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

Comparative Cost and Technology Evaluation Relating to Rural Electrification




PHASE II FIELDWORK

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FINAL REPORT

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

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Background

State of Electrification & Integrated Energy Development (IED) in Myanmar

Myanmar's electricity infrastructure is a major concern and priority as the nation opens its doors and strives to achieve more rapid and equitable economic development. Access to adequate, affordable and reliable power is required for the country to attract foreign and domestic investment, to promote effective industrialization and necessary upgrades in infrastructure, telecommunications, technology, and to improve its overall capacity to deliver services to businesses and consumers.

Electrification is also an integral component of social and economic development. Access to electricity is associated with increased time spent on education, improved quality of life and stimulation of local economies. It enables the use of lighting, radios and cell phones, income-generating activities and the operation of public institutions, such as schools, municipal buildings and healthcare centers. It also enables refrigeration, which can raise living standards and expand opportunities for small business, such as food or ice vendors. It will also allow expanded use of electric tools, machinery and irrigation pumps which can boost industrial and agricultural productivity.

Yet, Myanmar's installed capacity is, according to high estimates, under 3,500 MW. In comparison, according to the US Energy Information Administration, Thailand, which has a similar population and is Myanmar's largest export partner, has an installed capacity of 48,515 MW — nearly 15 times that of Myanmar.[*]

According to many estimates, just under half of Myanmar's population has access to electricity from a combination of sources including the national grid as well as off-grid and independent sources. The grid is said to reach about 26% of the population, mostly in urban environments. Outside this urban area, about 70% of Myanmar's population lives in a rural environment. Accurate and complete data in these areas, however, is hard to come by. This makes it very difficult to make national assessments. Rural villages can range from those in isolated areas that have no access or which rely on car batteries or solar lanterns and home panels, to those that have installed small gen-set or other microgrids, or where there is sufficient income, entrepreneurs have installed diesel power generated connections. There are also areas where the government has provided off-grid connections from hydro, gasifier and other facilities.

It therefore comes as no surprise that Myanmar has one of the world's lowest per capita electricity consumption rates, at just over 110 kWh per person in 2011, according to World Bank data.[†] This compares to 164 kWh per person in Cambodia, 680 kWh per person in Indonesia and 2,315 kWh per person in Thailand.[‡] Only Nepal, Haiti and a handful of sub-Saharan African countries consume less electricity per capita than Myanmar.

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[*] International Energy Statistics, U.S. Energy Information Agency
[†] Electric Power Consumption (kWh per capita), The World Bank Group, accessed: July 2, 2014
[‡] Ibid.

Demand for electricity is estimated to be growing at an annual rate of between 12% and 15%.[§][**][††] According to a 2012 Asian Development Bank (ADB) assessment, nationwide demand could reach 5,000 MW by 2020,[‡‡] while the government is aiming to produce to 23,594 MW of power by fiscal year 2030-31.[§§]

Adequate electrification, particularly where rural electrification is concerned, is as much a political as an economic issue. Rapid growth in electricity consumption strains capacity, and frequent blackouts have resulted in protests in major cities, as have proposed increases to government-subsidized electricity tariffs. Provision of adequate and reliable electricity are further complicated by the country's reliance on hydro-power, the availability of which fluctuates significantly between dry and rainy seasons.

Efforts to improve electrification have also met with resistance. Transmission lines were bombed by insurgents in 2012, while a number of energy projects funded by Chinese and Thai companies have been suspended or cancelled due to social and environmental concerns.

While grid extension has been the traditional method of achieving universal electrification, extending Myanmar's national grid is not a matter of addressing a few deficiencies within a largely functional infrastructure but rather building on a rudimentary and largely antiquated system almost from scratch. This is reflected in the comments of one senior engineer in Myanmar, who noted to the KWR Team ("Team") his belief, that about "70% of electrical wiring in Myanmar is 70 years or older". The Ministry of Electric Power (MOEP), charged with distributing electricity at a subsidized rate, is currently operating at a loss. This will only widen as grid extension initiatives are rolled out and MOEP takes on new consumers.

