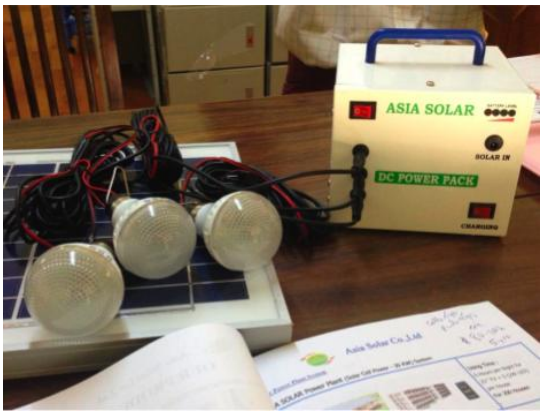
TURNING ON THE LIGHTS: INTEGRATED ENERGY AND RURAL ELECTRIFICATION DEVELOPMENT IN MYANMAR

The Critical Importance of Power Development



EXECUTIVE SUMMARY

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Produced for Economic Research Institute for ASEAN and East Asia (ERIA) by KWR International (Asia) Pte Ltd.

Myanmar Integrated Energy Fieldwork Site Visits

- **Phase I Fieldwork Visits – May-Aug 2013**
- **Phase II Fieldwork Visits – Jan-Jun 2014**
- **Phase III Fieldwork Visits – Jul-Dec 2014**
- **Multiple Visits during Project – 2012-2015**

Additional visits to Singapore, Tokyo, Jakarta, New York, Washington and other locations

Acknowledgements

KWR International (Asia) Pte. Ltd. (KWR) would like to thank the hundreds of individuals, institutions and companies who provided time and support to assist production of the three *Turning on the Lights: Integrated Energy and Rural Electrification Development in Myanmar* reports, stakeholder meetings and other related activities undertaken since this project began in 2012.

Beginning with our work to produce the energy and electrification contribution to the Economic Research Institute for ASEAN and East Asia (ERIA)'s Myanmar Comprehensive Development Vision (MCDV) report in cooperation with the University of Tokyo, exhaustive research, field visits, and other activities were undertaken over the past two and a half years. This included interactions with hundreds of individuals in Myanmar, Thailand, Singapore, Indonesia and other parts of ASEAN as well as Japan, Korea, the United States and other countries, who were kind enough to provide support and input into this initiative.

While the complete list of individuals and entities is too numerous to mention, KWR would like to give special thanks to ERIA and the University of Tokyo for their sponsorship and ongoing support of this project. KWR would also like to thank Japan's Ministry of Economy, Trade and Industry (METI), Overseas Human Resources and Industry Development Association (HIDA), the Institute for Energy Economics Japan and Japan External Trade Organization (JETRO).

Within Myanmar's government, KWR would like to thank the Office of the President and several Presidential Advisors, Pyithu Hluttaw (House of Representatives), Ministry of Livestock, Fisheries and Rural Development, Ministry of Electrical Power, Ministry of Energy, Ministry of Agriculture and Irrigation, Ministry of Science and Technology, Ministry of Industry and regional governments of Shan and Rakhine State and Ayeyarwady, Bago, Mandalay, Sagaing, Tanintharyi divisions as well as the Yangon Electricity Supply Board, in addition to many other national, regional and township officials, village representatives and local electrification committees throughout Myanmar.

KWR would also like to thank the Myanmar Engineering Society, Union of Myanmar Federation of Chambers of Commerce and Industry, Myanmar Industry Association, Renewable Energy Association of Myanmar as well as representatives of World Bank, ADB, JICA and other development agencies and foreign governments, in addition to Chulalongkorn, Columbia, Harvard and other universities, NGO's, journalists and analysts, multinationals, Myanmar and foreign companies and all others who provided input and support to this project.

Finally, KWR would like to thank its staff and consultants who worked tirelessly on this initiative. We are truly grateful and appreciative of the support and many friendships that were formed over the course of this project and look forward to continuing this important work moving forward.

Please send any comments, questions or suggestions to myanmar@kwrintl.com

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Introduction

Following Myanmar's 2010 election, the nation began to move from military rule and almost 60 years of stagnation, toward a democratic government and more open economy. Foreign and domestic stakeholders are gradually overcoming their concerns over whether this transition is sincere, initiating efforts to pursue emerging opportunities as well as to address numerous challenges. Blessed with abundant natural and human resources in a country that once possessed Southeast Asia's most dynamic economy, perhaps no economic issue is as pressing as the need to upgrade Myanmar's antiquated power sector. Presently, it is believed Myanmar's power grid connects to only about 30% of its 51 million people. More than half the wiring—in this country that is about the size of Texas—is estimated to be at least seventy years old.

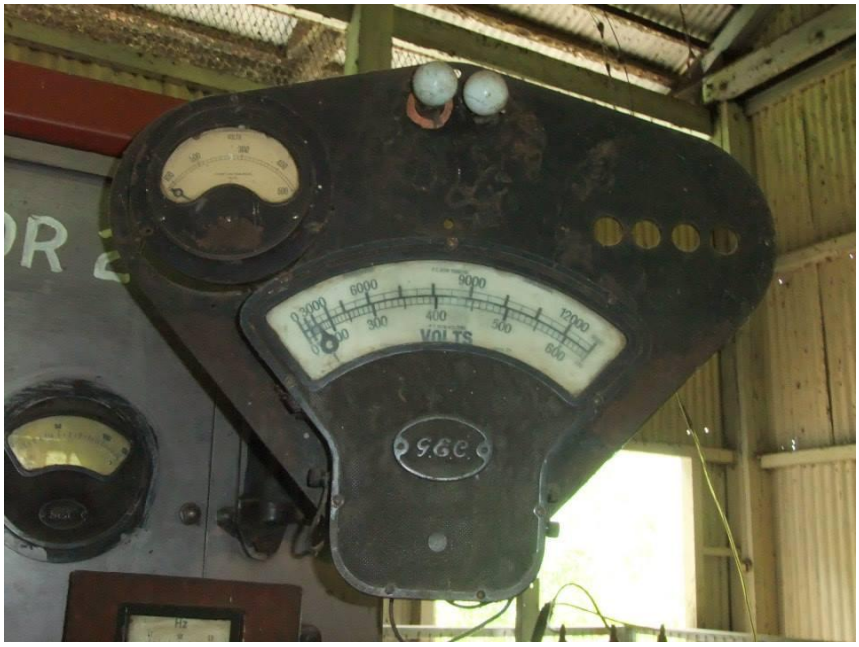
National electrification is profoundly important. It is a central element and foundation upon which to achieve needed advances in education, healthcare, industrial and regional development. Job creation, tourism, telecommunications, financial services and governance are also effected by power generation. So is the country's ability to raise incomes and living standards and to create a more inclusive and equitable society. Myanmar's government, development partners such as the World Bank, Asian Development Bank (ADB), the Japan International Cooperation Agency (JICA) and others are allocating substantial resources to support the design and development of a coherent and viable national electrification plan and energy development strategy. At the same time foreign leaders, executives, investors and other parties crowd Yangon and Naypyitaw to position themselves for this major infrastructure upgrade, and to partake in the decades of strong growth forecast in Myanmar moving forward.

In 2012, however, as Myanmar's government began working more actively with returning donors and others to define and address the nation's development needs, there was a real shortage of information. This was required to evaluate the overall situation, as well as the complex issues that impact power generation and other key sectors. Given the need for data to address these challenges, the Economic Research Institute for ASEAN and East Asia (ERIA) drafted a multi-sector Myanmar Comprehensive Development Vision (MCDV) review for Myanmar's Ministry of National Planning and Economic Development. KWR International (Asia) Pte Ltd (KWR), working in cooperation with the University of Tokyo (UT), prepared the energy and electrification component. This led to a multi-year study that included three phases of fieldwork and hundreds of interviews with key stakeholders; site visits to cities, towns, villages, border crossings, planned special economic zones and other locations both inside and outside Myanmar. Capacity building initiatives and workshops were also organized; and an effort maintained to continuously review and monitor available information.

The methodology employed in this effort extended far beyond the quantitative forecasts and technical evaluations that often characterize initiatives of this kind. This was due both to an inadequacy of reliable data as well as a recognition that the challenges Myanmar faces require wholesale redevelopment and review of essentially every sector. It also requires restructuring of government, rewriting of legislation and regulator regimes—some of which date to the 19th century—as well as a need to reconcile Myanmar's culture with international standards and business practices.

Nowhere is this dilemma more profound and important than in the power sector. Electricity demand in Myanmar is expected to grow at an annual rate of between 10-15%. This is double projected GDP, and could be as high as 2.5 times international norms. The nation's antiquated infrastructure is incapable of meeting current domestic needs, let alone anticipated demand from foreign investors, manufacturers and tourists.

Hydropower facility with equipment dating back to 1932 in Pyin Oo Lwin



Source: KWR International

Myanmar's grid is mostly concentrated in urban areas, leaving those that live in rural areas largely without grid access. Given its large size and geographic diversity this is not easy to resolve. The challenge is further complicated by complex political and social issues related to income inequality and ethnic conflict. In addition to technical concerns, Myanmar is also lacking in developed, as opposed to underlying, human resources as well as the institutional capacity needed to address the challenges of national electrification. Government decision-making in regard to energy and electrification is divided among eight or more Ministries. Data collection is weak, and electricity laws—which were recently updated—still lack adequate provisions, such as for power purchase agreements and feed-in tariffs, that would help to attract private sector investment. This is particularly true in rural areas that extend beyond the national grid.

Making matters worse, the use of subsidized tariffs means the government currently provides power to citizens at a loss -- which totaled over US$275 million in 2013. In the past, economic development and domestic energy use was less of a priority. Revenue gained from oil, gas and resource exports were used to finance the country's survival in the face of a harsh sanctions regime. This largely benefited a small group of elites and select institutions. The nation is now, however, pushing for Myanmar's energy to be used for the public good. At the same time market pricing and mechanisms, as well as the inefficiency of subsidies—are not well understood. This makes it difficult to remove subsidies to provide the funds and pricing needed to facilitate grid extension and to help ensure sustainability of socio-political and national economic growth.

Myanmar, however, does not suffer from a lack of resources. It has vast potential for hydroelectricity, gas, biomass, diesel and alternative energy. At the same time the nation has one of the world's lowest per capita electricity consumption rates -- ranking higher than only Nepal, Haiti and a handful of sub-Saharan African countries. In 2012, Myanmar's electricity supply was estimated at less than half of future demand and ADB, citing the Ministry of Electric Power (MOEP), forecast individual power consumption would grow from 204 kWh in 2012-2013 to 550 kWh in 2021-2022.

Village system powering television in Myanmar

Source: KWR International

Myanmar's installed capacity—approximately 3,500 MW in 2012—is far too low for a country its size. Thailand, by comparison, possesses roughly 30,000 MW. Further, although there were no significant reported upgrades in the years leading up to 2012, Myanmar experienced 15% annual increases in electricity generation between 2008-11.Blackouts became more frequent in Yangon and Mandalay, leading to tensions given rising public expectations. Adding to the problem, about 27% of electricity is lost in transmission due to antiquated equipment and relatively low voltage lines, as well as users diverting electricity. The latter is also a safety concern. More than one third of fires in Yangon in 2011 were reportedly caused by improper use of electrical appliances.

