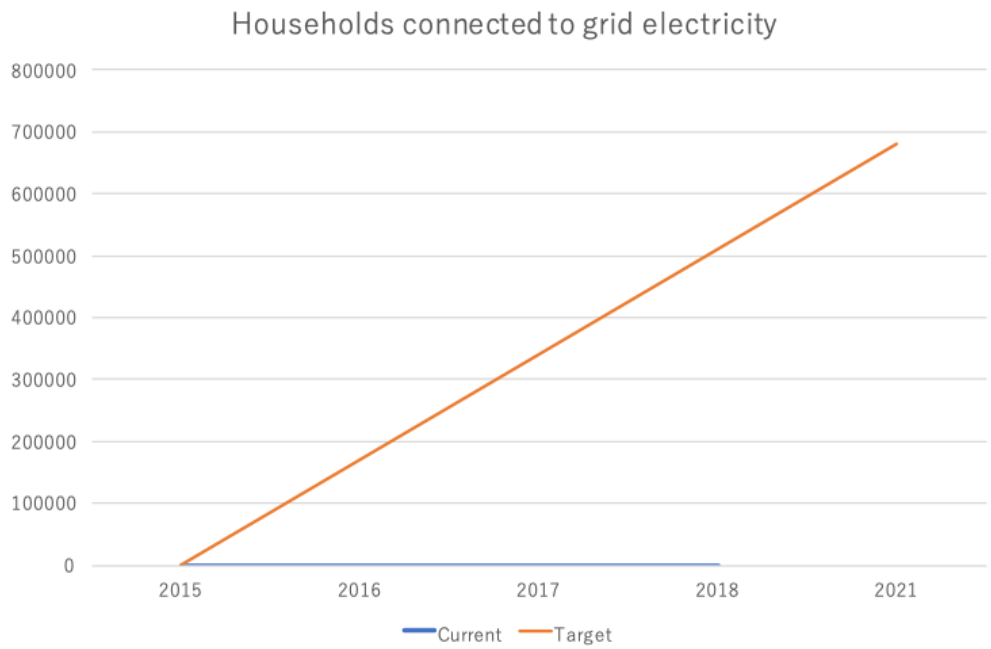
1.1. Situation of Rural Electrification

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).

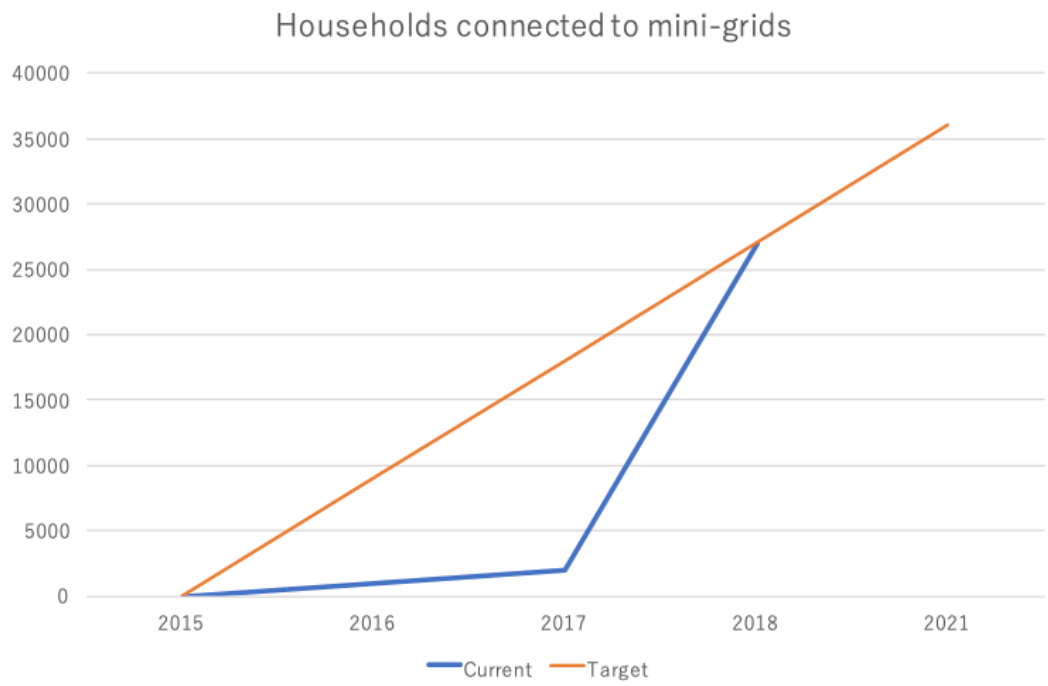
Mini-grids are preferred to SHSs because they have greater benefits: they enable socio-economic development by providing basic electricity services for households, and they enable rural industrial development by ensuring the productive use of electricity by small and medium-sized enterprises (European 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



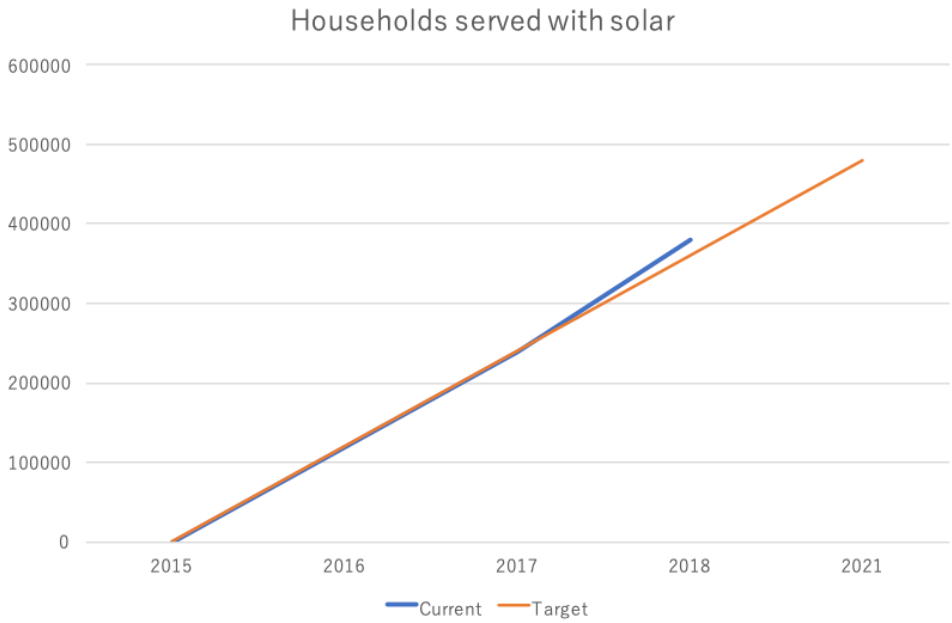
Source: World Bank (2019).

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

Private Operator Model

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

Overview

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.

Advantages and Disadvantages

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.

Chapter 6

Policy Recommendations

This report analysed power-sector policy in Myanmar and the GMS using various approaches. The research touched upon international grid connectivity, rural electrification, sustainable development, barriers to mini-grid diffusion, and a financing method for mini-grids. The following summarises the lessons from the analysis.

1. Renewables and the Peace Process

Large-scale development projects should employ a conflict-sensitive approach.

Poverty reduction is important but does not necessarily lead to immediate peace. When conducting a large-scale development project, policy makers should consider local circumstances and seek agreement with locals through an appropriate community consultation process. Otherwise, the risk of a conflict intensifying due to a large-scale development will be greater.

Pay attention to decentralised renewable energy as a component in cooperative projects.

Although their use is limited to basic applications, SHSs can satisfy increasing demand for mobile charging. SHSs are not politically sensitive and local people can derive significant benefits from them. SHSs can, therefore, serve as a starting point for a cooperative project, which can be followed by a mini-grid project as electricity consumption expands.

Increase the number of energy engineers.

One issue raised was the dearth of engineers in rural areas. Engineers hired by the government cannot cover every corner of a region, whilst few companies operate in rural areas, and few possess the needed technical capability. No one can check the quality of infrastructure such as roads. In the NCDDP, providing technical assistance through DRD engineers alone was no longer sufficient when the number of projects ballooned, and the project's organisational structure was enhanced. People are waiting to learn the technology, and expanding CSOs' efforts to provide them with technical education would be effective.

Review existing social service systems for collaborative opportunities.

To conduct cooperative projects, state authorities should recognise and respectfully work with local service providers (EAOs and CSOs). Although Burmese society is characterised by patron–client relationships, it is important to recognise that ethnic minorities are not clients in need of

central government protection. The central government should not aim to replace the EAO in its patron–client relationship with villagers.

2. Regional Power Connectivity for Myanmar and the GMS

The government should consider integration as a mechanism to foster equitable national development of renewable energy.

The government should ensure that the benefits from interconnection are shared across the country and are not captured only by populations and businesses in urban areas already connected to the national grid. National and state governments should work together so that benefit-sharing mechanisms with local communities can be considered from the beginning.

Myanmar should evaluate electricity imports to ameliorate insufficient power capacity in the short run and improve national energy security in the long run.