Despite the challenges, according to the World Bank, universal electrification is both "achievable and affordable" in Myanmar by the year 2030.[***] Toward this end, the institution has committed $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.[‡‡‡]

The Myanmar government has also undertaken efforts to coordinate policymaking on long-term energy planning. In January 2013, President Thein Sein announced the

[§] Simon Lewis and Kyaw Hsu Mon, Yangon Switches On, The Irrawaddy, April 17, 2014
[**] Pyae Thet Phyo, Power Struggle: Supply Falls Short, Myanmar Times, April 28, 2014
[††] Electricity Master Plan Hopes to Solve Myanmar's Electricity Woes. Myanmar Business Today. July 1, 2014
[‡‡] Asian Development Bank, Myanmar Energy Sector Assessment, 2012
[§§] Myanmar Business Today. *Op.cit.*
[***] Xiaoping Wang, Development of Myanmar National Electrification Plan Toward Universal Access, World Bank Presentation in Naypyidaw, March 20, 2014
[†††] Power to People: World Bank Group to invest US $2 billion in Myanmar to support reforms, reduce poverty, increase energy and health access, Press Release, World Bank Group, January 26, 2014
[‡‡‡] Xiaoping Wang, *Op.cit.*

creation of the National Energy Management Committee (NEMC) and the National Energy Development Committee (NEDC), comprised of members of seven of the ministries involved in energy policymaking.[§§§] These include Ministry of Energy (MOE), which is primarily concerned with the oil and gas sectors, MOEP (power sector), Ministry of Mines (coal development), Ministry of Agricultural and Irrigation (biofuels and micro-hydro for irrigation purposes), Ministry of Science and Technology (MOST) (renewable energy), Ministry of Environmental Conservation and Forestry (fuelwood, climate change, and environmental safeguards requirements) and Ministry of Industry (energy efficiency).[****] Myanmar plans to launch a 20-year Master Energy Plan, developed with support from ADB, which will include an energy demand forecast, supply options, legal and institutional arrangements and, importantly, investment requirements.[††††] In 2013 it was said that $200 million in investments for power generation were held up due to the lack of framework for private sector involvement in the industry, such as power purchase agreements or feed-in tariffs.[‡‡‡‡]

The national government also has plans to replace its Electricity Law of 1984, and the Ministry of Livestock, Fisheries and Rural Development (MLFRD), which has been appointed as the lead Ministry to implement rural electrification, has expressed an interest in developing legislation specific to facilitating electrification in rural areas.

A More Comprehensive Approach to Rural Electrification is Essential

At the same time, accessing the large segments of Myanmar's population living in rural areas, which lie beyond the national grid is difficult, due to geographical and financial constraints.[§§§§] This is complicated by the fact that Myanmar's rural population has rapidly rising expectations about their ability to improve living conditions, and the immensity of the challenge of electrifying large disconnected areas that cannot possibly all be managed at the same time.

Although urban electrification is relatively easier, rural electrification, in addition to helping the country develop and industrialize, is one means for the government to build trust with rural populations and broader support for reform as it becomes more dependent on political buy-in from traditionally marginalized and remote populations. As a result, a more comprehensive approach to rural electrification is essential.

Therefore, while grid extension represents a sound long-term strategy, 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 and

[§§§] Asian Development Bank, 46389-001: Institutional Strengthening of National Energy Management Committee in Energy Policy and Planning, Project Data Sheet, accessed July 2, 2014: http://www.adb.org/projects/46389-001/details
[****] Ibid.
[††††] Ibid.
[‡‡‡‡] KWR Interview with a Yangon-based provider of rural micro-finance and electricity solutions. August 2013.

which are more adaptable to local resources and conditions. The prospects for these are only improving with new technological developments, such as energy storage.

Ensuring the universal electricity access foreseen for Myanmar by 2030 by the World Bank and other institutions through both grid extension as well as off-grid alternatives requires a detailed examination of related factors and costs—monetary, as well as social and environmental—involved in the various energy resources and electrification schemes available to Myanmar's diverse population.