Based on its examination of available literature, background briefings, and the analysis incorporated into its MCDV findings, KWR worked with UT to focus its review on three main thematic areas. These included Grid Extension and Development, Off-Grid/Rural Electrification and Regional Integration/Cross-Border Electrification. This was then supplemented by the identification of short-, medium-, and long-term priorities as well as resulting policy implications, concerns, conclusions and recommendations. Following this review, three phases of fieldwork and research were conducted to assess:

- **Phase I:** On-the-Ground Conditions and Key Issues Relating to Rural Electrification
- **Phase II:** Comparative Cost & Technology Evaluation Relating to Rural Electrification
- **Phase III:** Cross-Border Electrification and Potential for Regional Energy Integration

Third stakeholder's meeting at UMFCCI

Source: KWR International

This comprehensive evaluation included workshops, discussions, capacity development and a peer-review process to gain input and involvement from key internal and external stakeholders. Through an ongoing examination of important issues and concerns, government officials, executives, investors, donor representatives, academics and analysts were able to provide feedback, encouraging public-private and intra-ministerial dialogue. This is helping to build consensus concerning viable policies and approaches, encouraging the cooperation needed to successfully develop Myanmar's power sector.

Through further examination and discussion of the many issues and concerns identified, it is hoped this process will continue, recognizing that the scope and scale of Myanmar's energy and electrification needs are too large for its government, development partners or the private sector alone. Cooperation will be critical, necessitating ongoing dialogue, continuous study and exchange of information, so Myanmar can both realize its potential as a vibrant, dynamic economy and contribute to the development, integration and emergence of an ASEAN Economic Community as a whole.

• **Phase I:** On-the-Ground Conditions and Key Issues Relating to Rural Electrification

Meeting with village leaders in Monywa

Source: KWR International

Following preparation of the MCDV analysis, Phase I fieldwork was undertaken to examine on-the-ground conditions and to determine key issues related to rural electrification and whether the “rhetoric” from the data assembled matched the “reality” in the field. From May-August 2013, fieldwork was undertaken in several regions in Myanmar. This included Bagan/Nyaung-Oo, an agricultural area that encompasses a burgeoning tourist destination; Mandalay, a large city in Myanmar's dry zone; Monywa, an industrial river city on route to the Indian border; Pathein, a delta city in a largely agricultural region with a growing industrial focus; Pyin Oo Lwin, a colonial outpost north of Mandalay; Tachileik, a rapidly growing city on Thai border near Laos; and Kengtung, in East Shan State where there is an abundance of hydro resources.

This fieldwork painted a broad picture of the electricity practices of rural populations in Myanmar's diverse regions. It underscored the fact that, despite the dire statistics on electricity access in Myanmar, many off-grid communities have obtained a power supply on a household or village level, albeit not in an ideal or sustainable fashion.

Site visits highlighted the fact that electricity access and economic development are inextricably linked. This applies to households—where villagers were able to start businesses or add value to existing revenue streams with the use of electric appliances or equipment—as well as larger scale industrial entities, whose ability to achieve profitability and competitiveness, increase production and create jobs was dependent on access to reliable power sources.

Village entrepreneur selling rental batteries

Source: KWR International

What also became clear is that Myanmar citizens have rapidly rising expectations. In some cases villages postponed plans to initiate village-level electrification strategies as they were optimistic the government would soon connect them to the national grid. This reflected the fact that, in its attempt to build a more representative democracy, Myanmar is becoming more dependent on the political support of traditionally marginalized and remote populations. Rural electrification, in addition to helping these regions and the country develop, is one means of building support among more diverse constituencies.

Field research also illustrated more clearly the complex challenges facing Myanmar's government as it seeks to balance the electricity needs of a largely rural population with those of a growing tourism sector, business and industry and urban populations. It also emphasized the need for electrification strategies that focus careful attention on the three themes that had been emphasized in the MCDV research: Grid Extension; Off-Grid Electrification and Cross-Border Energy and Electricity Sharing.

Grid Extension

Extending the national grid to rural populations is the most efficient strategy for national electification, both economically and technically speaking. The grid is easier to scale than other systems, reducing the generation cost per unit with the ability to draw, and integrate, distribution from a range of energy sources. Nonetheless, grid extension requires massive investment to meet the needs of Myanmar as a whole. Investors are also likely to choose urban centers, industrial zones and other areas where demand is high and incomes sufficient to allow positive returns on a commercial basis, before providing power to more marginal areas.

For rural populations who generally possess lower incomes than those residing in urban areas, the challenges of self-financing grid connections are significant. Fieldwork revealed MOEP's responsibility for grid extension ends at the township level, after which it is usually up to villages to connect households on a collective basis. Grid extension can cost in excess of US$35,000 a kilometer or US$250+ per household, not counting the final costs of connection into the home. This is more than double the average monthly income in Myanmar.

Villagers repairing locally installed power lines near Bagan

Source: KWR International

Village connectivity is governed by MOEP’s 24 Conditions on Grid Extension. Among other clauses, this requires villages to draw from collective savings and generally prohibits loans and other financing mechanisms. It states “Permission is only for the

village having the savings relied on themselves" and if "help from others are asked for, or donation is asked for, the project for the access to the electricity in the village shall not be permitted." While exceptions have been observed, few opportunities exist in any case for financing. Even when obtainable, loans in Myanmar are generally for one year. This makes it very difficult for villages to connect unless they can gain a rare exemption that allows for individual household, rather than collective, connectivity or funds from wealthy present or former residents or other sources.

Strong local leadership and management capacity is essential if a village is to collectively organize itself, resolve issues related to land and household affordability, and to fully understand the dimensions and requirements of their commitment. This is difficult and instances are reported where villages have installed generating equipment --- but not adequately provisioned for the final expense of household connection -- and therefore ran out of funds before they were fully connected.

Further, even if adequate financing and a structure is developed—which would allow villages to bypass the 24 conditions—and the nation was able to deal with the high costs and ramifications of grid extension—capacity must be expanded within the grid itself. The grid currently lacks sufficient generating power to deal with present connections. This necessitates a reliance on backup and auxiliary generators. That is problematic. While many consumers, particularly larger users, note a willingness to pay higher rates for adequate and reliable power, they are not only resistant if there remains a need to incur the costs of backup equipment, but they also become more dependent on low tariffs to compensate for the high cost of diesel generation. Therefore, if Myanmar is to both expand its grid, and to develop adequate capacity to satisfy both residential and industrial users at projected growth levels, the cost will be enormous.

High cost diesel generation near Dawei

Source: KWR International

Additionally, even if the nation is able to successfully implement planned initiatives, such as the World Bank's proposed National Electrification Plan, which calls for a national grid extension effort to almost the entire nation by 2030, Myanmar's large size and geographic diversity ensures some parts of the country will be connected before others. This will leave certain areas dependent on high-cost diesel and other sources that can cost up to MMK 500 per kWh, or which provide power only a few hours a day.

At the same time some of their neighbors and nearby areas, which are connected, will receive 24-hour power at the MMK 35 per kWh residential or MMK 75 per kWh industrial tariff rates. This is bound to exacerbate social tensions and promote a sense of inequity. Some towns and villages are already protesting their lack of a grid connection while others are brought online. As efforts to extend the grid are accelerated, this type of tension is sure to increase. It will require more extensive community relations and public outreach to facilitate this essential transition.

Inadequate capacity within the grid is even more troublesome for Myanmar's overall economic development. Industrial users in particular suffer from unstable electricity access, given their need to maintain predictable production schedules and secure supply chains. Auxiliary capacity must be installed for use when grid power is not available. This generally takes the form of higher cost diesel generators. Companies in Pathein and Mandalay reported up to 30% increases in production costs when these systems are in use. One foundry in Mandalay, for example, noted its use of two-tiered pricing. Machinery produced during rainy season, when ample hydro-sourced grid power was available, was sold at a lower price than machinery produced during the dry season, when they were more reliant on higher-cost auxiliary generation.

Workers at a foundry in Mandalay

Source: KWR International

Increased public-private cooperation is also vital given the immensity of these challenges as well as numerous legacy issues and inefficiencies, and the size of capital requirements. Resolution is essential if Myanmar is to increase income and living standards, develop tourism, industry and other sectors and satisfy rising expectations.

While there are many domestic and foreign investors, companies, donors and other entities interested in developing the power sector, Myanmar presently lacks the mechanisms needed to craft effective public-private partnerships. For example, despite passage of a new electricity law, the country is finding it difficult to negotiate the Power-Purchase-Agreements needed to maximize private sector involvement.

This not only impinges on the expansion of grid capacity, but also the nation's ability to finance energy-dependent facilities and industrial projects. New power projects are generally dedicated either to producing power for the grid, with the output subject to, or influenced by, tariff rates; or as stand-alone installations to power new industrial zones or off-grid areas where demand is speculative. As there is presently no provision for a feed-in-tariff or mechanisms by which new facilities can sell a variable and potentially decreasing portion of output to the grid as their underlying projects achieve viability, or converge with the grid once lines are extended to this area. Otherwise demand for promising new projects is speculative and unknown. This makes new, costly projects dependent on the risk of the project itself without the ability to hedge through sales to grid. This makes financing difficult. That in turn leads to more costly and inefficient strategies based on modular expansion and suboptimal implementation if possible at all.

Small Village Generator in Nyuang-Oo

Source: KWR International

Off-grid electrification

Many regions of Myanmar will lag behind planned grid extension efforts and other national development initiatives. This is due to their remoteness as well as the costs and a recognition the entire country cannot be wired at the same time. These areas will by necessity continue to rely on off-grid systems and self-help approaches to gain access to electricity over the short- and likely intermediate-term. For these areas, off-grid systems such as solar panels, micro-hydropower turbines, generators and traditional biomass must be examined.

By utilizing intermediate technologies and interim solutions, it is believed these least developed regions can begin to move forward. This could mean a steady step for modernization in these regions, without unnecessarily detracting resources and investment from grid extension initiatives in the urban and industrial areas that will drive Myanmar's economic development.

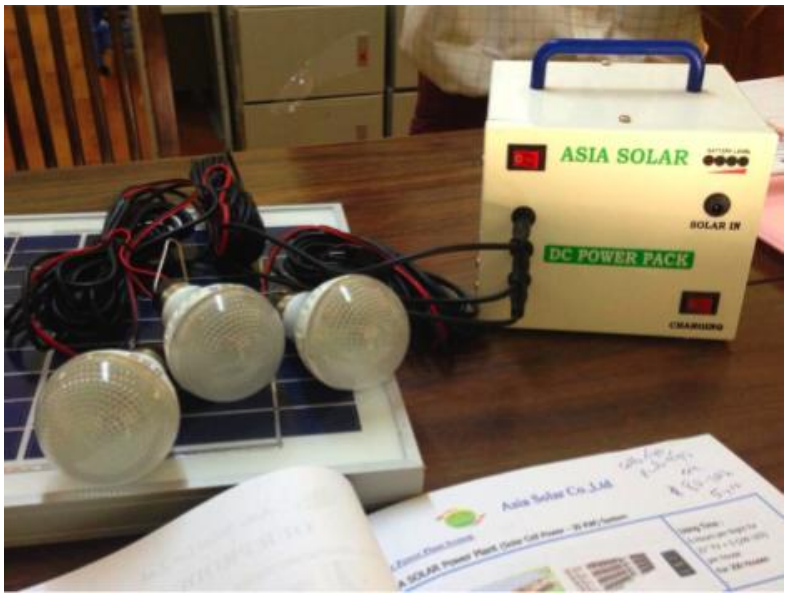
Diesel Generators are Perhaps Most Prevalent Form of Rural Electrification in Myanmar

Fieldwork demonstrated a number of solutions in use. Perhaps the most prevalent electrification mechanism on the village level are diesel generators. These are typically purchased and managed through a village electrification committee or by a local entrepreneur. Wiring and management is provided locally, usually by untrained personnel. Power is provided for several hours in the evening for US$2-5 a month per household, depending on whether it seeks only lighting or television and expanded use.