How to meet both needs should be further studied. Overdependence on electricity imports could become a concern in the long term. Exploring imports from other countries such as Lao PDR should continue to secure a diversified generation mix. Power imports from China could be planned jointly with exports to Bangladesh. The structure of contracts and price arrangements between the three countries will be critical: no party should dominate.

Consider strengthening and expanding the national grid.

The country has no single 500 kV line, which limits the viability of transboundary power trade. The construction of such infrastructure, already in plan, is critical to make the imports from neighbours economical. Ageing infrastructure leads to high technical losses.

3. Barrier to Development of Renewable-based Mini-grids

Increase the tariffs for the main grid to pay for development and operation costs.

A subsidised national grid tariff not only causes economic losses for the national grid but also hinders the development of mini-grids. A possible increase in the national grid tariff has been discussed, but it is politically sensitive and has been repeatedly postponed. Current electricity charges cannot cover power generation costs of the national grid, and various reports mention the need to increase prices. The tariff increase in the summer of 2019 is in the right direction, but a higher price hike should be pursued.

Give instruction to villagers in advance.

Instructing villagers in advance could help to reduce potential complaints about the mini-grid. Villagers should understand the do's and don't's such as running many appliances at one time.

Fill the education gap of local developers.

Local developers need help in applying for soft loans from international donor organisations. However, they cannot afford to pay for support because they operate the mini-grids at low profit rates. If the loan aims to assist local operators, lenders should provide support services in-house or outsource them.

Use affordable technology.

Often, aid projects install high-quality technology in rural areas, but operation and maintenance pose difficulties. Lack of parts and engineers is a problem.

4. Financing Mini-grids

To secure significant government support, provide a public financing mechanism such as a dedicated fund.

Where the banking sector is not mature, as in Myanmar, a fund mechanism is important to achieve multi-year targets. A law legalising a rural development fund is in its final deliberation. As the law states that the fund can be used for rural infrastructure such as electrification, communities can reasonably expect the fund mechanism to support mini-grids.

Fund sources can be secured as an ear-marked tax such as a gasoline tax.

The initial cost of a mini-grid needs to be subsidised, especially in the community model. DRD support for one project is around US$0.18 million. As the minister of MOEE states, 2,000 villages in peripheral regions need mini-grids. Around US$360 million is needed to achieve mini-grid targets in conflict-prone areas. In Thailand (Energy Conservation [ENCON] Fund), the petroleum tax is the feasible option. Assuming surging transportation use in urban areas, a 5% tax rate on gasoline and on diesel is sufficient to fund mini-grids in Myanmar.

Line ministries should be reformed to diffuse mini-grid systems on a large scale.

The MOEE oversees on-grid electrification whilst the MoALI conducts off-grid electrification projects such as the '60-20-20' programme. As MoALI is not an 'energy' ministry, the programme remains small. To expand the scale and integrate off-grid systems with on-grid ones, institutional reform of MOEE and MoALI is required for their deeper integration and coordination. Ultimately,

an integrated policy and planning body such as the previous government's National Energy Management Committee is required.

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Appendices

Appendix 1: Semi-structured Interviews

Name	Affiliation	Location	Date
Saw Kaw Muh Too (Henry)	BHN	Hpa-an, Kayin State, Myanmar	2019/2/11
Zar Ni	BHN	Hpa-an, Kayin State, Myanmar	2019/2/11
	BHN	Hpa-an, Kayin State, Myanmar	2019/2/11
	BHN	Hpa-an, Kayin State, Myanmar	2019/2/11
Nicola Williams	The Asia Foundation	Yangon, Myanmar	2019/2/22
Kyi Phyo	MEE Net Myanmar	Yangon, Myanmar	2019/2/22
Peter Barwick	United Nations	Yangon, Myanmar	2019/2/21
Naw Thet Thet Htun	Karen Women Empowerment Group	Yangon, Myanmar	2019/2/21
Aung Myint	Renewable Energy Association Myanmar	Yangon, Myanmar	2019/2/21
Pyi Pyi Thant	Heinrich Böll Stiftung Myanmar	Yangon, Myanmar	2019/2/18
Khin Ma Ma Myo	Myanmar Institute of Gender Studies	Yangon, Myanmar	2019/2/17
Fukio Tsuji	Peace Winds Japan	Hpa-an, Kayin State, Myanmar	2019/2/16
Saw Tha Moo	Local organisation	Yangon, Myanmar	2019/2/15

Ugan Manandhar	WWF Myanmar	Yangon, Myanmar	2019/2/13
Akio Takahashi	Institute of Advanced Studies on Asia, The University of Tokyo	Tokyo, Japan	2019/3/11
Ashley South	Independent researcher	Skype	2019/3/27

Appendix 2: Brief History of Ethnic Armed Organisations

Appendix 2-1: British Colonial Period

Two methods of governance were used during the British colonial period. One was direct governance in the flat plain regions of present-day Tanintharyi region, Rakhine state, Bago region, and Ayeyarwady region, which were then called Burma proper or ministerial Burma. In contrast, peripheral areas such as the Shan kingdom were left autonomous (Myint-U, 2011; Burke et al., 2017; Nemoto, 2014). The colonial government also supported the construction of Christian mission schools, which then expanded mainly amongst the Kachin, Chin, and Karen peoples (Encyclopedia Britannica, 2018). The colonial government appointed members of minorities who were primarily Christian to be part of the military and the police, thereby connecting them to British rule (Myint-U, 2011).

At this time, Myanmar was a part of the British colony of India, and many people of different classes from India, including merchants and moneylenders, began to migrate into Myanmar. Bamar farmers often gave up their land to repay debts owed to Indian moneylenders (Encyclopedia Britannica, 2018). In colonial Burma, the upper class was mainly made up of the British; the middle class of Chinese, Indians, Karen, and Bamar; and the lower class of working-class Indians and Bamar (Nemoto, 2014). Antagonism between ethnic groups deepened as a result. However, it is not sufficient to simply say that a firm ethnic consciousness formed during the colonial period and led to the outbreak of the civil war, as misgovernment following independence also contributed significantly (Kubo, 2014).

Appendix 2-2: Kayin State[9]

Independence from the British following the Second World War was also the beginning of the long period of conflict between ethnic groups. During the war, the independence forces of General Aung San and others switched from cooperating with the Japanese to resisting them and, after the war, turned to wresting independence from the British. During this series of political events, the first Panglong Agreement was concluded in February 1947 and signed by General Aung San and various minority peoples. However, the minority peoples participating were limited to the Shan, Kachin, and Chin, with the Karen and Karenni (or Kayah) being mere observers. The Mon and Arakan did not attend the conference. Aung San was assassinated shortly after in July 1947. His successor, U Nu, became prime minister and Myanmar gained independence from Britain in 1948. However, as priority had been given to independence itself, the Karen state demanded by

[9] Kayin, the name of the state as established by the Myanmar government, has been used, but Karen is used for the ethnic group.

the Karen people was not established at the outset, and conflicts with the Karen National Union (KNU), which was established in 1947, began in 1949 (Nemoto, 2014). The national military used methods such as encouraging the internal collapse of ethnic armed organisations (EAOs) by approaching dissatisfied lower-ranking members of the EAO leadership (Jolliffe, 2014). As a result, EAOs that separated from or re-joined the KNU during the long history of the conflict include Nationwide Ceasefire Agreement signatories Democratic Karen Benevolent (Buddhist) Army and KNU/Karen National Liberation Army Peace Council (Saferworld and Karen Peace Support Network, 2019).

Appendix 2-3: 8888 Uprising

The democratic movement inspired by student fatalities in confrontations between students at the Rangoon Institute of Technology (RIT, today Yangon Technological University) and the police in 1988 brought about the retirement of Ne Win, but was also connected to a Tatmadaw coup d'état and ultimately the beginning of the military regime that lasted until 2011. The students who had formed the democratic movement organised the All Burma Students' Democratic Front and became active in areas controlled by the Kachin Independence Organization (KIO) and KNU (Myanmar Peace Monitor, 2016).

The military regime, which feared that the student movement would strengthen the movement for democracy, clamped down on the universities, closing undergraduate education at Yangon Technological University until 2011 and at Yangon University until 2013, with only the graduate school accepting students (University of Yangon, n.d.; Yangon Technological University, n.d.). This resulted in the lack of well-educated human resources.

Appendix 2-4: Push for a Bilateral Ceasefire

The push for a bilateral ceasefire began to strengthen in the 1990s. The Thailand government, which had deepened ties with the Myanmar government since the second half of the 1980s, placed pressure on EAOs in areas along the Thailand border to participate in peace negotiations. The Thailand government also pressured a group of 8,000 to 10,000 internally displaced ethnic Mon to return to Myanmar (Jolliffe and South, 2014), and in 1995 the New Mon State Party, which was primarily active in Mon state, concluded a ceasefire agreement with the government (Kramer, 2012). Although ceasefire agreements had been concluded with a number of groups, the push for ceasefires waned with the 2004 overthrow of Khin Nyunt, who had supported them (Durieux and Dhanapala, 2008). Peace was left unachieved and the next push for ceasefires would have to wait for the beginning of the Thein Sein administration.