Overview

Prior KWR/UT Research on Electrification and IED in Myanmar

To date, KWR International (Asia) Pte. Ltd. (KWR), in cooperation with the University of Tokyo (UT), has completed three phases of extensive research on energy and electricity in Myanmar for the Economic Research Institute for ASEAN and East Asia (ERIA). Beginning in May 2012, an in-depth review of several hundred documents and data sources was undertaken in an effort to draft the electrification and energy component of the ERIA-led Myanmar Comprehensive Development Vision (MCDV) initiative. This included media reports, government statistics and presentations, consultations with technical advisors and other experts and reports from multilateral donor agencies and development banks, nongovernmental organizations and academic institutions as well as interviews with targeted individuals in Myanmar.

This research provided a detailed overview of the current state of Myanmar's electricity sector and infrastructure, including: governance and decision-making processes; current electrical capacity and projected demand; the state of the national grid, as well as grid extension plans; energy policy and diversification strategies; social and environmental concerns associated with certain types of power generation; and foreign investment in the energy and electricity sectors. The report also analyzed the complex set of political, economic, technical, social and environmental considerations the government must balance in devising a comprehensive energy and electrification policy moving forward. Additional attention was given to identifying gaps in the data and "roadmapping" concerns that need to be addressed if the Government of Myanmar, donors, private companies and other entities are to develop the policy, strategies and other inputs needed to attract investment and initiate the dramatic expansion of capacity necessary to achieve Myanmar's electrification goals.

This initial report, completed in July 2012, prepared KWR and UT to undertake Phase I Fieldwork, which included site visits to eight locations: 1) Bagan/Nyaung-Oo, 2) Monywa, 3) Mandalay, 4) Pathein, 5) Pyin Oo Lwin, 6) Pathein, 7) Tachileik, and 8) Kengtung. The Team conducted over 50 interviews with villagers and village leaders, local electricity officials and private power providers. The visits covered a number of issues, ranging from availability of electricity, local uses of electricity, projected and aspirational demand for electricity, sources of electricity generation, willingness and ability to pay for electrification, and the cost-effectiveness of various electrification schemes. Follow-up visits were made to Monywa and Mandalay to obtain additional information concerning incentive programs and activities of local regional government.

Over 50 additional interviews and meetings were also held in Yangon, Naypyitaw, Bangkok and Singapore and other locations within Myanmar and throughout the region, including with individuals and entities including, but not limited to Director Generals of the MOE, MOEP, and MOST; Representatives of a leading solar energy company in Myanmar; Management of Renewable Energy Association of Myanmar; Large and Mid-sized project developers and industrialists in Myanmar; Social Enterprises and Micro-

Finance Institutions involved in rural electrification; President, Myanmar Engineering Society; representatives of the World Bank, ADB and other donors; Fund Managers and investors; Commercial and Trade Officers and representatives of other business and trade associations; Lawyers and Accountants; Analysts; other individuals/entities with an existing or potential involvement and interest in Myanmar's electricity sector, journalists and other targeted individuals.

During this first Fieldwork phase an emphasis was placed on visiting towns, urban areas, and other locations, where individuals from nearby villages were brought together so the Team could define broad "area-wide" themes and gain insight into the dynamics of particular projects and regions. Sometimes these visits were supplemented by brief visits to one or more villages in these areas. For example, during the first phase of fieldwork in 2013, the Ministry of Agriculture organized several visits to irrigation pumping stages in areas such as Bagan/Nyuang-Oo, Mandalay and Monywa. In addition to receiving information about these facilities, and these areas as regional destinations, the Ministry invited several neighboring villages to send their head-person and selected town residents to participate in "focus-group" style meetings. This enabled the project team to ask questions about their respective situations and how they managed their electrification needs, both in respect to their individual locations but also comparatively to the other villages that were invited.