Solar Power Is Increasingly Popular as Off-Grid Energy Source in Myanmar

Solar is also becoming increasingly popular as an off-grid energy source in Myanmar. It is sometimes used in villages that have collective generators as a means to provide auxiliary power both to facilitate commercial activity such as small weighing stations, refrigeration for a shop, or light machinery. Some individuals also seek power in the off-hours for their own use. For example in one village a young man showed off the solar panel he had just installed to play loud music in the afternoon.

Solar lighting kit provided to Sagaing Division villages



Source: KWR International

In Myanmar, rural solar generally consists of home units. While mini-grids should be examined in future research, home units creates less need for strong village leadership and cohesion than in the case of collective grid extension since individuals can make decisions on the household level. While traditionally purchases were made by households, national and regional governments in Myanmar have begun to develop

programs to assist isolated villages in procuring this equipment. In Sagaing Division, for example, a relatively sparsely populated region located in Myanmar's dry zone, which has extremely bright sun and is therefore suited for solar, 130 villages in 2013 were reported to have taken advantage of a solar cost-sharing program. The regional government paid 50% of the cost of a solar panel, converter and three lights, which were then distributed in villages to individual users. One company interviewed won a tender with two other firms, in which more than 1,000 solar kits were purchased from each firm and distributed to villages in the division. The interviewed company noted they assembled the units in their own facility in Yangon but procured the panels by sending technicians up to Muse, on the Myanmar-China border, where they tested and sourced individual panels from China, then transported them down for sale within Myanmar.

The provision of solar home units to small and isolated villages in Myanmar gained further momentum in 2014-2015 as the Ministry of Fisheries, Livestock and Rural Development, which was appointed the lead ministry for rural electrification, initiated national procurements in 2014. This has dramatically expanded this program, though there has been concern, both over the anticipated life-span of sourced equipment, and since they are provided without charge to villagers, whether this will upset existing market-based distribution channels.

Hydro Also Important but Location-Dependent for Off-Grid Transmission

Given Myanmar's abundant hydropower potential, hydropower is also seen as having potential in providing off-grid solutions both within and beyond the village level. Given there has traditionally been no grid connection east of the Thanlwin River, municipalities such as Kengtung, a city of about 100,000 people and nearby areas, for example, receive power from two off-grid hydropower plants under administration of the MOEP.

Mini-hydro turbine in waterfall powers a restaurant in Pyin Oo Lwin

Source: KWR International

Households and facilities fortunate enough to be located near viable water sources can take advantage of micro-hydro technologies. In Pyin Oo Lwin, for example, a local

restaurant owner proudly demonstrated a small turbine, placed in a small waterfall, which supplied their restaurant with electricity 24 hours a day. The facility possessed several florescent lights, a television, appliances and a normal size refrigerator. The owner reported purchasing the generator ten years ago for US$300 and aside from routine checks and maintenance, consisting primarily of replacing its ball mechanism once per year for a cost of about US$15, this is adequate for their power needs.

The problem with hydro as a recommended solution for off-grid areas in Myanmar, however, it that it is not viable for those that lack an adequate water source. Small villages and households can experiment and make arrangements as the restaurant owner described above to locate the small turbines needed to access micro-hydropower as a source. Larger-scale facilities, however, first require speculative allocations for advanced engineering and studies, and should they prove feasible, considerations for resulting environmental and social impact. Investment can prove large, and unless the facility is primarily dedicated to supplying the national grid, hard to obtain. Further, given that hydro can be a seasonal resource, it must be supplemented by auxiliary sources.

MOEP hydropower facility to power Kengtung

Source: KWR International

Gasification Requires Resolution of Operational & Environmental Concerns

Geographic and climatic differences have a large impact on optimal off-grid electrification schemes given the need to build on regional strengths and concerns. While solar is considered optimal in areas such as the Central Dry Zone, and micro-hydro in locations that possess adequate free-flowing water, areas such as the Ayeyarwady Delta suffer from flooding, strong winds and occasional cyclones. It is also relatively level so there are fewer viable water sources for hydropower. In fact, solar kits configured for the Delta area cost more than those for areas in Myanmar where more sun power is available. As a result, gasification, powered by rice husks and other agricultural byproducts, are seen as an attractive energy source. It is reported there are presently 1,000 or more gasification facilities in Myanmar.

Abundant rice paddy in the Delta makes rice husk gasifiers a preferred alternative or supplement to diesel generators in this region. In Myaungmya Township, for example, a hybrid rice husk gasifier, which receives supplemental power from diesel, has a capacity of 8 KW. Half is used to electrify 80 households in a nearby village and half a pumping station. Electricity is reportedly available for five hours per day in the evening. Although economically viable, the environmental impact of rice husk gasifiers is questionable given the lack of enforceable standards and concerns over discharge. According to interviews with suppliers of gasifier equipment in Myanmar more environmentally friendly technology is feasible but will add up to 50% onto the cost of the equipment.

Gasifier Installation in Mandalay

Source: KWR International

In the absence of environmental safeguards, however, rice husk gasifiers cannot be seen as a viable solution. Further, aside from these important concerns, gasification generally requires more maintenance and care than generators that are powered by diesel alone. This makes them difficult to operate on the village and township level. While there are instances of rice mills, factories and irrigation facilities using gasification equipment and providing excess power to neighboring villages, this is not always feasible. That is because commercial use is during the day and consumers require electricity in the evening when the machinery is not in operation.

Cross-border energy and electricity sharing

Enhanced cooperation across borders can help to power Myanmar’s outlying regions, some of which have been troubled by ethnic conflict. It can also provide essential capital, technology and other goods and services. While much of the discussion on Myanmar's role in cross-border and regional energy integration focuses on exports, there is in fact much to be gained by Myanmar from its more developed neighbors. This can include its traditional role as a valued customer as well as a supplier of energy. Vast potential exists along the borders with China and Thailand for hydroelectric power, which can flow in both directions. There is also potential for offshore oil and gas

development in coastal areas and biofuel in Myanmar's agricultural heartland. Finding a balance between domestic generation and supply and exports is crucial for a mutually beneficial cross-border energy flow.

Tachileik—which lies along the Thai border near Laos, far-east of the Thanlwin River, which currently delineates the national grid from the rest of Myanmar's Shan State, initially connected to Thailand's grid in 1995. The area's population has grown from about 20,000 people to a reported 100,000 or more with small-scale factories and workshops. Despite such rapid growth, electricity supplied by Thailand is reportedly very reliable with no blackouts. There are, however, transmission losses of roughly 15% per year, about half of what is incurred by Myanmar's national grid. Although the cost of electricity from Thailand is significantly higher than that from the Myanmar grid, these areas have experienced significant growth and higher incomes, in part as a result of readily available electricity which allows them to initiate the economic activity needed to sustain these costs. Higher rates also allow for a return on investment, which can be used to upgrade equipment and expand Tachileik's electrification supply and capacity.

Power Lines from China Extend More than 50 Miles into Myanmar

Source: KWR International

Similar arrangements exist along other parts of the Myanmar-Thai as well as the Myanmar-China border. Although technically regulations prohibits the purchase of power from foreign countries, such arrangements have been tacitly allowed and can be seen as a sound short- to medium-term solution until the Myanmar grid reaches these areas. It also alleviates the strain on the resources available for Myanmar's national electrification, allowing focus on areas which do not have other options. Further, since some of these areas are troubled by ethnic conflict, having this electricity supplied from neighboring countries lowers risk and the need for maintenance on the Myanmar side. Reliable power supply in border zones, however, is nonetheless important. It encourages economic development and can attract foreign factories to the Myanmar side of the border where international firms can take advantage of Myanmar's competitive wages. The country can also take advantage of capital, technologies and

other inputs from its more advanced neighbors.

Development Partners Move to Meet Electrification Challenges

Despite the challenges, universal electrification, according to the World Bank, is both "achievable and affordable" in Myanmar by the year 2030. Toward this end, the institution has committed US$1 billion in financial support to expand electricity generation, transmission and distribution for the national grid and is assisting with the development of a National Electrification Plan through 2030. Other donors, including ADB and JICA have sought to expand their involvement as well.

While grid extension represents the long-term focus of most development partners, the need for complementary short- to medium-term solutions is clear. These may come in the form of decentralized electrification initiatives, off-grid home systems and mini-grids, which are considered to be more feasible for communities located far from the national grid. The prospects for these are only improving with new technological developments, such as energy storage.

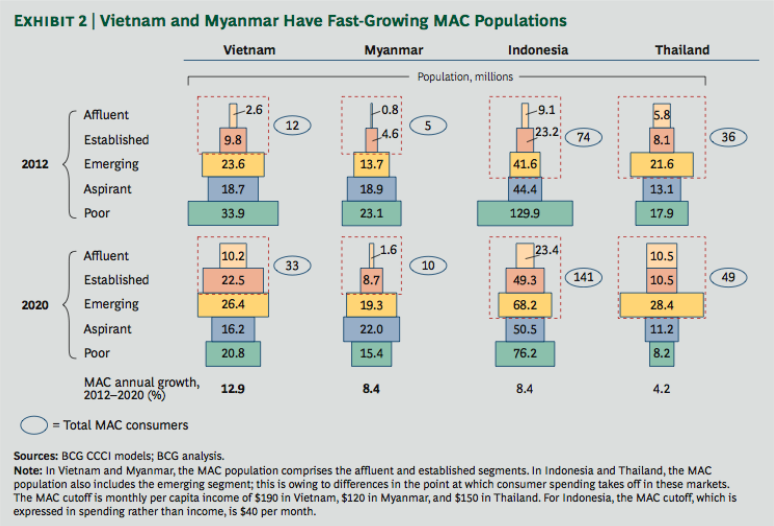
Phase I fieldwork unveiled a number of factors—ranging from village leadership to geographical, financial and other concerns—that influence electrification strategies in Myanmar. Achieving universal electricity access in Myanmar by both grid extension and off-grid alternatives requires a detailed examination of these factors and the costs. This includes monetary, as well as social and environmental concerns. It includes examination of a range of potential energy sources and electrification approaches for Myanmar's diverse population.

• **Phase II:** Comparative Cost & Technology Evaluation Relating to Rural Electrification

Recognizing the need for a framework to compare technologies available for rural electrification in Myanmar, Phase II fieldwork focused on development of a cost model to analyze commonly-used electrification strategies in relation to village-level data and circumstances. By examining the dynamics driving rural electricity supply and demand in Myanmar, a more comprehensive understanding was developed of the costs, benefits and feasibility of various electrification technologies. This includes solar home systems, mini-hydro turbines, generators, gasifiers and grid extension.