Nationwide Ceasefire Agreement Non-signatories

Amongst the NCA non-signatories are the members of the Northern Alliance, which have been active and engaged in many battles in recent years (Raleigh, 2018). The Northern Alliance was established in 2016 by four non-ceasefire EAOs: the KIO, Arakan Army (AA), Ta'ang National Liberation Army, and Myanmar National Democratic Alliance Army. The KIO spearheaded the establishment of the Northern Alliance (Bynum, 2018). After this, the four EAOs established the Federal Political Negotiation and Consultative Committee together with three others: the United Wa State Army (UWSA), Shan State Progress Party, and National Democratic Alliance Association–East Shan State (NDAA) (Tønnesson et al., 2019). The UWSA boasts the largest forces of any EAO in Myanmar (Yun, 2017) and is thought to maintain a close relationship with China, which touches the border of the UWSA's special administrative district (Myint-U, 2011), and has had an impact on the four EAOs of the Northern Alliance (Tønnesson et al., 2019). China is thought to be acting as a broker between the Northern Alliance and the Myanmar government (Mangshang and South, 2019). The China–Myanmar Economic Corridor, which is proceeding under the Chinese 'One Belt, One Road' initiative, runs from the town of Muse in Shan state through the former capital of Mandalay and connects to Kyaukphyu in Rakhine state. The condition of this route is of serious importance to China (United States Institute of Peace, 2018). Below, the origins of the main NCA non-signatories are examined.

- Ethnic Armed Organisations Originating in the Communist Party of Burma

After independence from Britain, one combatant that the independent government had to fight was the Communist Party of Burma (CPB). It was established in 1939, primarily by Aung San, but fractured after the Second World War and entered into armed conflict with the government following independence (Bi, 2012). The Kuomintang invaded Shan around 1950, having lost its war against the Chinese Communist Party (Nemoto, 2014). In the early 1960s, the China–Myanmar relationship was positive enough for the government to cooperate with China in mopping up the Kuomintang army. However, in 1962, the military regime followed the coup d'état by Ne Win and China shifted its policies to support foreign communist parties. This changed the Myanmar–China relationship, which further deteriorated due to the revolt in 1967. As the relationship between the two countries worsened, China's government turned to supporting the CPB. The CPB controlled 100,000 km^2 at the height of its power, including nearly all of the border between China and Myanmar (excluding Muse) (Bi, 2012; Kramer, Russell, and Smith, 2018; Kramer, 2012). However, beginning in the latter half of the 1970s, China's government reduced its support for the CPB due to a shift in its foreign policy. Although the CPB proceeded to produce opium as a separate source of funds, it ultimately collapsed internally in 1989, with each ethnic

group forming its own EAO: in north-east Shan, the Myanmar National Democratic Alliance Army (MNDAA) of the Kokang, the UWSA of the Wa, and the NDAA of the Mong La Shan and the Aka; and in north-east Kachin state, the New Democratic Army–Kachin (NDA-K) of the Kachin. The military regime took this as an opportunity to begin peace negotiations directed by Khin Nyunt, who would later become prime minister, eventually concluding a ceasefire agreement (Bi, 2012).

These four EAOs were allowed to turn the areas they controlled into special administrative districts and engage in sophisticated forms of self-rule (Bi, 2012). The narcotics business produced great wealth, and the UWSA became the world's largest producer of heroin (Myint-U, 2011). The cultivation of alternative crops was promoted under government leadership, but the cultivation of heroin was never eradicated (Bi, 2012).

Afterwards, the four EAOs took different paths. The UWSA continues to obtain great wealth from the narcotics business, has more than 30,000 soldiers and weapons, including surface-to-air missiles (Myint-U, 2011), boasts the largest forces of any EAO, and is considered the 'world's mightiest non-state army' (Yun, 2017). In the UWSA-controlled area, most residents are connected to China's electric grid, Chinese is spoken, and the towns are prosperous (Myint-U, 2011). In the NDAA-controlled area, Mong La has become famous for casinos and the illegal wildlife trade (Myint-U, 2011). In contrast, the MNDAA broke up following armed conflict with the national military in 2009, and a portion of it has been converted into the Border Guard Force (BGF), described later. In the same year, the NDA-K was also converted into the BGF (Kramer, 2012).

- Kachin State and Shan State

In recent years, combat has most repeatedly broken out in north-east Myanmar, specifically Shan state and Kachin state (Raleigh, 2018). Shan has historically been governed by local lords (*sawbwa*), and even during the British colonial period, with the exception of those who opposed colonial rule, these lords were allowed to remain and their authority was reinforced (Myint-U, 2011). Those who converted to Christianity, such as the Kachin mountain people, were given appointments within the colonial government. Christian schools were constructed in Kachin, which increased the level of education (Burke et al., 2017). At the beginning of Burmese independence, the Shan agreed to participate in the Burmese government and federation. Their right to a certain degree of self-governance was recognised, but because of the civil war with the CPB, the situation in Shan deteriorated. The local lords were arrested during the 1962 coup d'état. The rights of minority peoples were weakened during the period of Burmese socialism and self-

government was abolished (Nemoto, 2014). As the scope of the war expanded, the KIO was formed by the Kachin people in Kachin, and the Shan State Army[10] was formed in Shan.

The military regime adopted the infamous 'four cuts' strategy in the 1960s to deprive the EAOs of food, funds, intelligence, and recruits from villages. Villagers were unable to farm and some were forcibly moved to locations with no access to food or medical care (Smith, 1994; Burke et al., 2017). These forced relocations continued even after ceasefire agreements had been concluded with the leaders of the minority peoples (JICA and Yachiyo Engineering Co., 2013; Jolliffe, 2014; Kubo, 2014).

As a result, many villagers were displaced. Those whose villages were burned down or who evacuated their homes due to nearby combat were also displaced. The 'four cuts' strategy is not merely a relic of the past and is reported to have been used in conflicts between the AA of Rakhine state and the Tatmadaw in 2019 (Pwint, 2019); 99,000 people were displaced in the 3 years of conflict that reignited beginning in 2011 in the northern part of the country, such as in Kachin and Shan (Benson and Jaquet, 2014; Visser, 2016). Repatriating these people and improving their living environment are major challenges (Arraiza and Leckie, 2018).

The KIO agreed to a ceasefire that lasted from 1994 until 2011 (Bynum, 2018). This ceasefire involved selling the abundant resources of Kachin state to Chinese companies, which helped line the pockets of the Tatmadaw and KIO leaders and was unpopular with local residents (Tønnesson and Nilsen, 2018). However, there were certainly few conflicts in Kachin in 2000 and the situation had become more stable. KIO and Tatmadaw soldiers were seen at local festivals in Kachin. People were not displaced in Kachin in 2006, although some were in 2016 (Burke et al., 2017). The impetus for the ceasefire violation is said to be the administration's demand that the KIO convert into the BGF (Visser, 2016; Myanmar Peace Monitor, n.d.-a). In 2009, the Myanmar government demanded that EAOs enlist in the BGF based on the 2008 Constitution and remain under the command of the Tatmadaw. The demand to convert into BGF was, in actuality, a demand to put them under the control of the national armed forces, a difficult demand for the EAOs to accept (Myint-U, 2011). In recent years, the KIO has lost a lot of territory in combat and is thought to be leaning towards dialogue with the government (Tønnesson et al., 2019).

[10]This became the base of the armed wings of the Shan State Progress Party and Restoration Council of Shan State: the Shan State Army–North and Shan State Army–South.

- Rakhine State

In recent years, Rakhine has garnered increased attention due to the Rohingya refugee problem,[11] but the AA has also become increasingly active and engaged in more combat. The AA was organised comparatively recently, in 2009, and was periodically active in Kachin, which is controlled by the KIO, with which the AA maintained a cooperative relationship. However, from 2015 onwards, the AA moved its activities to Rakhine and southern Chin (Tønnesson et al., 2019). At first the AA was thought to have had only 1,000 members in 2011 (Burma News International, 2017), but it grew rapidly by recruiting through social network services and is now thought to have 7,000 members (*The Irrawaddy,* 2019). The AA's adversary is not the Rohingya Muslim population but the Tatmadaw. The Tatmadaw appear to be occupied with the Northern Alliance and announced a 4-month unilateral ceasefire in December 2018, which covered Shan and Kachin in the north-east (Nyein, 2018b). Directly after this, the AA attacked four border guard police outposts in Rakhine in January 2019. Combat has since intensified (*The Irrawaddy*, 2019). (The 4-month unilateral ceasefire did not include Rakhine [Lat, Tun, and Thu, 2018].)

[11] The Rohingya refugee problem is extremely politically sensitive and is not dealt with in this paper, as the issue has a different background and should be understood in a different way than the discussion of minority peoples in this chapter.

Appendix 3: Materials Used in Chapter 4

Appendix 3-1: Questionnaire in English

Mini-grid's Barrier

Overview

The objective of this survey is to ask you about barriers to deployment of mini-grids, which are increasingly promising options for energy access. There are already many governmental projects, but mini-grids are yet to scale.

In this survey, we employ a method called analytic hierarchy process, (AHP), which has been extensively used in the energy policy field. You'll be asked to compare two items one time, and repeat this over multiple combinations.