KWR's model was based on demand assumptions for nine villages. This included an examination of the number of households, income and resulting estimated usage, non-household demand, including monasteries, schools and community centers

Income categorizations used in comparative cost and technology evaluation



Estimated household electrification use based on income

Income Bracket	Minimum Electricity Goals	Potential Electricity Usages
Poor	120 W	Lighting, portable DVD player
Aspirant	500 W	Lighting, portable DVD player, portable fan, television
Emerging	1,000 W	Lighting, portable DVD player, portable fan, television, rice cooker
Established	2,500 W	Lighting, portable DVD player, music system, television, air conditioning, rice cooker
Affluent	5,000 W	Lighting, portable DVD player, music system, television, air conditioning, rice cooker, water heater, microwave, refrigerator,

Source: KWR International

This data was overlaid with cost estimates for the various technologies, integrating location-specific data and national assumptions. The model accounted for capital costs of installation as well as operations and maintenance (O&M). While it reflected the technologies commonly used in Myanmar, the model factored in more proper installation and design. Estimated costs for solar, for example, included a mounting structure, controller and battery specifically designated for deep cycle charging.

In addition to analyzing the costs of each technology, the Team considered other factors that affect feasibility. This included availability of resources, population size, location and geographical considerations, local and accessible knowhow and village cohesion and leadership. All of these factors are important, as there is no one-size-fits-all solution to rural electrification. A village, for instance, may have the cohesiveness and income to

organize and finance a grid connection, but part of the village may be down a ravine, making it difficult and far more costly to access with grid lines. Another village may be lucky to have a water supply sufficient to power a micro-hydro turbine, or it may be in a politically important area and benefit from a government-led grid extension initiative. These geographic, economic, social, political and demographic characteristics ultimately influence choices regarding optimal primary, secondary and often hybrid and multidimensional electricity solutions. These differences, which became evident in Phase II fieldwork, must be addressed in conjunction with the availability of physical and financial resources and other relevant factors.

In one village, for example, Kyar Kan Daung, a poor community with an economy based primarily on day labor and fishing, many households were reliant on kerosene, candles and, in some cases solar-powered batteries. Despite the villagers' inability to afford more advanced electrification systems, strong leadership and a cohesive Christian community had allowed them to access external sources of support and leverage what few resources they had toward the purchase of solar panels and a generator for communal use. There was therefore optimism about the potential for this village to organize and generate support for a village-wide electrification strategy.

Challenges, however, did exist, including a lack of attention to O&M. In this village a shared generator, despite being relatively new, was not functioning due to a cracked cylinder head and other problems and the village's inability to pay for repairs. Considering these and other factors, including the villagers' familiarity with solar technology, as well as the comparative costs, solar panels were recommended moving forward. Although up-front costs per household were higher for solar than generators, the next best technology, factoring in the annual cost of O&M made solar a lower cost investment after only two years.

Challenges with O&M were a common theme in Phase II fieldwork and were most evident in a visit to Chaungthar, the site of a now-defunct hybrid system that had been initially developed utilizing state-of-the-art technology, including solar photovoltaic panels, Myanmar’s first wind turbine and a diesel generator. Despite well intentioned efforts, however, the project ultimately failed due in part to the lack of the locals' ability to adequately finance and maintain the equipment.

Generators at the EPC office compound in Dawei

Source: KWR International

During Phase II, village-level fieldwork was supplemented with visits to two planned special economic zones, one in Dawei in southern Myanmar, the other in Kyaukpyu in Rakhine State, where a energy pipeline has been constructed between Myanmar's western coast and China. In both locations public-private partnerships played a key role in supplying electricity to the areas. In Dawei, regular, 24-hour access to electricity was made possible due to the area's proximity to Thailand and the involvement of Thai companies in distribution. Despite the fact that the Dawei SEZ had stalled, economic development in the Dawei area was stronger and incomes higher than in most parts of the country. This was due to the availability of jobs in neighboring Thailand and a steady supply of electricity to run shops and add economic value to activities. Electricity nonetheless was supplied through privately-owned diesel generators at a cost of up to ten times more than the national tariff.

Meanwhile, the Kyaukpyu area benefited from a government-led initiative, carried out in partnership with local and foreign energy companies, to offer low-cost diesel power to the area. This was largely seen as a means of appeasing the locals in Rakhine State who were reportedly paying up to MMK 1,200 per kWh for off-grid electricity.

Electricity choices for villages located near these two industrial areas differed significantly. For Za Di Ya, a village located near the Kyaukpyu SEZ, grid extension was the recommended strategy given its high demand and proximity to both infrastructure put into place by the government's initiative, as well as the fact this initiative lowered pricing to the national tariff rate. By contrast, in Mu Du, a long-established and relatively affluent village located near the then-stalled Dawei SEZ, the use of generators was recommended as a temporary power supply given the village is subject to relocation once the SEZ moves forward.

• **Phase III:** Cross-Border Electrification and Potential for Regional Energy Integration

Plastics factory in Muse

Source: KWR International

Phase III Fieldwork was then initiated focusing on cross-border electrification and the potential for regional energy integration between Myanmar, its neighbors and ASEAN as a whole. Site visits were conducted within Shan State. Located in Northeast Myanmar and bordering China, Thailand and Laos, Shan State is known for its vast energy resources. This is particularly true of hydropower, as the Thanlwin River Basin, Mekong River Basin and a number of smaller water sources run through this region. Drawing on electricity from grids in three countries—Myanmar, Thailand and China—makes it an ideal area to study cross-border electrification and regional energy integration in Myanmar.

Perhaps due to this region's remoteness and its economic importance, distribution of electricity in Northern Shan State is administered with less government involvement than in most other parts of the country. Muse, for example, serves as the highest border trade transaction point between Myanmar and China into Yunnan Province. Merchandise over this crossing during 2013-14 was reported to have accounted for US$2.7 billion in exports to China and US$1.76 in imports. This was more than 39% of Myanmar's total border trade.

While power had traditionally been transmitted to Muse from China at market rates, when hydropower from Myanmar's Shweli 1 project became available in 2010, MOEP began transmitting local hydropower in Muse at lower rates, in line with the national tariff. Unlike most other areas in Myanmar, MOEP has been able to provide ample supply and has outsourced distribution to a private firm, Junction River Trading Company. The company pays MOEP MMK 42 per kWh but must sell to residents at an initial tariff price of 35 per kWh. The company seeks to achieve profitability, however,

through sale and use of smart meters and other efficiencies. This includes reclassifying industrial users that had been taking advantage of low residential rates. Major clients include a plastics factory, paper mill and cold storage facility. Demand has risen, creating strains on Muse's inadequate and antiquated grid, which was designed for a smaller city and transmission at market rates. This is problematic for Junction River, which does not possess the margins needed for large capacity upgrades. It must therefore manage transmission carefully so that it does not overpower the system.

Junction River technology introduced to MOEP

Source: KWR International

At the same time electricity from China continues to flow into Muse. The Muse Central Business District initiative (CBD), for example is a 1.2 kilometer, estimated US$500 million development now being constructed. It plans to encompass shop houses, a jade mall, hotels, retail outlets, banks, offices, three villa and resort areas, a bus station and other facilities. The development currently uses power from China though a temporary cable but has plans to build a proper underground cabling system. It will consume an estimated 28 MW on completion.

There are also at least two grid lines extending more than 50 miles from China into Myanmar. One travels down from the Muse border for about 66 miles and the second through Kokang to about 50 miles east of Lashio. In Kokang, electricity generation and distribution are sold through a private utility. Power is sourced from China as well as the company's own facilities and sold at market prices. Since margins are higher than with the subsidized rates that are mandatory elsewhere in Myanmar, it has allowed in reinvestment into grid extension, equipment upgrades and plant development. Prior to the conflict that broke out in recent months, there were plans to also connect the area to the Myanmar grid, though the local utility maintained they would not be bound by the national tariff.

Unsupervised Myanmar-China Border with Taxi Line on China Side

Source: KWR International

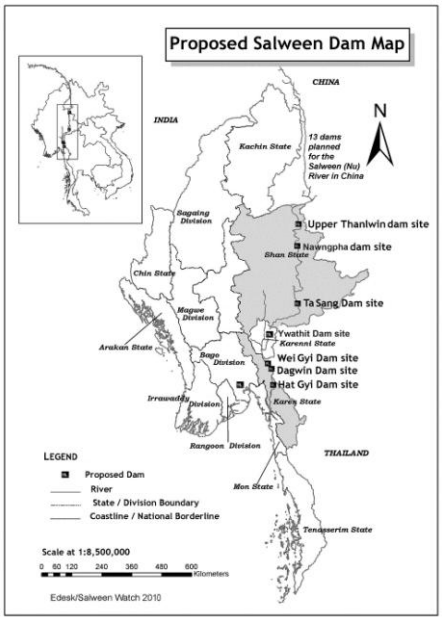
According to a presentation by the Chief Minister of Shan State in Taunggyi, four MOEP hydro projects, with combined 684 MW of capacity have been completed in the region. No less than ten hydro and two coal projects are under development or in the initial planning stages. These projects are being carried out as part of a broader plan to develop 67 hydropower projects with total capacity of 41,655 MW over the next 20 years. This includes 11 state-owned projects, with capacity of 2,132MW, four domestic BOTs, with capacity of 377 MW, and 43 foreign JV/BOT schemes. A significant portion of hydropower generated will likely be exported to Thailand and China.

In addition to substantial technical and engineering input, these developments will require considerable attention to social, environmental and other factors, including interactions with local communities. Many of these projects are also located in conflict-affected areas. Home to roughly 30 ethnic groups, Shan State is the site of up to 13 armed rebel organizations, including the United Wa State Army, the largest of Myanmar's rebel groups, and the Myanmar National Democratic Alliance Army, which is engaged in clashes with Myanmar forces along the China border.

Given the large size and economic and strategic importance of these initiatives, implementation of these projects has become a key issue in peacemaking and national reconciliation efforts. In fact several analysts and officials interviewed have questioned whether these power projects can move forward without a ceasefire agreement or in the run-up to Myanmar’s presidential election. Environmental and social factors are also a concern as well as potential displacement of local residents. The lack of adequate social and environmental impact studies and related regulations has been a concern in this regard. This is problematic as failure to address these issues can cause public opposition and indefinite delays in the development of the new energy resources and industries that could both contribute to the social and economic development of the country as well as provide revenues for other projects.

Energy Integration in GMS Will Bring Considerable Benefits to ASEAN

Proposed Thanlwin (Salween) Dam Map



Source: Salween Watch

Energy integration in the Greater Mekong Subregion (GMS) is expected to reduce dependence on imports from outside the subregion. This will lower overall costs of generation and drive efficiency and productivity in the energy sector. Total discounted energy costs for the GMS are estimated at US$200 billion, or 19% of total energy costs, while a fully integrated ASEAN is expected to result in 3% savings in carbon emissions. In addition to lower tariffs for countries with high demand, energy integration presents revenue-generating opportunities for exporting countries.

Between 2008 and 2011, China imported nearly 5 billion kWh of electricity from two dams in Myanmar. Chinese imports of Myanmar natural gas began in 2013 with the completion of the Shwe natural gas pipeline. Oil imports are expected soon through a parallel line that runs from Rakhine State to Yunnan Province.

Thailand, according to its Power Development Plan, will purchase 5,099 MW of power from neighboring countries between 2012 and 2030. Natural gas exports to Thailand, which currently account for approximately 70% of Myanmar's natural gas output, are expected to increase with new operations in the Zawtika gas field.

Electricity from China Powers Appliances in Ho Saung near Muse

Source: KWR International

All of this must also be considered in the context of regional energy integration and Myanmar's historical role as an energy exporter vis-à-vis its need to devote resources and attention to its domestic energy needs. While a history of inequitable distribution and domestic neglect has tainted views on energy exports, there is no reason Myanmar cannot benefit from the export of certain resources and invest the revenues generated in the development of national grid as well as off-grid renewable electrification projects.

Further, Myanmar can play a more multifaceted role in regional energy integration than that of exporter. At present, the availability of reliable and affordable energy from Myanmar's more developed neighbors contributes to the relatively strong social and economic growth observed in Myanmar's periphery. In fact, connecting off-grid populations to neighboring country grids was a core element of rural electrification strategies in Northern Shan State. More lax regulations over privatization, tariffs and foreign involvement in the power sector has also allowed for more rational operating environments and greater opportunities for profit. This has allowed for upgrades to equipment and capacity as well as an incentive to bring more users onto the network.

Examining the model for the Muse CBD project

Source: KWR International

While the Future is Bright, Myanmar Must Overcome Many Obstacles Moving Forward

As Myanmar moves toward the development of regional and national electrification strategies, it has no shortage of interest from development partners, multilateral agencies, academic institutions, NGOs, foreign governments as well as domestic and foreign investors and companies seeking opportunities in the sector. Nor are the opportunities for trade and investment lacking, given the country's vast resource wealth, geostrategic location, growing demand from locals and tourists and its potential for manufacturing and consumerism for a wide array of goods and services.

Nonetheless, a number of economic, political, institutional, financial, environmental and other obstacles exist to developing energy and electricity policies for Myanmar that are both functional and socially and politically acceptable. Improvements to data collection, capacity building, communication and information sharing are all prerequisites to moving forward with policies and legislation. This is necessary to build consensus and public-private cooperation as well as to avoid duplication among the various ministries, urban and rural populations, corporations, donors and investors involved in policymaking and the provision of resources, including funding and technical expertise.

CONCLUSIONS AND RECOMMENDATIONS

Based on the research and activities conducted over the past two and a half years, which are highlighted within the linked Phase I, Phase II and Phase III fieldwork reports, conclusions and recommendations include:

A) MACRO CONCLUSIONS AND RECOMMENDATIONS

1. There Is No "One" Rural Electrification Solution—in Myanmar or Elsewhere.

A variety of geographic, economic, social, political and demographic characteristics influence choices regarding optimal primary, secondary and often hybrid and multidimensional electricity solutions. For example, a village may be lucky to be in a politically important area, such as Kyaukpyu and benefit from a government-led electrification initiative, while another may be just outside the reach of the grid extension mandate or located on an island or other difficult terrain that makes grid connection unfeasible. Another village may have the money collectively to connect to the grid but lack the leadership and cohesiveness needed to organize and meet the 24 conditions for grid connection, or vice versa. These differences must be addressed in conjunction with the availability of physical and financial resources and relevant time factors. While hybrid solutions were not explicitly addressed in the comparative cost calculations included in this study, given the immense additional complexity it would entail, village-level recommendations did in some cases include such recommendations. The most notable example is the suggested use of solar as an auxiliary source to supplement small diesel micro-grids and/or to provide occasional backup and relief from the high cost of diesel.

2. Rural Electrical Development in Myanmar Must Balance Optimal with Feasible.

While steps need to be taken to advance rural electrification beyond installation of the least expensive generators, gasifiers and solar panels with no regard to quality, life-span or environmental concerns, one must also acknowledge the realities that exist in rural villages, and seek incremental and feasible improvements. That is one of the lessons of the Chaungthar hybrid facility, where cutting-edge technology was installed without sufficient attention to the ability of local caretakers to provide adequate operational and maintenance care. In other cases, project lifecycle costs may dictate a choice of solar or gasification but a lack of financing options prevents installation of these technologies over generators, which have lower initial costs but, with the price of fuel and O&M, prove more costly over the long term. That said, in terms of policies and guidance, it would appear best to promote progressive incremental improvement as well as knowledge dissemination. This is why the cost analysis conducted uses incrementally higher quality solar panels and equipment than what is commonly used in Myanmar, as the lower quality commonly found, requires lower up-front investment, but proves more expensive over the long term.

3. Financial Considerations are Almost as Important as Technical Concerns.

From a technical standpoint, achieving universal electrification in Myanmar is fairly straight-forward. With the development of the National Electrification Plan, consensus is emerging over the promotion of national grid extension to most of the nation by 2030. It also suggests auxiliary movement to utilize solar and other renewable technologies to provide interim power to rural and other areas that are either beyond the reach of the grid or which will be electrified in later stages. Financing these plans, however, will prove challenging. While the country has a significant number of talented engineers, it is lacking in financial analysts, economists and the bankers who could help structure projects in a way that would be financially viable from the standpoint of foreign investors. Further, as yet there is no clarity whether funding for grid extension plans will come from grants, loans, rate increases or other sources. These financial challenges must be addressed as part of the broader electrification plans for Myanmar.

4. Maintenance, Efficiency and Operational Upgrades Are Low-Hanging Fruit.

In the rush to add capacity, substantial attention is being devoted to development of new projects and installations in both urban and rural areas. Planning and funding these projects will require extensive engineering and financial resources. At the same time there is seemingly little effort being placed on the development of mechanisms to teach villagers how to better maintain and operate facilities that are already in place. This would help to reduce losses and ensure equipment remains operational and efficient over its maximum life span. Likewise some analysts believe simply replacing existing generators with more modern equipment could potentially double power output generated from the current energy supply. While transmission losses, partially due to antiquated power lines, stand at about 20%.

5. Electricity Solutions Can Come From Domestic Suppliers, Benefiting the Overall Economy.

Upgrades and efficiency measures do not need to depend upon outside sources. To date, there has not been a thorough evaluation of Myanmar's in-country capacity to support electrification, including the manufacturing of engines, solar cells, boilers, pipework, instrumentation, cable, insulators, switchgear, transformers, and other equipment. Such manufacturing, in addition to benefiting electricity development and efficiency, can also play a role in creating jobs and boosting Myanmar' overall economy.

6. Improved Regulatory and Environmental Standards and Enforcement Are a Necessity.

Myanmar lacks adequate regulations and standards, environmental and otherwise, as well as an ability to monitor and enforce adherence. This has negative consequences as it impinges on the development of a coherent and integrated system and the ability of the government to introduce incentives that encourage efficiencies and the use of technologies, such as gasification, which are potentially advantageous but create risks as toxic waste and other undesirable outputs are

introduced into the environment. Even where standards do exist, as with those developed by the Myanmar Engineering Society, they are implemented on a voluntary basis. As a result, there is little provision for enforcement and oversight. In addition to ensuring greater health and safety, such regulatory provisions and guidelines and enforcement are necessary to encourage investment in the sector.

7. Convergence of Public and Private Sector on Policy and Strategy is Essential.

The challenge of electrifying Myanmar, both in urban and rural areas, is immense and far beyond the scope of either the government or companies to achieve single-handedly. It is therefore critically important for the public and private sectors, both domestic and foreign, to work together to successfully develop policies that reward and facilitate private participation in the electricity sector. This includes independent power provision and power purchase agreements. In addition to clarifying legislation on these issues, adjustments may also be made to tariffs, microfinance laws, and other regulation to encourage a market-oriented approach that is less dependent on government directives. Passage of a Rural Electrification Act is also vital. There is also a need for public and private actors to engage in dialogue to minimize duplication of efforts and to facilitate the development of public-private partnerships. Toward this end, stakeholder meetings, such as those organized as part of this initiative, which bring together government officials, private sector leaders and other energy and electrification experts, should be expanded and continued.

8. Distinguishing between Short- and Long-Term Concerns Is Vital.

Myanmar must carefully consider its options as it determines future policies and plans to meet growing demand for electricity while balancing a mix of reliable and sustainable energy technologies and sources. Universal electrification through grid extension is the long-term goal for Myanmar, as envisioned by the World Bank and ADB. As outlined in the chart below, however, there are many stages involved in developing the grid system in a realistic and effective manner. In the short-term, off-grid solutions are also needed and must account for the possibility of eventually connecting off-grid sources to the grid system. Off-grid initiatives should also consider that certain villages, due to geographic or financial constraints, may not be able to economically connect to the national grid for the foreseeable future and thus require alternatives that are reliable, affordable and sustainable over the long-term. This is also one of the drivers why adoption of a Rural Electrification Act that can offer incentives and a structure to facilitate electrification activity on the village level.

1. <u>Short-term:</u>	• Subject to cost, maintain power plants and distribution system that are already installed • Subsidize diesel for high-speed diesel captive-power in exchange for a percentage of supply to the grid • Renegotiate Chinese, Thai and other electricity export contracts to divert higher percentage for national supply • Rent gas (CNG) or marine fuel-oil (MFO) fired

	reciprocating engines for decentralized power (note these have higher efficiency than gas turbines (GT) and require less infrastructure) • Where gas is available, rent trailer-mounted aero-gas turbines • Promote energy conservation (e.g. compact fluorescent light bulbs)
2. Medium-term:	• Install open-cycle gas turbines • Install mini-hydro in rural areas • Install high-voltage transmission to urban and industrial centers • Encourage industry to invest in efficient / reciprocating captive-power plant with a percentage for domestic consumers
3. Long-term:	• Maximize hydropower/coal reserves for base-load • Develop gas pipelines • Optimize use of natural gas resources, primarily for peak-lopping during maximum demand • Minimize imported oil and coal • Evaluate the geothermal opportunity • Promote biofuels and other cost-effective renewables

9. Adding Electrical Capacity Will Ignite Exponential Increases in Demand.

Some analysts and government policymakers in Myanmar believe there is adequate capacity in the grid if line losses can be addressed and efficiencies realized. While this may or may not be true, it is in fact immaterial, as successful grid extension will ignite exponential increases in demand. Villagers, who were formerly content with a few lights run off a small generator, battery or solar panel will want television and those who currently have television will want rice cookers, and then refrigerators and more. These demand increases can be seen in the Kyaukpyu experience where villagers who formerly minimized consumption as access was limited and expensive, now enjoy 24-hour access to affordable electricity. This has increased consumption not only on the consumer level but has also led to significant increases in industrial demand as seen in the emergence of water bottling and other factories. This means that planning must be done on projected rather than present demand.

10. Social Tensions Will Increase as Myanmar Intensifies Electrification Efforts.

In the past, rural communities protested the existence of subsidized power in Yangon and Naypyitaw while they endured high off-grid pricing, due to a reliance on diesel, or insufficient electricity, absence of a grid connection and lack of reliable alternatives. As Myanmar steps up grid extension and other efforts and begins to successfully expand generation outside urban areas, this will begin to unleash measurable economic progress and momentum. It will also, however, bring the contrast between the “haves” and “have-nots” closer to home. In Kyaukpyu, for example, where 24-hour subsidized power is present to any individual with 2 lakhs

(US$200) that lives within 100 yards of the main power line, it will be difficult to avoid discontent among those who live 101 meters from the line and beyond. Even if the radius that is eligible for grid connection were widened it is clear that Myanmar cannot successfully expand access to every town and village at same time. This necessitates government emphasis on off-grid electrification plans in conjunction with ongoing grid extension initiatives. It also necessitates greater attention to community relations and public information campaigns that can help rural residents to better understand the process and how they will benefit over the longer-term.