Barrier categories;

1. Financial Barriers, 2. Economic Barriers, 3. Social/Cultural Barriers, 4. Regulatory Barriers, 5. Technical Barriers

Example

We first walk through an example of new car purchase.

Suppose you're thinking of buying a new car, and there are two features you have to think about: design and price.

If you think price has very strong importance compared to design, you should check 7 on the "price" side.

Example	*Extreme importance*	*Very strong importance*	*Strong importance*	*Moderate importance*	***Equal importance***	*Moderate importance*	*Strong importance*	*Very strong importance*	*Extreme importance*	
Buy car	**9**	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Design								✓		Price

On the other hand, you think design is slightly more important than price, you should check 3 on the design side:

Example	*Extreme importance*	*Very strong importance*	*Strong importance*	*Moderate importance*	***Equal importance***	*Moderate importance*	*Strong importance*	*Very strong importance*	*Extreme importance*	
Buy car	**9**	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Design				✓						Price

Mini-grid's Barrier

Now please answer the questions on mini-grid barriers.

Financial Barriers

In this category, we have identified following barriers, based on the literature survey and discussions with stakeholders:

Access to finance	Difficulty in access to finance due to the immaturity of Myanmar financial sector.
High cost of capital	Even if funds can be procured, capital costs (interest rates, loan fees) are high.
Insufficient customers' capital	customers' access to finance is also limited.
Currency risk	When funds are procured in a foreign currency, businesses take a currency risk with the revenue in Myanmar Kyat.

Please answer the following pair-wise comparisons:

Financial Barriers	*Extremely important*	*Very strongly important*	*Strongly important*	*Moderately important*	***Equally important***	*Moderately important*	*Strongly important*	*Very strongly important*	*Extremely important*	
	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Access to finance										High cost of capital
Access to finance										Insufficient customers' capital
Access to finance										Currency risk
High cost of capital										Insufficient customers' capital
High cost of capital										Currency risk
Insufficient customers' capital										Currency risk

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Mini-grid's Barrier

Economic Barriers

In this category, we have identified following barriers, based on the literature survey and discussions with stakeholders:

Small market size	The scale of Myanmar's renewable energy market is still small.
Low demand	Creation of electricity demand beyond basic use for lighting and charging cell phones is necessary to make business sustainable.
Cost-revenue gap: tariff structure	Difficulty of balance between the customers' ability to pay and the costs.
Fee collection	Fee collection risk should be reduced.

Economic Barriers	*Extremely important*	*Very strongly important*	*Strongly important*	*Moderately important*	***Equally important***	*Moderately important*	*Strongly important*	*Very strongly important*	*Extremely important*	
	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Small market size										Low demand
Small market size										Cost-revenue gap
Small market size										Fee collection
Low demand										Cost-revenue gap
Low demand										Fee collection
Cost-revenue gap										Fee collection

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Mini-grid's Barrier

Social/Cultural Barriers

In this category, we have identified following barriers, based on the literature survey and discussions with stakeholders:

Negative externalities by international organizations	The business environment of existing spontaneous mini-grid has changed before/after the installment of mini-grid projects subsidized by international organizations.
Ethnic/ language difference	Unelectrified regions overlap with areas inhabited by ethnic minorities who don't speak Burmese.
Education gap	It is sometimes difficult for local companies to meet credit standards of international soft loan providers not because of creditability but because of education gap.
Perception of inferior quality	It is difficult to achieve 24 hours/7 days supply. Perception of customers is needed.

Social/Cultural Barriers	*Extremely important*	*Very strongly important*	*Strongly important*	*Moderately important*	***Equally important***	*Moderately important*	*Strongly important*	*Very strongly important*	*Extremely important*	
	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Negative externalities by int'l organizations										Ethnic/ language difference
Negative externalities by int'l organizations										Education gap
Negative externalities by int'l organizations										Perception of inferior quality
Ethnic/ language difference										Education gap
Ethnic/ language difference										Perception of inferior quality
Education gap										Perception of inferior quality

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Mini-grid's Barrier

Regulatory Barriers

In this category, we have identified following barriers, based on the literature survey and discussions with stakeholders:

Lack of regulatory framework	There is currently no legislation covering mini-grids.
Lack of technical standards	Since there are no technical standards or codes, it is difficult to ensure the quality of mini-grids.
Institutional capacity	Coordination across ministries is time-consuming. On-grid systems fall under the Ministry of Electricity and Energy, while off-grid systems fall under the Department of Rural Development, the Ministry of Livestock, Fisheries and Rural Development.
Threat of grid extension	When there is unplanned grid extension, there haven't been settled any compensation or guarantee of business for existing mini-grids.

Regulatory Barriers	*Extremely important*	*Very strongly important*	*Strongly important*	*Moderately important*	***Equally important***	*Moderately important*	*Strongly important*	*Very strongly important*	*Extremely important*	
	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Lack of regulatory framework										Lack of technical standards
Lack of regulatory framework										Institutional capacity
Lack of regulatory framework										Threat of grid extension
Lack of technical standards										Institutional capacity
Lack of technical standards										Threat of grid extension
Institutional capacity										Threat of grid extension

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Mini-grid's Barrier

Technical Barriers

In this category, we have identified following barriers, based on the literature survey and discussions with stakeholders:

Technology gap	Local technology sometimes differs from international current practice; e.g., design policy.
Lack of interconnectivity with main grid	The risk of an unplanned extension of the main grid will increase without interconnectivity with the main grid.
Intermittency	Renewable energy is often intermittent; day/night and dry/rainy seasons for solar power, and rainy/dry seasons in the case for hydropower. A system to compensate is needed.
Operation and maintenance (O&M)	Without local expertise, O&M becomes more difficult and it affects durability and to keep quality.

Technical Barriers	*Extremely important*	*Very strongly important*	*Strongly important*	*Moderately important*	***Equally important***	*Moderately important*	*Strongly important*	*Very strongly important*	*Extremely important*	
	9	**7**	**5**	**3**	**1**	**3**	**5**	**7**	**9**	
Technology gap										Lack of interoperability with main grid
Technology gap										Intermittency
Technology gap										O&M
Lack of interoperability with main grid										Intermittency
Lack of interoperability with main grid										O&M
Intermittency										O&M

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	General information							
	Please attach your name card. If you don't have a name card, please fill the below.							
	Name							
	title							
	organization name							
	Your experience							
1	Do you have experiences of energy sector?							
	☐ Yes	☐ No						
2	If yes, how long?							
	( ) years							
3	If yes, what kind of energy?							
	☐ Oil							
	☐ Gas							
	☐ Electrical power							
	☐ Coal							
	☐ Solar photovoltaics							
	☐ Hydropower							
	☐ Biomass							
	☐ Rice husk	☐ Other kind of Biomass ( )						
	☐ Wind							
	☐ Others ( )							
4	Your sector?							
	☐ Policy							
	☐ Research & Academia							
	☐ NGOs & Associations							
	☐ Business							
	☐ Media							
	☐ Public at large							
	☐ Others ( )							
	Thank you for your cooperation!							

Appendix 3-2: Questionnaire in Burmese

အေသးစားလွ်ပ္စစ္စာတ္အားေပးစနစ္၏ အခက္အခဲမ်ား

ဤစစ္တမ္းေကာက္ယူျခင္း၏ ရည္ရြယ္ခ်က္မွာ စြမ္းအင္ရရွိမႈႏွင့္ပတ္သက္ၿပီး အလား အလာေကာင္းသည့္ အေသးစားလ်စစ္စာတ္အားေပးစနစ္မ်ားကို ထိေရာက္စြာ အသံုးျပဳရာတြင္ အဟန္႔အတား ျဖစ္ေနသည့္အေၾကာင္းအရာမ်ားကို ေမျမန္းရန္ျဖစ္ပါသည္။ အစိုးရမွ ခ်မွတ္ ေဆာင္ ရြက္ေနသည့္ စီမံကိန္းေပါင္းမ်ားစြာ ရွိၿပီးျဖစ္ေသာ္လည္း အေသးစားလွ်ပ္စစ္စာတ္အားလုိင္းမ်ားမွာ ယခုတိုင္ အခ်ိဳ့က်ိန္သည္းေနပါေသးသည္။

ဤစစ္တမ္းေကာက္ယူျခင္းတြင္ စြမ္းအင္ဗ်ဴဟာနယ္ပယ္တြင္ အက်ယ္တဝင့္ အသံုးျပဳေန သည့္ (Analytic Hierarchy Process, (AHP)) ေခၚ အဆင့္သတ္မွတ္ခ်က္ အရ စီစစ္သည့္ နည္းလမ္းတစ္ခုကို အသံုးျပဳသြားပါမည္။

အခက္အခဲ အမ်ိဳးအစားမ်ား

၁။ ေငြေၾကးဆိုင္ရာ အခက္အခဲမ်ား၊ ၂။ စီးပြားေရးဆိုင္ရာ အခက္အခဲမ်ား၊ ၃။ လူမႈေရး/ယဥ္ေက်းမႈ ဆိုင္ရာ အခက္အခဲမ်ား၊ ၄။ စည္းမ်ဥ္းစည္းကမ္းဆုိင္ရာ အခက္အခဲမ်ား၊ ၅။ နည္းပညာဆိုင္ရာ အခက္အခဲမ်ား