11. Roles of Local vs. National Government Must Be Clarified and Defined.

In addition to clarifying and codifying the role and ability of private entities to participate in the development of Myanmar's electricity sector, more attention should be devoted to enhancing the ability of local governments to better define and respond to projects and electrification needs in their respective regions and communities. These local actors should also have the ability to obtain more input from the central government and to benefit from the synergies that can only be achieved at the national level. According to an interview conducted with a regional chief minister, local government has generally been focused on implementation rather than project definition and planning. This is true not only between local and national representatives of MOEP and other Ministries, but also local and national administrators, different ministries and with the private sector. At the same time, being locally-based they are better able to assess local conditions and to respond to local needs. Therefore more interactive dialogue is advised.

12. Electrification Enhanced Through Convergence of On- and Off-Grid Initiatives.

Presently on- and off-grid development projects are viewed largely as discrete initiatives without regard to the potential for synergies and the enhancements that can be obtained if they were viewed as part of an integrated effort. For example, 90% of new household connections carried out under the National Electrification Plan will be grid-based, with about 250,000 connections expected to use "pre-electrification" solutions. This includes temporary mini-grids and off-grid solar home systems. While it may be too early and complex to begin developing a feed-in tariff and other policy measures that would facilitate financing and development of private and off-grid power, more emphasis could be introduced to encourage cooperation between on- and off-grid power. This includes the development of mini-grids and a grid connection standard, which encourages connection to the national grid down the road. This is in contrast to the current perception that off-grid electrification initiatives are largely temporary phenomena that are only necessary until full grid extension can be achieved.

13. Tariff Reform is Vital to Realize Myanmar's Economic Objectives.

Grid extension is very difficult with the present tariff structure whereby MOEP is faced with the challenge of increasing capacity for a product that is then sold at a loss. The investment plan for the National Electrification Plan suggests the financing gap for the grid roll-out can be eliminated by raising tariffs to the levels of Vietnam.

These are in the range of MMK 95 to MMK 100 per unit, a roughly three-time increase over Myanmar's current residential rates. Reducing subsidies is not an easy task, as any increase in tariffs results in political backlash. The current tariff structure is also problematic from a private sector perspective. It is believed there is no shortage of investors with an interest in Myanmar's power sector, however, currently companies need to plan off-grid sources largely as captive power. Financing and planning is therefore based strictly on demand forecasts of the particular project in question. By contrast, if it were possible to sell excess power back to the grid at even breakeven prices, it would minimize development risk. The current system of tariffs and subsidies must also be overhauled to meet rising demand from residential users and to encourage industrial consumption at higher rates. One option might be to consider an increase in overall tariffs with a percentage of increase reserved for rural electrification. This type of system, similar to Japan's Electric Power Generation Promotion Law, calls for a charge on electricity production to be used for research and development, plant siting and other uses.

B) COST/FACTOR/TECHNOLOGY ANALYSIS CONCLUSIONS

SOLAR

1. Solar Home Units Most Suitable for Small, Isolated Villages with Low Demand.

Scalability factors work against solar as village size and demand increases. Solar home systems seem best suited for relatively poor villages of about 100 households or less with minimal demand. Even though the installation costs are higher than with generators and gasifiers, cost differentials can be addressed within approximately one year when considering the cost of fuel and O&M. This, however, does not account for financing costs.

2. Pros of Solar Home Units as Primary Energy Source Less Clear in Larger Setting.

While use of solar home systems also provides potential benefits in larger settings of either villages with more than 100 households and/or those whose income dictates larger consumption/demand, these benefits are eroded by the lack of scalability of this platform. This results in a higher price differential when compared to the costs of installing a generator or gasification facility. While it is arguable that the added costs can be amortized over several years, given the high cost of diesel and other inputs, this does not account for financing costs. In Myanmar this can total 30% annually in a microfinance setting. Irrespective, most villages, which lack initial capital in any case, will not seek to finance the added costs over this longer period of time.

3. Solar Home Units Help Address Needs of Villages Lacking Social Cohesiveness.

Grid extension and micro-grid development require organization and cohesiveness, while solar home systems can be installed on an individual basis. For villages that lack leadership or the ability to organize collective payment schemes, and for which demand is low, solar home units can be an ideal solution to household electrification needs.

4. Solar Home Units Can Provide Benefits as Auxiliary Power Source.

Even in larger settings where economic factors favor generators and gasifiers over solar home units as a primary energy source, solar home units can play a valuable auxiliary role. That is because generators and gasifiers commonly used in villages and rural settings run for only two to three hours per night to provide power over the entire micro-grid. Therefore, any individual or commercial use during other times requires auxiliary provision through platforms such as solar home systems.

5. Future Study Can Determine Potential Scalability Benefits of Solar Farms.

Solar home systems were chosen as the basis for analysis as this is the commonly used platform for solar in Myanmar. This contrasts to generator sets and gasifiers that utilize a micro-grid approach. Future study needs to be conducted to determine the differences between utilization of solar home units and a solar farm/mini-grid

platform to determine potential benefits and whether solar farms/mini-grids can address some of the scalability issues seen with home units.

Mini-Hydro

6. Mini-Hydro Installations Dependent on Identification of Viable Energy Source.

Myanmar is clearly rich in hydropower potential, but this energy source is site specific. Installation of viable facilities requires identification of an adequate energy source. This generally requires locating the generating facility close to the point of consumption, and this can be a challenge in rural environments. Otherwise, with lengthy transmission distances, one runs into the same costs with mini-hydro that can make grid extension an expensive and technically challenging proposition.

7. Attractiveness of Mini-Hydro Impinged by Need for Up-Front Engineering.

Identification of a viable energy source creates a need for up-front engineering and feasibility studies. This can be costly and time intensive and makes it difficult to utilize in a rural electrification context, except in special cases. That is because villages lack the financial resources and knowledge needed to initiate the advanced work that must be initiated before an installation can be planned and considered. This is very different from larger hydro projects, where there is sufficient scale for engineering services. At the same time it is also different from micro-hydro, where trial and error siting can be initiated to find optional locations, allowing small turbines to be placed next to viable water sources to generate power for individuals, or small groups of households.

8. Mini-Hydro Usually Generates Capacity Beyond Needs of Single Towns/Villages.

As mini-hydro installations often have generating capacity beyond the need of individual towns or villages, the high up-front costs associated with mini-hydro development could be offset if a group of towns/villages joined together to achieve sufficient scale. This creates greater need for input from national, regional and local government and other entities that can encourage, coordinate and facilitate this activity. This is another process where regulatory guidance could assist, as opposed to leaving it up to the leadership abilities of village heads or the cohesion of villagers.

9. Mini-Hydro Generation Can Vary Significantly Depending on Seasonal Factors.

Another challenge of mini-hydro is that its feasibility varies considerably between the rainy and dry season. This problem is borne out on a national level as the grid, which is highly dependent on hydropower plants, suffers supply inadequacies during the dry season. This is particularly difficult for rural agricultural areas where demand for irrigation is highest during the dry season.

10. Mini-Hydro More Sensitive to O&M Than Other Platforms.

Small mini-hydro projects, with the exception of individual micro-hydro projects, require a basic level of maintenance that place the resource beyond the reach of,

and makes it less viable for, individual towns and villages and even small groups of towns and villages. Lacking the scale of larger installations they are even more expensive on a relative basis. This underscores the importance of greater technical training and capacity building around O&M.

Generators

11. Generators Key to Rural Electrification Despite High Diesel Costs.

Despite having the highest O&M costs of all technologies examined and potential environmental consequences, generators rated second highest by a wide margin in the factor analysis conducted. Generators also represented the optimal "market" solution in areas such as Dawei and Kyaukpyu, although electricity rates are high. In the case of PTC, an independent power provider in Myoma, and which operates in the area near Dawei and also in Rakhine State, rates are MMK 490 per unit.

12. Generators Not Only Rate High but Second Lowest Deviation of all Platforms.

Whereas Grid Extension, Mini-Hydro and Gasifiers are very dependent on the unique factors of a particular village, Generators can be more widely deployed. Therefore they rated the second highest both in terms of positive responses but also in terms of second lowest deviation across all sites visited, showing strength in all factors examined.

Summary of Comparative Factor Analysis for Fieldwork Site Visits

	Solar Home System	**Grid Extension**	**Hydro Mini-Grid System**	**Gen-set Diesel Mini-Grid System**	**Gasifier Mini-Grid System**
Tha Yet Taw	46.5	19.5	12	41	26
Kyar Kan Daung	46	24	14	45	34
Aung Mingalar	45.5	14.5	8	42.5	26.5
U To	45	24.5	15.5	46.5	27
Mezali	46.5	34	14	44.5	45.5
Za Di Ya	45	52	15	44.5	31.5
War Taung	44.5	19	12	41	32
Myoma	46.5	35	33.5	48	36.5
Mu Du	45.5	21.5	13.5	45	32.5
Total	411	244	137.5	398	291.5
Average	45.67	27.11	15.28	44.22	32.39
Standard Deviation	0.75	11.51	7.19	2.36	6.09

13. Benefits of Generators Erode Over Time with High Fuel Costs.

While generators cost less in terms of capital costs, any cost savings quickly erode when one factors in the high cost of diesel, as seen in the following charts. Given the lack of financing options and low levels of savings, many villages may opt for diesel despite higher cost over the long term, as it may be seen as the only option for increasing capacity within available resources.

Total Estimated Cost Comparison of Capital Costs with Generators

Village Name	Solar	Gasifier	Generator	Grid Extension
Tha Yet Taw	125%	115%	100%	1498%
KyarKan Daung	170%	114%	100%	1482%
Aung Mingalar	194%	123%	100%	3452%
U To	235%	123%	100%	1868%
Mezali	312%	133%	100%	538%
Za Di Ya	399%	124%	100%	31%
War Taung	226%	118%	100%	1037%
Myoma	442%	132%	100%	3838%
Mu Du	449%	122%	100%	4161%
Average	284%	123%	100%	1989%

Total Estimated Cost Comparison of Annual O&M Costs with Generators

Village Name	Solar	Gasifier	Generator	Grid Extension
Operating Hours	6	3	3	24
Tha Yet Taw	2%	87%	100%	43%
KyarKan Daung	2%	76%	100%	50%
Aung Mingalar	2%	68%	100%	56%
U To	1%	64%	100%	58%
Mezali	1%	57%	100%	63%
Za Di Ya	1%	52%	100%	66%
War Taung	2%	61%	100%	60%
Myoma	1%	51%	100%	66%
Mu Du	1%	51%	100%	66%

14. High Cost of Generators Accentuated Due to Inefficient Wiring and Lack of Maintenance.

Despite the high cost of diesel, the overall O&M costs associated with generator use would be substantially reduced if proper care were given to the equipment. Many instances were witnessed of poor wiring and inefficiencies that led to power losses, as well as improper care that required equipment to be repaired and replaced more often than would have otherwise been necessary.

Gasifier

15. Gasifiers Attractive but Complicated by Environmental Concerns.

Gasifiers make sense in theory given Myanmar's rich agricultural resources and abundant rice husks. Pollution, however, is a real concern, and it is estimated more than 1,000 facilities were installed with little regard to toxicity and environmental

degradation. Now they are being developed in more populous and higher income areas, where the environmental impact is more noticeable. There are complaints and this issue needs to be addressed. That will be difficult given the reluctance of developers to bear the extra costs associated with more environmentally friendly technology, and the difficulty of achieving oversight and enforcement.

16. Gasifiers Need More Operational and Maintenance Care than Alternatives.

Gasifiers require constant care from the provisioning of rice husks to the monitoring and maintenance of equipment. That is beyond the capacity of most villages, particularly from a technical standpoint. Electrification through gasification was, however, seen as successful in Pathein, where the facility was run by the Ministry of Agriculture. Therefore O&M was not the village's responsibility.

17. Gasifiers Viable in Coordination with Rice Mills and Producers of Feedstock.

There were successful examples of gasifiers owned and operated by rice mills, and which provided electricity to villages seen in fieldwork visits. One such example was located in Nayaung, roughly 45 km northeast of Tachileik in Shan State. In addition to powering the rice mill operations, it is also connected to a reported 100 meters. One obstacle, however, which was seen in Mezali, which has two rice mills, is that rice mills operate during the day and villages need electricity in the evening. Rice mills tend to be reluctant to add staff or increase the maintenance requirements necessary for longer operations.

18. Gasifiers Can Provide Significant Savings Through Reduced Diesel Costs.

Due to the high cost of diesel, compared with the much less expensive, and sometimes free, feedstock used in rice husk gasifiers, the cost savings of gasifiers are significant. According to the Team's analysis, detailed in the chart below, the annual O&M costs associated with gasifiers can be nearly half that of diesel generators, particularly in areas with high demand.

Comparative Estimated Village Gasifier/Generator Annual Operating & Maintenance Costs

Village Name	# Households	Tot. Demand (KW)	Gasifier	Generator	Gas/Gen
Tha Yet Taw	48	9	$5,795	$6,663	87%
Kyar Kan Daung	72	15	$7,178	$9,429	76%
Aung Mingalar	110	24	$9,402	$13,877	68%
U To	120	32	$11,172	$17,417	64%
Mezali	94	70	$20,143	$35,359	57%
Za Di Ya	520	269	$66,874	$128,821	52%
War Taung	161	41	$13,190	$21,452	61%
Myoma	600	421	$102,509	$200,091	51%
Mu Du	700	352	$86,345	$167,763	51%

19. Gasifiers Can Utilize Alternative Feedstocks but Need Testing and Pilot Studies.

Myanmar holds significant potential in terms of waste-to-energy as well as a range of other feedstocks, due to its large supplies of fish, coconuts and other potential sources. Despite the numerous possibilities, the actual viability of the sources is largely unknown in Myanmar and need to be tested and subjected to pilot projects.

Grid Extension

20. Grid Extension Clearly Optimal Though Beyond Reach of Most Villages.

Grid extension provides 24-hour electrification, dramatically raising quality of life and economic activity. However, it also requires a huge investment in up-front capital costs not only on the national, but also the local level. This is beyond the reach of most villages by themselves. That makes the adoption of a Rural Electrification Act imperative, as it would establish clear goals in respect to, as well as mechanisms to facilitate, rural electrification and the governance and financing mechanisms necessary to achieve them.

21. Grid Extension Requires High Social Cohesion Given Current Policies.

While it is the role of MOEP to provide power to the township level, it is generally up to villages to fulfill the 24 conditions for grid connectivity and raise comparatively high levels of capital to fulfill the “self-help” requirements to successfully connect to the grid. This requires a high level of social cohesion, which is beyond the abilities of most villages. Where individual connections become possible, however, as was seen in Kyaukpyu, most households participate.

22. Grid Extension Is Dependent on Availability of Financing Mechanisms.

Connecting to the grid on a village level also requires significant capital, which is not readily available, particularly in remote, rural areas. There is currently no uniform financing mechanism for grid connection that might facilitate the process. Where such options are available, they tend to be with terms of one year. This means there is no ability to pay from cash flow. Compounding the situation, interest rates for microfinance can be as high as 30%, which is prohibitive. A Rural Electrification Act could provide for appropriate financing and loan mechanisms. This proved crucial to achieving rural electrification in other countries, including the United States.

23. Grid Extension Best Connected to Off-Grid, Not as Parallel System.

Off-grid electrification initiatives need to be carried out in conjunction with long-term goals related to national grid extension, and should not be seen as isolated initiatives. Instead the same national standards that apply to grid extension should be ensured in the form of a grid connection code so as to eventually allow and encourage connection of off-grid and capitive facilities to the national grid. This would lower the cost of grid connection as well as the ability to finance these developments. Likewise, there should be coordination to facilitate electricity access

in locations that may be near to grid extension initiatives but unable to connect due to geographic, financial or other constraints.

24. Grid Extension Initiatives Are Highly Dependent on Tariff Levels.

While the development of off-grid and mini-grid electrification alleviates some of the burden that government subsidies for grid-generated power places on MOEP, over the long-term Myanmar's tariff system will need to be addressed to make grid extension and the connection of mini-grids more feasible. This may require a politically unpopular rate increases and development of commercial and industrial users who can pay a higher rate and to some extent subsidize residential use.

C) INSTITUTIONAL CONCLUSIONS

1. Capacity Development Needed to Match Intentions to Implementation.

While there is often criticism over the government's intentions, extensive meetings with Ministries and private companies demonstrates definite commitment and good intentions but an evident lack of capacity and ability to define, plan, finance and manage projects on the scale required. This is true in government as well as in the private sector and applies to the way institutions are structured and the overall decision-making process. It also applies to the professional level in terms of technical know-how. Training is vital to overcoming these challenges.

2. Intra-Ministerial Coordination Is Crucial to Effective Policy Making.

Greater coordination among ministries is imperative to more effective policymaking. At present, it is difficult for ministries to communicate and coordinate internally between different levels and departments, and even much more difficult to do so across different ministries and institutions. While the establishment of two coordinating bodies, the National Energy Management Committee and National Energy Development Committee, are major steps in the right direction, these committees will need to become institutionalized and structured so they can manage the ongoing implementation process. This potentially includes a secretariat or officials who can help to maximize intra-ministerial coordination, including project reviews to minimize duplication. This body could also be used as a central clearinghouse to facilitate knowledge-sharing and implementation of projects in the electricity sector. This includes development of public-private partnerships and foreign direct investment.

3. Political Will Is an Important Component of Effective Policy Making.

Just as strong leadership on the village level is important for areas that seek to connect to the national grid, leadership is also important at the highest levels of national government. This goes for both national grid extension and rural electrification initiatives. Particularly evident in Kyaukpyu, a presidential directive brought affordable, 24-hour electricity to a region that previously suffered from high electricity prices, irregular and insufficient access and social unrest. Not all initiatives, however, must come from the President's office, but can also be initiated at other levels.

4. Regulatory Guidance Must Accompany and Enhance Political Will.

Political will should not be based purely on individual personalities and charisma, or one-time stand-alone initiatives, such as the Kyaukpyu mini-grid. There is a need to codify as much as possible into longer-term and definitive regulatory guidance and mechanisms, such as a Rural Electrification Act and complementary policies that lay out clear goals for electrification and which establish an institutional framework for implementation. Legislation should encompass: definitions of rural electrification and standards for when a village is considered electrified; targets for the percentage of the rural population and number of villages or districts to be electrified by a certain

date; strategy and goals for rural electrification; administration and governance structures; long-term budget; provisions on theft of electricity; financing and loan assistance; involvement and management of the private sector; maintenance and warranty; tariffs; and monitoring and quality check. Electrification goals should also be integrated into five-year plans and other supporting legislation.

5. Roles of National and Regional Government Must Be Better Coordinated.

Just as better coordination is needed at a national level, the roles of national and local governments must be better-defined and coordinated to match policy with implementation. This will help balance local knowledge and responsiveness with the potential scale and synergies achievable at the national level. It will also allow local needs and priorities to become integrated into a national framework. Codifying these various roles and responsibilities may also make villages less dependent on the individual personalities of village leaders in terms of their ability to organize and finance grid connectivity.

6. Greater Coordination Among Government, Private Sector and International Agencies Is Necessary.

The Myanmar Government cannot achieve universal electrification single-handedly. A number of parallel, independent electrification projects are ongoing, with the help of donor organizations and private sector actors. There is a need to explore how these projects overlap and can eventually converge with planned grid expansion. A number of projects have also been held up due to a lack of adequate legislation defining private sector involvement in electrification. Ministries should seek to structure themselves in a way that allows for easier communication and coordination with the private sector so as to incorporate the concerns of businesses and investors into its policy frameworks. Likewise, ADB, World Bank and other actors involved in policy advisory support should reinforce efforts to fully coordinate with all branches of Myanmar government and other key stakeholders. Stakeholder dialogues will facilitate this interaction.

D) CROSS-BORDER/REGIONAL INTEGRATION CONCLUSIONS AND RECOMMENDATIONS

Regional Energy Integration

1. Regional Energy Integration Requires Myanmar to Carefully Balance External with Domestic Concerns.

While much of the discussion taking place around regional energy integration focuses on Myanmar's role as an exporter of oil and gas—a controversial stance given rising domestic energy supply needs—it is clear from the fieldwork conducted that Myanmar in fact has much to gain from cross-border electricity trade. While there will there be difficulty building political support within Myanmar for regional plans that emphasize oil and gas exports, this stance overlooks the myriad examples of power supply from China and Thailand that have facilitated economic growth along the periphery. In addition, these cross-border arrangements present an opportunity for Myanmar to learn from its neighboring countries' expertise to help establish more rational electricity distribution structures. One area where Myanmar could enhance the benefit is by strictly enforcing a favorable royalties system on actors distributing power in its territory.

2. Regional Integration Must Balance Political and Economic Concerns.

Despite the benefits of the electricity supply certain border areas in Myanmar receive from China, the Myanmar government is moving to switch the areas over to power supplied by the Myanmar national grid. It is understandable that Myanmar would like to maintain and enhance its sovereignty and ensure that electricity provision is not used as a means of exerting foreign influence over the country. Myanmar residents have largely encouraged the shift as they will be able to pay government-subsidized rates that are lower than the market rates they pay to Chinese power providers. The tariffs, however, are not economically feasible and do not allow for the profits necessary to undertake proper upgrades and maintenance to the grid system. The Myanmar power supply is also less reliable than that from China and cannot accommodate large-scale development or industrial needs. Further, switching over areas to the national grid that already receive adequate power supply from China diverts electricity and resources from more remote, unelectrified areas that could make better use of a grid connection. Therefore, the Myanmar government might question whether it is better to prioritize other areas and switch the border regions to the Myanmar power supply during the latter stages of national electrification.

3. Myanmar Is a Beneficiary As Well As a Contributor to Regional Energy Integration.

In addition to the benefits accrued from Myanmar's cross-border arrangements with China and Thailand, revenues from energy exports—which are generally seen as less desirable than domestic use given the country's history of poor resource management—can, if handled properly, be used in a way that will contribute to rural development and electrification. This can also drive improvements to the national grid and power stations. Instead of dismissing exports, Myanmar can seek to put into place a system that acknowledges the stabilizing role of energy exports in

Myanmar's financial history and that learns from and corrects past mistakes. Hydropower generation, for example, is more sustainable than gas and exporting this resource may have less of an impact domestically. In addition, reports on Shweli 1 power, the majority of which is slated for China's use, suggest the developer has been flexible in allocating a greater share of power to Myanmar in the midst of severe power shortages. While a more detailed analysis would need to be undertaken to determine the specific balance between exports and imports that would maximize the benefits to Myanmar, the conversations on regional integration must first transition from that of a zero-sum game to one that acknowledges the potential for a mutually beneficial and multi-faceted role for Myanmar.