ဥပမာ

ပထမဦးစြာ ကားအသစ္တစ္စီး ဝယ္ျခင္းျဖင့္ ဥပမာေပးၿပီး စတင္ လုပ္ေဆာင္ပါမည္။ လူႀကီးမင္းအေနျဖင့္ ကားအသစ္တစ္စီး ဝယ္ရန္ စဥ္းစားမယ္ဆိုပါစို႔။ ဒီဇုိင္း(ပံုစံ) ႏွင့္ ေစ်း(တန္ဖိုး) ဟူသည့္ အဂၤါရပ္ (၂) ခုကို ထည့္သြင္းစဥ္းစားရပါမည္။

လူႀကီးမင္းအေနျဖင့္ ေစ်း(တန္ဖိုး)သည္ ဒီဇုိင္း(ပံုစံ)ႏွင့္ယွဥ္ၿပီး အလြန္အမင္းအေရးႀကီးသည္ဟု ယူဆပါက ေစ်း(တန္ဖိုး)ဘက္ျခမ္းတြင္ (၇) ကို အမွန္ျခစ္(✔) ျခစ္ေပးရပါမည္။

ဥပမာ	အလွန်/အလွန်	အလွန်ပိုမို အရေးကြီးသော	အလွန် အရေးကြီးသော	အတော်အသင့်	တန်းတူ အရေးကြီးသော	အတော်အသင့်	အလွန် အရေးကြီးသော	အလွန်ပိုမို အရေးကြီးသော	အလွန်/ အလွန်	
ကား ဝယ်ခြင်း	၉	၇	၅	၃	၁	၃	၅	၇	၉	
ဒီဇိုင်း (ပုံစံ)								✔		ဈေး (တန်ဖိုး)

အခြားတစ်ခုတွင် လူကြီးမင်းအနေဖြင့် ဒီဇိုင်းသည် ဈေးနှုန်းထက် အနည်းငယ် ပိုအရေးကြီး သည်ဟု ထင်မြင်ယူဆပါက ဒီဇိုင်းဘက်ခြမ်းတွင် (၃) ကို အမှန်ခြစ် (✔) ခြစ်ပေးရပါမည်။

ဥပမာ	အလွန်/အလွန်	အလွန်ပိုမို အရေးကြီးသော	အလွန် အရေးကြီးသော	အတော်အသင့်	တန်းတူ အရေးကြီးသော	အတော်အသင့်	အလွန် အရေးကြီးသော	အလွန်ပိုမို အရေးကြီးသော	အလွန်/ အလွန်	
ကား ဝယ်ခြင်း	၉	၇	၅	၃	၁	၃	၅	၇	၉	
ဒီဇိုင်း (ပုံစံ)				✔						ဈေး (တန်ဖိုး)

အေသးစားလွ်ပ္စစ္ဓာတ္အားလိုင္း၏ အခက္အခဲ

ယခု အေသးစားလွ်ပ္စစ္ဓာတ္အားလိုင္းမ်ားႏွင့္ပတ္သက္ၿပီး ေမးခြန္းမ်ားကိုေျဖၾကားေစလိုပါသည္။

ေငြေၾကးဆိုင္ရာ အခက္အခဲမ်ား

ဤကဏ္ဍတြင္ သက္ဆိုင္ရာစီးပြားေရးလုပ္ငန္းရွင္မ်ား (ကုမၸဏီမ်ား)ထံမွ အျပန္အလွန္ေဆြးေႏြးမႈ မ်ားႏွင့္ စာအုပ္ စာေစာင္၊ စာတမ္းမ်ားတြင္ စူးစမ္းေလ့လာမႈမ်ားကို အေျခခံကာ ေအာက္ပါ အခက္အခဲမ်ားကို ပိုင္းျခား ေဖာ္ျပထားပါသည္။

ေငြေၾကး ရယူသံုးစြဲႏိုင္မႈ	ျမန္မာႏိုင္ငံ၏ ဘဏ္ေရးဆိုင္ရာအခန္းက႑၏ ဖြံ႕ၿဖိဳးမႈနည္းေသာေၾကာင့္ ေငြေၾကးရယူသံုးစြဲႏိုင္မႈဆိုင္ရာ အခက္အခဲမ်ား
ေငြအရင္းအႏွီး ကုန္ကၽြမ္းျခင္း	ဘဏ္ေငြမ်ား ရယူႏိုင္သည့္တုိင္ အရင္းအႏွီး ကုန္ကၽြမ္းမွာ (အတိုးႏႈန္းမ်ား၊ ေခ်းေငြ အဖိုးအခမ်ား) ျမင့္မားေနပါသည္။
သံုးစြဲသူ၏ ေငြအရင္းအႏွီး မလံုေလာက္ျခင္း	အသံုးျပဳသူမ်ားအတြက္ ေငြေၾကးရယူသံုးစြဲခြင့္ကိုလည္း ကန္႔သတ္ထားပါသည္။
ေငြေၾကးလဲလွယ္မႈ ျပႆနာ	ရန္ကုေငြဘဏ္မ်ားကို ႏိုင္ငံျခားေငြျဖင့္ ရယူရာတြင္ လုပ္ငန္းရွင္မ်ားအေနျဖင့္ ျမန္မာက်ပ္ကို ေျပာင္းယူ ရသည့္အခါ ႏိုင္ငံေတာ္ဘဏ္အခြန္ႏွင့္ ပတ္သက္သည့္ အခက္အခဲမ်ားကို ႀကံဳေတြ႕ေစပါသည္။

ေက်းဇူးျပဳ၍ ေအာက္ပါ အတြဲလိုက္ ယွဥ္တြဲခ်က္မ်ားကို ေျဖေပးေစလိုပါသည္။

ေငြေၾကးဆိုင္ရာ အခက္အခဲမ်ား	အလြန္အလြန္ အေရးႀကီး	အလြန္အေရးႀကီး	အေရးႀကီး	အတန္အသင့္ အေရးႀကီး	တန္ဖိုးမရွိ	အတန္အသင့္ အေရးမႀကီး	အေရးမႀကီး	အလြန္အေရးမႀကီး	အလြန္အလြန္ အေရးမႀကီး	
	၅	၄	၃	၂	၁	၀	-၁	-၂	-၃	
ေငြေၾကး ရယူသံုးစြဲႏိုင္မႈ										ေငြအရင္းအႏွီး ကုန္က်ေငြ မ်ားျခင္း
ေငြေၾကး ရယူသံုးစြဲႏိုင္မႈ										သံုးစြဲသူ၏ ေငြအရင္းအႏွီး မလံုေလာက္ျခင္း
ေငြေၾကး ရယူသံုးစြဲႏိုင္မႈ										ေငြေၾကးလဲလွယ္မႈ ျပႆနာ
ေငြအရင္းအႏွီး ကုန္က်ေငြ မ်ားျခင္း										သံုးစြဲသူ၏ ေငြအရင္းအႏွီး မလံုေလာက္ျခင္း
ေငြအရင္းအႏွီး ကုန္က်ေငြ မ်ားျခင္း										ေငြေၾကးလဲလွယ္မႈ ျပႆနာ
သံုးစြဲသူ၏ ေငြအရင္းအႏွီး မလံုေလာက္ျခင္း										ေငြေၾကးလဲလွယ္မႈ ျပႆနာ

စီးပြားေရးဆိုင္ရာ အခက္အခဲမ်ား

ဤကဏ္ဍတြင္ သက္ဆုိင္ရာစီးပြားေရးလုပ္ငန္းရွင္မ်ား (ကုမၸဏီမ်ား) ထံမွ အျပန္အလွန္ေဆြးေႏြးမႈ မ်ား ႏွင့္ စာအုပ္စာေစာင္၊ စာတမ္းမ်ားတြင္ စူးစမ္းေလ့လာမႈမ်ားကို အေျခခံကာ ေအာက္ပါ အခက္ အခဲမ်ားကို ပိုင္းျခား ေဖာ္ျပပါသည္။

အေသးစား ေစ်းကြက္ အရြယ္အစား	ျမန္မာႏုိင္ငံ၏ ျပန္ျဖစ္မဲစြမ္းအင္ေစ်းကြက္ ပမာဏသည္ အေသးစားအဆင့္သာ ျဖစ္ပါသည္
ရလိုအား နည္းေနျခင္း	ဖုန္းအားသြင္းျခင္းႏွင့္မီးထြန္ျခင္း စသည့္ အေျခခံအသံုးျပဳျခင္းမ်ား တြင္သာမကပဲ လွ်ပ္စစ္မွာတ္အား လိုအပ္ခ်က္ ဖန္တီးေပးျခင္းသည္ ေရရွည္စီးပြားေရးလုပ္ငန္းအျဖစ္ ေဆာင္ရြက္ရန္ အေရးႀကီးပါသည္။
အခြန္ ကုန္က်စရိတ္ ကြာဟခ်က္ - အခြန္ ေကာက္ခံသည့္ ပံုစံ	အသံုးျပဳသူမ်ားအေနျဖင့္ ေပး(ေဆာင္)ႏိုင္မႈႏွင့္ ကုန္က်စရိတ္မ်ား အၾကား ထိန္းညွိရန္ အခက္အခဲ
အသံုးျပဳခ စုယူျခင္း (ေကာက္ယူျခင္း)	အသံုးျပဳခ ေကာက္ယူျခင္းဆိုင္ရာ အခက္အခဲမ်ားကို ေလ့ာ့ခ်သင့္ ပါသည္။