4. Regional Energy Integration Can Assist in Catalyzing Myanmar's Growth and Development.

The development of the Muse area in general, and the CBD in particular, has relied on the availability of stable power from China which provides the capacity to handle high demand projections. This project would not have likely been able to access financing or make development plans without a guarantee of stable and sufficient power, which the Myanmar grid could not supply. In turn, as the region develops and the CBD is launched, the area is likely to see increased trade, tourism and economic activity. A visit to Tachileik along the Myanmar-Thai border demonstrated similar outcomes: higher incomes, greater economic activity and population growth generally follow reliable, stable power supply.

5. Regional Energy Integration Requires Myanmar to Address Social and Environmental As Well As Financial Concerns.

Potential negative social and environmental impact from Myanmar's ongoing and future energy projects—ranging from pollution and carbon emissions to displacement of local communities and destruction of livelihoods—requires greater attention. This is particularly true in relation to projects along the Thanlwin, where the stakes are high both in terms of the potential power output as well as the potential political and economic backlash that would occur if a disaster were to affect Myanmar and it's neighbors. Financial considerations are also important and, in some cases, intersect with social/socioeconomic impact. For instance, villagers in Ho Saung, just outside Muse, despite having access to power from China, are seeking to transition to the Myanmar national grid and reliance on a subsidized tariff even though that may mean less reliable supply and have a subsequent negative impact on economic activity. Further, on a national level, this line of thinking will divert resources from off-grid areas that are in greater need of power supply from the national grid.

6. Myanmar Can Play a Key Role in Facilitating Regional Integration.

A changing Myanmar, with its economic opening and political reforms, has attained a higher profile on the international stage, most recently as host of the ASEAN summit in November 2014. The country can leverage its international standing to contribute to policies on regional energy integration, as well as economic integration, in a way that not only facilitates regional connectivity but also promotes growth

within Myanmar and the region as a whole. As a major link to regional powers, Shan State and the direction taken with energy projects under development with Thai and Chinese investment, can play a critical role in shaping these policies.

7. Regional Energy Integration Can Take Many Forms.

Whereas certain areas of Myanmar currently gain access to Chinese and Thai power, primarily through informal, independent lines such as those seen in Laukkai and Tachileik it is also possible that electricity supply from China and Thailand can be provided through the Myanmar national grid. While there are political and other implications that need to be resolved, and perhaps a trade-off made in respect to export sales of gas or hydropower, this would provide for continuous connectivity during peak periods while eliminating the need for cross-border distribution lines with payments going directly to a foreign utility. Myanmar would therefore be providing for its citizens through its own national grid and maintaining its sovereignty and control of power provision. If for some reason power from China and Thailand were shut off, Myanmar could continue to supply power through the national grid at reduced levels. This could position Chinese and Thai power as a substitute for the costly procurement of many individual generators, which is seen throughout Myanmar as a back-up to Myanmar's unreliable supply. As Myanmar's national energy and electrification plans develop, supply from China and Thailand could be reduced if it is decided the country's resources can adequately power its residential and commercial needs.

Electricity Generation and Distribution

8. Rural Electrification Becomes Less Complex with a Rational Structure.

Shan State is home to several self-administered and special regions, and its northern areas are somewhat isolated and more integrated into China, with less involvement from Naypyitaw. This has significance in terms of electricity generation and distribution. As a result, there appeared to be more room for experimentation and greater involvement by the private sector, with a prevalence of public-private partnerships in electricity generation and distribution. Policies on electrification were different in border areas, particularly in the Self Administered Region of Kokang. Tariffs were not always subject to government-subsidized rates, meaning private providers were able to generate the higher returns needed to connect villages, replace equipment and scale up capacity based on economic factors, with national political or institutional considerations playing a lesser role than in other places in Myanmar. It also placed less emphasis on off-grid solutions or home units, given the relative ease of grid connection and mini-grid development in the region.

9. Electrification Becomes More Feasible When Motivated by Entrepreneur.

Private involvement in the electricity sector was more widespread in border areas than much of the country. With an incentive to profit from power provision, either due to higher, unregulated tariffs or existence of industrial users with whom there is room for profit even with government-subsidized rates, private actors have introduced efficiencies and capital investment into Northern Shan State. While household

electrification has been prioritized within Myanmar's national electrification efforts for political and other considerations, for the public-private partnerships witnessed, household electrification loses money when sold at the residential tariff rate. While this is also true for power provided by MOEP, private concerns do not have the same political concerns and objectives and must achieve profitability to maintain solvency. Therefore it is a more immediate priority. Thus the emphasis by entrepreneurs and developers is on promoting growth of the industrial base. Therefore, such border area practices can inform Myanmar policies as the country moves toward the creation of new regulations governing the power sector and private and foreign investment.

10. Stable Power Supply Benefits Industrial and Residential Activity.

A stable supply of power, as was seen along the border—either due to supply from China or functioning public-private relationships—helped local industry develop and increase capacity without concerns over power availability. This generated employment opportunities, greater economic activity and, in turn, more demand for power. Households, likewise, benefited from relatively advanced appliances, as well as tools that could add value to agriculture and other activities. The introduction of such appliances and tools also allows individuals to save time on menial tasks and turn attention to income-generating activities. This further adds to economic development. Therefore electrification policies cannot be divorced from industrial and commercial activity. While arguably somewhat longer-term than immediate residential connections, placing an emphasis on industrial and commercial usage and the economic benefits of electrification will provide a more sustainable base. It will also lead to higher income generation and ability of the local population to afford power consumption and maintenance.

11. Particular Attention Should Be Given to Areas Where Economic Inequality Exists.

Fieldwork visits witnessed villages wherein roughly half of residents had functioning electricity schemes, while the other half, generally corresponding to the poorest households, were said to have only batteries or kerosene as a power source. Discussions with MLFRD in Lashio in Shan State suggested that the national government decides priorities for rural electrification assistance based on village income, however, merely looking at average income may overlook the needs of the poorest households in villages with income inequality.

12. Data Collection and Coordination Remains an Important Challenge to National Planning.

Discussions with regional and self-administered governments underscored the challenges that still exist in data access and collection in Myanmar. One engineer in a regional government office confided they had not received enough hands-on training on data collection to provide sufficient data to donors and other international organizations seeking to develop national electrification plans. Poor data was also sited as a challenge to private sector involvement in the power sector, as investors need accurate data to make business decisions. In the case of Junction River in

Muse, the company was able to obtain and analyze data on residential versus household users and adjust inaccuracies to raise the number of industrial users and increase revenues.

13. *More Coordination Is Needed Between Electricity and Rural Development Policies.*

Increased cooperation between MOEP and MLFRD—the two ministries charged with facilitating national electrification and rural electrification development—would assist in efforts to improve data collection, prevent duplication of efforts and enhance the ability to coordinate off-grid and grid extension initiatives in a way that would eventually converge. The importance of this was noted by both MOEP and MLFRD officials, in separate interviews, noted the lack of coordination between the two ministries as a hindrance to rural electrification initiatives. Furthermore, as a number of international agencies and NGOs are engaged in rural development and economic empowerment initiatives in Myanmar, in particular in Shan State, these activities could likely be enhanced if coordinated with rural electrification schemes.

E) NEXT STEPS

The development of a framework by which various electrification options can be assessed according to national, regional and village resources and circumstances has been lauded by a number of stakeholders seeking to contribute to Myanmar's electrification plans. Furthermore, dissemination of information, workshops and convening of key public and private stakeholders, whose work and focuses overlap, but who were not previously interacting to discuss issues of this kind, has proven extremely valuable. It has helped to build shared understanding and consensus and to provide a forum in which discussion of important issues can be held. Future activities can be focused on the following four areas:

1) Research and Fieldwork

Through extensive site visits and examination of the three core issues of grid extension, off-grid electrification and cross-border energy and electricity sharing, this research has helped to contribute to a broad understanding of the dynamics that underlie Myanmar's national electrification efforts. Myanmar, however, is a large and diverse country. Further research and fieldwork can help frame other geographic and functional issues that need to be addressed. This might include study of planned large-scale Thanlwin hydropower projects, Myanmar's energy relationship with India, and the potential of solar and other mini-grids. As much of the focus of past rural electrification research and initiatives in Myanmar has been on residential connectivity, examination of the relationship between, and how best to synergize, electrification and economic activity in rural areas would also prove valuable.

Further study might also be initiated to detail potential parameters of a Rural Electrification Act, to facilitate better provision of operations and maintenance training and certification for off-grid installations, and how to best frame standards to allow more effective use of gasification technologies. Grid convergence and potential characteristics of a grid connection code might also be examined so that off-grid installations can potentially be planned in a way that will allow them to ultimately be connected to the grid. This would help encourage private sector activity as presently off-grid installations face high risk given their utility is threatened once grid lines reach their respective areas and generation begins under Myanmar's tariff regime.

2) Strategic Analysis, Integration & Report Preparation

Substantial data has been assembled through this research on Myanmar and its electrification and rural electrification needs. This is true both on the macro/national as well as on micro/village level, including identification of many of the factors and policy issues that need to be addressed for the country to achieve its electrification and rural electrification objectives. While the primary emphasis on this research and fieldwork to date has been on the development of this information, additional attention should be focused on analyzing and integrating this data through a strategic framework so that it can be refined using policy evaluation metrics and utilized in a manner that will help to give focused insight and direction into Myanmar's rural electrification needs moving forward.

3) Policy & Network Development, Consensus-Building & Facilitation

Numerous public and private entities in Myanmar as well as foreign stakeholders have provided input into this initiative. These people and institutions are seeking help in their efforts to better understand energy and electrification issues in Myanmar as well as how best to navigate and help transform its complex and evolving regulatory environment. The Myanmar government is also seeking support and assistance as it tries to engage and involve foreign investors, and other new actors, and to adapt new policies and regulation after decades of sanctions and isolation.

Distribution of reports and materials, as well as activities and events organized as part of this initiative, including stakeholder and other meetings as well as international symposia, have played an important role in promoting communication across these groups and building a shared consensus on how to resolve these issues. To continue and maximize the benefits of these activities, these initiatives should be expanded and continued moving forward.

In a similar vein, interactions with government ministries, regional officials, business associations and companies should be reinforced, through formal discussions, relationships, the provision of advisory support and a dedicated in-country presence developed and maintained to respond to needs and requests as required.

4) Creation of a Myanmar Integrated Energy & Capacity Development Center

A number of economic, political, institutional, financial, environmental and other obstacles exist to developing an integrated energy and electricity policy for Myanmar that is both functional and socially and politically acceptable. Capacity building, communication and information sharing must all be improved to move forward with viable policies and legislation. This is essential to build consensus and public-private cooperation as well as to avoid duplication among the various ministries, urban and rural populations, corporations, donors and investors involved in policymaking and the provision of resources, including funding and technical expertise.

The creation of a Myanmar Integrated Energy and Capacity Development Center can facilitate interactive dialogue and organize workshops and briefing sessions for, and among the various stakeholders involved in, energy and electricity development in Myanmar. This can include involved participants in training programs and stakeholder meetings, as well as domestic and foreign investors, companies and project developers and sponsors, development partners and other entities that will play important roles in developing the energy and electrification sector in Myanmar.

This entity could address a number of topics including but not limited to rural electrification, tariff structure, energy efficiency, grid extension, grid convergence, renewable technologies and regional integration. It will also help Myanmar to successfully draw from the energy and electrification plans proposed by World Bank, ADB, JICA and other entities as it moves forward toward a goal of universal electrification.

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Cross-Border Electrification and Potential for Regional Energy Integration in Myanmar