စီးပွားရေးဆိုင်ရာ အခက်အခဲများ	အပြင်း/အပြင်း	အပြင်းထန်ဆုံး အရေးပါမှု	အပြင်း အရေးပါမှု	အလယ်အလတ်	တန်းတူ အရေးပါမှု	အလယ်အလတ်	အပြင်း အရေးပါမှု	အပြင်းထန်ဆုံး အရေးပါမှု	အပြင်း/အပြင်း	
	၉	၇	၅	၃	၁	၃	၅	၇	၉	
အသေးစား ချေးကြေး အရင်းအနှီး										ရလဒ်အား နည်းပါးချင်း
အသေးစား ချေးကြေး အရင်းအနှီး										အချိန် ကုန်စရိတ် ကြာမြင့်မှု
အသေးစား ချေးကြေး အရင်းအနှီး										အသုံးပြုမှုဖြင့် ကောက်ယူခြင်း
ရလဒ်အား နည်းပါးချင်း										အချိန် ကုန်စရိတ် ကြာမြင့်မှု
ရလဒ်အား နည်းပါးချင်း										အသုံးပြုမှုဖြင့် ကောက်ယူခြင်း
အချိန် ကုန်စရိတ် ကြာမြင့်မှု										အသုံးပြုမှုဖြင့် ကောက်ယူခြင်း

လူမှုေရး/ယဥ္ေက်းမႈဆိုင္ရာ အခက္အခဲမ်ား

ဤကဏ္ဍတြင္ သက္ဆုိင္ရာစီးပြားေရးလုပ္ငန္းရွင္မ်ား (ကုမၸဏီမ်ား)ႏွင့္ အျပန္အလွန္ေဆြးေႏြးမႈ မ်ားႏွင့္ စာအုပ္စာေစာင္၊ စာတမ္းမ်ားတြင္ စူးစမ္းေလ့လာမႈမ်ားကို အေျခခံကာ ေအာက္ပါ အခက္အခဲမ်ားကို ပိုင္းျခား ေဖာ္ျပထားပါသည္။

ႏိုင္ငံတကာအဖြဲ႕အစည္းမ်ားႏွင့္ဆက္စပ္ျဖစ္သည့္ ဆန္႔က်င္ဘက္ဆိုးက်ိဳးမ်ား	နဂိုရွိၿပီးသည့္ အေသးစားလွ်ပ္စစ္လုိင္းမ်ား၏ လုပ္ငန္းအေျခအေနသည္ ႏုိင္ငံတကာအဖြဲ႔အစည္းမ်ား၏ ကူညီမႈျဖင့္ အေသးစားလွ်ပ္စစ္စာတ္အားလိုင္းမ်ား တပ္ဆင္ၿပီးသည့္ ေနာက္ပိုင္းအေျခအေနမ်ားသည္ ၎၏ မတုိင္မီအေျခအေနမွ ေျပာင္းလဲသြားပါသည္။
လူမ်ိဳဘာသာစကား ကြဲလြဲမႈ	ျမန္မာစကားေျပာ(ႏိုင္ငံ)သည့္ လူနည္းစု တုိင္းရင္းသားမ်ား ေနထိုင္သည့္ ဧရိယာမ်ားႏွင့္ လွ်ပ္စစ္မီးမရသည့္ေဒသမ်ားမွာ ထပ္တူက်ေနပါသည္။
အတန္းပညာ တတ္ေျမာက္မႈ ကြာဟခ်က္	ႏုိင္ငံတကာမွ သက္သာသည့္ ေခ်းေငြေထာက္ပံ့သူမ်ား၏ ေခ်းေငြစံႏႈန္းျပည့္မီရန္မွာ ယံုၾကည္စိတ္ခ်ရမႈအရ သာမက အတန္းပညာတတ္ေျမာက္မႈ ကြာဟခ်က္မ်ားေၾကာင့္ တစ္ခါတစ္ရံ ေဒသခံကုမၸဏီမ်ားအတြက္ အခက္အခဲရွိပါသည္။
အရည္အေသြး မျပည့္မီျခင္းအေပၚ သေဘာထားအျမင္	၂၄ နာရီ၊ တစ္ပတ္(ရက္သတၱပတ္) ရရွိရန္မွာ ခက္ခဲပါသည္။ အသံုးျပဳသူမ်ား၏ သေဘာထားအျမင္ လိုအပ္ပါသည္။

လူမႈေရး/ယဥ္ေက်းမႈ ဆုိင္ရာ အခက္အခဲမ်ား	အလြန္႔အလြန္ အေရးႀကီး	အလြန္အမင္း အေရးႀကီး	အလြန္ အေရးႀကီး	အေတာ္အသင့္ အေရးႀကီး	တန္းတူ အေရးႀကီး	အေတာ္အသင့္ အေရးႀကီး	အလြန္ အေရးႀကီး	အလြန္အမင္း အေရးႀကီး	အလြန္႔ အလြန္ အေရးႀကီး	
	၉	၇	၅	၃	၁	၃	၅	၇	၉	
ႏိုင္ငံတကာအဖြဲ႕ အစည္းမ်ားႏွင့္ဆက္စပ္ ျဖစ္လာသည့္ ဆန္႔က်င္ ဘက္ ဆိုးက်ိဳးမ်ား										လူမ်ိဳး/ဘာသာ စကား ကြဲလြဲမႈ
ႏိုင္ငံတကာအဖြဲ႕ အစည္းမ်ားႏွင့္ဆက္စပ္ ျဖစ္လာသည့္ ဆန္႔က်င္ ဘက္ ဆိုးက်ိဳးမ်ား										အတန္းပညာ တတ္ေျမာက္မႈ ကြာဟခ်က္
ႏိုင္ငံတကာအဖြဲ႕ အစည္းမ်ားႏွင့္ဆက္စပ္ ျဖစ္လာသည့္ ဆန္႔က်င္ ဘက္ ဆိုးက်ိဳးမ်ား										အရည္အေသြး မျပည့္မီျခင္း အေပၚ သေဘာ ထား အျမင္
လူမ်ိဳး/ဘာသာစကား ကြဲလြဲမႈ										အတန္းပညာ တတ္ေျမာက္မႈ ကြာဟခ်က္
လူမ်ိဳး/ဘာသာစကား ကြဲလြဲမႈ										အရည္အေသြး မျပည့္မီျခင္း အေပၚ သေဘာ ထား အျမင္
အတန္းပညာ တတ္ေျမာက္မႈ ကြာဟခ်က္										အရည္အေသြး မျပည့္မီျခင္း အေပၚ သေဘာ ထား အျမင္

စည္ေးမ်ဥ္ေးစည္ေးကမ္ေးဆုိင္ရာ အခက္အခဲမ်ား

ဤကဏ္ဍတြင္ သက္ဆုိင္ရာစီးပြားေရးလုပ္ငန္းရွင္မ်ား (ကုမၸဏီမ်ား) ထံမွ အျပန္အလွန္ေဆြးေႏြးမႈ မ်ားႏွင့္ စာအုပ္စာေစာင္၊ စာတမ္းမ်ားတြင္ စူးစမ္းေလ့လာမႈမ်ားကို အေျခခံကာ ေအာက္ပါ အခက္အခဲမ်ားကို ပိုင္းျခား ေဖာ္ျပထားပါသည္။

စည္ေးမ်ဥ္ေးစည္ေးကမ္ေးဆုိင္ရာ ေဘာင္မူဝါဒ မရွိျခင္ေး	အေသးစားလွ်ပ္စစ္ဓာတ္အားလိုင္ေးမ်ားကို အကာအကြယ္ေပးသည့္ နည္ေးဥပေဒသည္ လက္ရွိတြင္ မရွိပါ။
နည္ေးပညာစံခ်ိန္ေးနွဳန္ေးမ်ား မရွိျခင္ေး	နည္ေးပညာစံခ်ိန္ေးနွဳန္ေးမ်ား သို႔မဟုတ္ က်င့္ဝတ္စည္ေးကမ္ေးမ်ား မရွိျခင္ေးေၾကာင့္ အေသးစားလွ်ပ္စစ္ဓာတ္အားလိုင္ေးမ်ား၏ အရည္အေသြးကို ေဖာ္ျပရန္မွာ ခက္ခဲပါသည္။
အဖြဲ႕အစည္ေး၏ ေဆာင္ရြက္ေးပုံစံခြဲမ္ေး	ဝန္ႀကီးဌာနမ်ားမွတဆင့္ ညွိနွိုင္ေးေဆာင္ရြက္ျခင္ေးသည္ အခ်ိန္ေပးရပါသည္။ ေနေရာင္ျခည္ စြမ္ေးအင္မွ တစ္ဆင့္ ဘက္ထရီပါဝါသံုေး လွ်ပ္စစ္ဓာတ္အား အသံုေးျပဳသည့္ စနစ္မ်ား (Off-Grid System)သည္ စိုက္ပ်ိဳေရး ေမြးျမဴေရေးႏွင့္ ဆည္ေျမာင္ေးဝန္ႀကီးဌာန၊ ေက်းလက္ဖြံ႕ ၿဖိဳေရးဦးစီးဌာနေအာက္ ရွိေနခ်ိန္တြင္ ပင္မလွ်ပ္စစ္လုိင္ေးကို ခ်ိတ္ဆက္ကာ ေနေရာင္ျခည္စြမ္ေးအင္ေးနွင့္ ပင္မလွ်ပ္စစ္စြမ္ေးအင္တို႔ အလိုအေလ ွဝ်ာက္ေျပာင္ေးလဲ အသံုေးျပဳသည့္ စြယ္နံုသံုေးလွ်ပ္စစ္ဓာတ္အားလုိင္ေး စနစ္မ်ား (On-Grid System)မွာမူ လွ်ပ္စစ္ေးနွင့္စြမ္အင္ဝန္ႀကီးဌာန ေအာက္တြင္ ေရာက္ရွိေနပါသည္။
ဓာတ္အားလိုင္ေးတုိေးခ်ဲ႕ ရန္ အလားအလာ	ဆကိတီတင္စီစဥ္ထားဘဲ ဓာတ္အားလိုင္ေး တိုးခ်ဲ႕ သည့္အခါမ်ိဳးတြင္ မည္သည့္နစ္နာေၾကးမွ မေပးသလို ရွိေနေသာ အေသးစားလွ်ပ္စစ္ဓာတ္အားလိုင္ေး လုပ္ငန္ေးအတြက္လည္ေး အာမခံ မရွိပါ။

စည္းမ်ဥ္း စည္းကမ္း ဆုိင္ရာ အခက္အခဲမ်ား	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	၄	၃	၂	၁	၀	၁	၂	၃	၄	
စည္းမ်ဥ္းစည္းကမ္း ဆုိင္ရာ ေဘာင္မူ၀ါဒ မရွိျခင္း										နည္းပညာ စံခ်ိန္စံႏႈန္းမ်ား မရွိျခင္း
စည္းမ်ဥ္းစည္းကမ္း ဆုိင္ရာ ေဘာင္မူ၀ါဒ မရွိျခင္း										အဖြဲ႕ အစည္း၏ ေဆာင္ရြက္ ႏုိင္စြမ္း
စည္းမ်ဥ္းစည္းကမ္း ဆုိင္ရာ ေဘာင္မူ၀ါဒ မရွိျခင္း										ဓာတ္အားလုိင္း တုိးခ်ဲ႕ရန္ အလားအလာ
နည္းပညာ စံခ်ိန္ စံႏႈန္းမ်ား မရွိျခင္း										အဖြဲ႕ အစည္း၏ ေဆာင္ရြက္ ႏုိင္စြမ္း
နည္းပညာ စံခ်ိန္ စံႏႈန္းမ်ား မရွိျခင္း										ဓာတ္အားလုိင္း တုိးခ်ဲ႕ရန္ အလားအလာ
အဖြဲ႕ အစည္း၏ ေဆာင္ရြက္ ႏုိင္စြမ္း										ဓာတ္အားလုိင္း တုိးခ်ဲ႕ရန္ အလားအလာ

နည္းပညာဆိုင္ရာ အခက္အခဲမ်ား

ဤကဲ့သို့ သတ္ဆိုင္ရာစီးပြားေရးလုပ္ငန္းရွင္မ်ား (ကုမၸဏီမ်ား)ထံမွ အျပန္အလွန္ေဆြးေႏြးမႈ မ်ား ႏွင့္ စာအုပ္စာေစာင္၊ စာတမ္းမ်ားတြင္ စူးစမ္းေလ့လာမႈမ်ားကို အေျခခံကာ ေအာက္ပါ အခက္ အခဲမ်ားကို ပိုင္းျခား ေဖာ္ျပထားပါသည္။

နည္းပညာ ကြာဟမႈ	ျပည္တြင္းမွ နည္းပညာမ်ားသည္ ႏိုင္ငံတကာမွ လက္ရွိ အသံုးခ်ေနေသာ လက္ေတြ႕ နည္းပညာမ်ားႏွင့္ တစ္ခါတစ္ ရံ ကြာျခားမႈ ရွိပါသည္။ ဥပမာ - ဒီဇုိင္းေရးဆြဲမႈ မူဝါဒပံုစံ
ပစၥည္းပစ္ပစ္သြားလိုင္းႏွင့္ ခ်ိတ္ဆက္မႈ မရွိျခင္း	ပစၥည္းပစ္ပစ္သြားလိုင္းႏွင့္ ခ်ိတ္ဆက္မႈ မရွိပါက ဆက္သြယ္စီစဥ္ထားဘဲ ပစၥည္းသြားလုိင္းတိုးခ်ဲ့ ရာတြင္ ျဖစ္လာမည့္ ျပႆနာမ်ားကို တိုးလာေစပါသည္။
ျပတ္ေတာင္း ျပတ္ေတာင္း ျဖစ္ျခင္း	ျပန္ျဖစ္စမဲ စြမ္းအင္သည္ တစ္ခါတစ္ရံ ျပတ္ေတာင္း ျပတ္ေတာင္း ျဖစ္တတ္ပါသည္။ ဆိုလာစြမ္းအင္သံုး လွ်ပ္စစ္တြင္ ေန႔/ည ႏွင့္ ေႏြ/မိုးရာသီတို႔တြင္ အျဖစ္မ်ားၿပီး၊ ေရအားလွ်ပ္စစ္တြင္ ေႏြ/မိုး ရာသီတို႔တြင္ ျပတ္ေတာက္မႈ မၾကာခန ျဖစ္တတ္ပါသည္။ အစားထိုးေဆာင္ရြက္ရန္ စနစ္တစ္ခု လိုအပ္ပါသည္။
လုပ္ငန္းလည္ပတ္ျခင္းႏွင့္ ျပဳျပင္ ထိန္းသိမ္းျခင္း	ျပည္တြင္း ပညာရွင္မရွိပါက လုပ္ငန္းလည္ပတ္ရန္ႏွင့္ ျပဳျပင္ထိန္းသိမ္းရန္ ခက္ခဲေစႏိုင္ကာ တာရွည္ခံမႈအေပၚ အက်ိဳးသက္ေရာက္ေစၿပီး အရည္အေသြးကို ထိန္းသိမ္းရန္ လုိအပ္ပါသည္။

နည္းပညာဆိုင္ရာ အခက္အခဲမ်ား	အလြန္႔ အေရးပါမႈ	အလြန္ျမင့္ အေရးပါမႈ	အလြန္ အေရးပါမႈ	ေအာက္ေလင့္	ထိန္း အေရးပါမႈ	ေအာက္ေလင့္	အလြန္ အေရးပါမႈ	အလြန္ျမင့္ အေရးပါမႈ	အလြန္႔ အေရးပါမႈ	
	၉	၇	၅	၃	၁	၃	၅	၇	၉	
နည္းပညာ ကြာဟမႈ										ပင္မလုပ္ငန္းစဥ္ ဓာတ္အားလိုင္း ႏွင့္ ခ်ိတ္ဆက္မႈ မရွိျခင္း
နည္းပညာ ကြာဟမႈ										ျပတ္ေတာင္း ျပတ္ေတာင္း ျဖစ္ျခင္း
နည္းပညာ ကြာဟမႈ										လုပ္ငန္းလည္ပတ္ျခင္း ႏွင့္ ျပဳျပင္ ထိန္းသိမ္းျခင္း
ပင္မလုပ္ငန္းစဥ္ဓာတ္အားလိုင္း းႏွင့္ ခ်ိတ္ဆက္မႈ မရွိျခင္း										ျပတ္ေတာင္း ျပတ္ေတာင္း ျဖစ္ျခင္း
ပင္မလုပ္ငန္းစဥ္ဓာတ္အားလိုင္း းႏွင့္ ခ်ိတ္ဆက္မႈ မရွိျခင္း										လုပ္ငန္းလည္ပတ္ျခင္း ႏွင့္ ျပဳျပင္ ထိန္းသိမ္းျခင္း
ျပတ္ေတာင္း ျပတ္ေတာင္း ျဖစ္ျခင္း										လုပ္ငန္းလည္ပတ္ျခင္း ႏွင့္ ျပဳျပင္ ထိန္းသိမ္းျခင္း

အေထြေထြအခ်က္အလက္မ်ား

နာမည္ (လိပ္စာ) ကဒ္ျပားရွိပါက ပူးတြဲေဖာ္ျပပါ။ မရွိပါက ေအာက္ပါတို႔ကို ျဖည့္ပါ။

အမည္ _____

ရာထူး/ဌာန _____

အဖြဲ႕အစည္းအမည္ _____

အေတြ႕ အႀကံဳမ်ား

၁။ စြမ္းအင္အခန္းက႑ႏွင့္ပတ္သက္ၿပီး အေတြ႕အႀကံဳ ရွိပါသလား။

□ ရွိပါသည္ □ မရွိပါ

၂။ ရွိလ ွ်င္၊ ဘယ္ေလာက္ၾကာလဲ

( ) ႏွစ္

၃။ ရွိလ ွ်င္၊ မည္သည့္စြမ္းအင္ အမ်ိဳးအစားလဲ။

□ ဒီဇယ္(ေရနံ)ဆီ

□ ဓါတ္ေငြ႕

□ လွ်ပ္စစ္ စြမ္းအင္

□ ေက်ာက္မီးေသြး

□ ေနေရာင္ျခည္စြမ္းအင္သုံး လွ်ပ္စစ္ (ဆိုလာ လွ်ပ္စစ္)

□ ေရအားသံုးစြမ္းအင္

□ ဇီဝေလာင္စာ

□ စပါးခြံ □ အျခား ဇီဝေလာင္စာမ်ား ( )

□ ေလအားလွ်ပ္စစ္

□ အျခား ( )

၄။ လူႀကီးမင္း ပါဝင္/တာဝန္ယူ ရသည့္ အခန္းက႑

□ မူဝါဒ

□ သုေတသနႏွင့္ပညာရပ္ဆုိင္ရာမႈ

□ အဖြဲ႕ အစည္းမ်ား (NGOs)ႏွင့္ အသင္းအဖြဲ႕ မ်ား

□ လုပ္ငန္းရွင္

□ မီဒီယာ

□ အမ်ားျပည္သူ

□ အျခား ( )

လူႀကီးမင္း၏ ပါဝင္ကူညီေဆာင္ရြက္ေပးမႈအတြက္ ေက်းဇူးတင္ပါသည္။

Appendix 4: Workshops and symposium

Appendix 4-1: Workshop 1

The Energy Policy Workshop

AUGUST 15–16, 2018

TARAPHI room, Hilton Nay Pyi Taw, Myanmar

Hosted by

Policy Alternatives Research Institute (PARI), The University of Tokyo

Supported by

The Association for Overseas Technical Cooperation and Sustainable Partnerships (AOTS)

and

Economic Research Institute for ASEAN and East Asia (ERIA)

	Morning / Afternoon	Evening 18:00-21:00	
14 AUG (TUE)	NA	Preparatory Dinner (w/t Central Economic commission of NLD)	
15 AUG (WED)		*DINNER*	Lecture 1 **Overview of Energy Policy** 1) Global Trend and Opportunities in Myanmar 2) Some Key Issues: - Black-out - Rural Electrification - Electricity Tariff - etc 3) Planning and Operation
16 AUG (THU)	Lecture 2 (8:00-10:00) **Participatory Session** 1) Group Discussion 2) Q & A by Prof. Yoshikawa	*DINNER*	Lecture 3 **Session Wrap-up (Group Presentation)** 1) Group Presentation 2) Response from Lectures 3) Way Forward - Action Plan

Burmese/Japanese

[Lecturer]

Prof. Hisashi Yoshikawa
Project Professor, Policy Alternatives Research Institute (PARI)
The University of Tokyo

[Participants]

10–15 Parliament members from relevant committees (i.e. energy, environment, international)

Appendix 4-2: Workshop 2

The Energy Policy Workshop (SESSION 2)
SEPTEMBER 12, 2018
TARAPHI room, Hilton Nay Pyi Taw, Myanmar

Hosted by
Policy Alternatives Research Institute (PARI), The University of Tokyo
Supported by
The Association for Overseas Technical Cooperation and Sustainable Partnerships (AOTS)
and
Economic Research Institute for ASEAN and East Asia (ERIA)

12 SEP (WED)	**Lecture (All Parliament Members)** **'Energy and Energy Policy in Myamanr'** **by** **Prof. Yoshikawa**

Burmese/Japanese

[Lecturer]
Prof. Hisashi Yoshikawa
Project Professor, Policy Alternatives Research Institute (PARI)
The University of Tokyo
[Participants]
600 Parliament members from Upper and Lower Houses

Appendix 4-3: Workshop 3

The Energy Policy Workshop (SESSION 3)

February 18–19, 2019

TBA, Nay Pyi Taw, Myanmar

Hosted by

Policy Alternatives Research Institute (PARI), The University of Tokyo

Supported by

The Association for Overseas Technical Cooperation and Sustainable Partnerships (AOTS)

and

Economic Research Institute for ASEAN and East Asia (ERIA)

	Morning / Afternoon	Evening 18:00-21:00	
18 FEB (MON)	NA.	*DINNER*	Lecture 1 **Overview of Rural Electrification (Lecture)** 1) Importance of Rural Electrification 2) Barrier of Electrification in Myanmar 3) Removal of Barriers - Discussions
19 FEB (TUE)	NA.	*DINNER*	Lecture 2 **Session Wrap-up (Group Presentation)** 1) Group Presentation 2) Response from Lectures 3) Way Forward - Action Plan

Burmese/Japanese

[Lecturer]

Prof. Hisashi Yoshikawa
Project Professor, Policy Alternatives Research Institute (PARI)
The University of Tokyo

Assistant Prof. Kensuke Yamaguchi
Project Assistant Professor, Policy Alternatives Research Institute (PARI)
The University of Tokyo

Appendix 4-4: International Symposium

International Symposium IFI–ERIA Myanmar

Sustainable energy policies in Myanmar and the Greater Mekong Subregion

In the pursuit of economic development, energy development often widens the social divide. In the era of sustainable development, energy development must be directed to fill the social divide in our and future generations. Tackling this concern, Myanmar seeks urgent rural development, on which the Institute for Future Initiatives (IFI) has been conducting advisory work based on its policy research since 2013, supported by ERIA.

In this upcoming symposium, government officials, parliament members, political leaders, and key stakeholders will gather to discuss this issue. After the closed morning session, there are two sessions in the afternoon. In the first afternoon session, in line with our research achievement, relevant legislation for a rural development fund and a mini-grid case study will be presented by a Parliament member and the Nippon Foundation, respectively.

In the second afternoon session, we will locate the Myanmar case in the regional and international context. Since Thailand has already experienced energy development for 30 years, its Ministry of Energy will draw an implication from the experience of the Energy Conservation Fund. Other stakeholders (e.g. UN ESCAP) discuss their role in such a policy transfer as a tool for sustainable development.

Date: 5 June 2019

Venue: Park Royal Hotel, Nay Pyi Taw

Time	**Agenda**
MORNING [Closed]	
9:00 – 9:30	*Registration*
9:30 – 9:40	Welcome remarks (U Han Than Minh, Chairman of CEoC, NLD)
9:40 – 9:45	Opening remarks (Prof. Yoshikawa, UTokyo)
9:45 – 10:00	Keynote 1: (Mr. Wataru Matsumura, IEA)
10:00 – 10:15	Keynote 2: (U Maw Win, Deputy Director General, DRD)
10:15-10:25	*Break*
10:25 – 11:45	Research Discussion (each 20min, incl. comment) [Dr. Anbumozhi, ERIA] • Dr. Daniel del Barrio Álvarez (The University of Tokyo)

	• Ms. Masako Numata (The University of Tokyo) • Dr. Kensuke Yamaguchi (The University of Tokyo)
11:45 – 12:00	Further Steps / Concluding Remarks [Prof. Arima, The University of Tokyo]
12:00 – 13:30	*LUNCH*
Language: English	

Time	**Agenda**
AFTERNOON [Open]	
14:00 – 14:30	*Registration*
14:30 – 14:40	Opening remarks (Prof. Hisashi Yoshikawa, The University of Tokyo)
14:40 – 14:50	U Zaw Thein (International Relations Committee, Chairman, Lower House)
14:50 – 15:00	United Nations Economic and Social Commission for Asia and the Pacific message Initiatives and progress towards SDG7 in Asia (Dr. Liu Honpeng, Director, Energy Division, UN ESCAP)
15:00 – 15:45	Panel Discussion 1: Policy Transfer for the sustainable ASEAN (10–15 min each) [Prof. Hideaki Shiroyama, The University of Tokyo] • Innovative Policy Options for low-carbon society (Dr. Noah Kittner, North Carolina University) • Budget for Rural Electrification in Myanmar (Deputy Director General, Budget Department, MOPF) • Thailand ENCON fund (Mr. Uthai Mungseemuengdee, Director, EPPO, Thailand)
15:45 – 16:00	*BREAK / Photo Session*
16:00 – 16:15	Keynote: ERIA's Energy Research in ASEAN (Prof. Jun Arima, The University of Tokyo)
16:15 – 17:00	Panel Doscussion2: Research to Practice (10-15min for each) [Prof. Hisashi Yoshikawa] • As a practitioner (Mr. Yuji Mori, Nippon Foundation) • Leaning from HRD (Energy Development Committee, Lower House, Myanmar) • Implication from Research (Prof. Hisashi Yoshikawa, The University of Tokyo)
17:00 – 17:15	Closing remarks (Prof. Jun Arima)
18:00 – 20:00	*DINNER*
Language: English / Burmese (simultaneous)	