The site visits conducted during Phase I Fieldwork revealed a number of important insights about grid extension initiatives, off-grid electrification and border-zone electrification in Myanmar. These included:

Grid Extension

Myanmar's national grid largely covers major cities—Yangon, Naypyidaw and Mandalay—in the center of the country with large areas along the periphery left off-grid. According to MOEP data, electricity from the national grid is distributed to 2,323,467 out of 8,905,674 families, or 26%. The electricity covers 220 out of 396 towns and approximately 1,600 of 6,774 villages in the current distribution network. Myanmar has a total of 64,346 villages.[*****] Only one in five rural households is said to be connected to the grid.[†††††]

According to the most recently available data, Myanmar's national grid system connects major electric power stations—consisting of 20 hydropower plants, one coal-fired plant and ten gas-powered plants—to substations and end users using eight types of transmission and distribution lines.[‡‡‡‡‡] The country has 4,793.24 miles of transmission lines, comprised of 39 230 kV, 37 132 kV and 117 66 kV lines.[§§§§§] There are 27 23 kV,

[*****] Electricity Prices to Be Doubled, *op.cit.*

[†††††] Kyaw Hsu Mon, ADB to Loan $60 Million for Burma's Electricity Network, *The Irrawaddy*, December 17, 2013

[‡‡‡‡‡] Kan Zaw, Challenges, Prospects and Strategies for CLMV Development: The Case of Myanmar in ERIA Research Project Research 2007 No.4: Development Strategy for CLMV in the Age of Economic integration (Tokyo: IDE-JETRO, 2008)

[§§§§§] The Republic of Union of Myanmar: Country Report, *op.cit.*

24 132 kV, and 108 66 kV substations with a total transformation capacity of 5,875.4 megavolt amperes.[******] Transmission losses are high in Myanmar, estimated at between 21% and 27% as of 2011, due to the relatively low voltage used and antiquated equipment.[††††††][‡‡‡‡‡‡] This is down from about 30% between 2003-09.[§§§§§§]

Adding to the problem, users sometimes use transmission line voltage regulators, or step-up transformers, which can create supply imbalances and blackouts. Beyond being uncompensated, this creates safety issues. More than one third of fires that broke out in Yangon in 2011 were reportedly caused by improper use of electrical appliances. Transformers are seen as a leading cause. This makes upgrading Myanmar's distribution system imperative.

The government plans to build 36 additional substations with 5,675 MVA and 6,444 miles of transmission lines using four 500 kV, 41 230 kV, 8 132 kV, and 20 66 kV lines.[*******] It is likely most new transmission lines will bring power from northern hydro-power and southern gas-fired power plants at 230 kV and 117 kV.

Villagers repairing locally installed power lines near Bagan

Expanding the grid system can be the least expensive means to increase connectivity, with a capital cost, according to one analyst's estimate, of between $13 billion and $18

[******] Ibid.
[††††††] Electric power transmission and distribution losses (% of output). World Bank Databank, accessed July 2, 2014.
[‡‡‡‡‡‡] Asian Development Bank, *op.cit.*
[§§§§§§] Ibid.
[*******] Ibid.

billion. The World Bank has plans to assist with the comprehensive extension of Myanmar's grid by 2030.

As part of this effort, the World Bank has committed a $140 million interest-free loan toward upgrading a power plant to feed the national grid and local mini-grids in Mon State. The plant, after replacing existing gas turbines with more advanced technology, will be 250% more efficient using the same amount of gas, while improving health and safety standards.[†††††††] The World Bank is also working in partnership with the Earth Institute at Columbia University to develop low-cost, off-grid electrification solutions using geospatial technologies, to help satisfy interim demand and reduce social tensions among the electricity "haves" and "have nots."

Village-level grid connections

According to official policy, which was detailed to the Team during Phase I Fieldwork, the national government is responsible for extending Myanmar's grid to the township level through the MOEP, at which point it is the role of individual village committees to organize and finance village-level grid connection. Likewise, loans and grants for electrification needs, where they exist, often come from regional or local governments, foundations and other locally-oriented individuals and entities, while the national government, under its 24 rules on grid access, prohibits requests for donations or financial assistance from being made by villages to the MOEP. (For additional details on the 24 Rules of Grid Access, see Appendix 5) It should be noted, however, that exceptions to these rules have been observed in fieldwork visits.[‡‡‡‡‡‡‡]

Phase I Fieldwork also revealed that villages tended to be highly dependent on village committees to determine and organize electricity access. Payment structures, whether for grid connection or power provision from independent or communally-owned providers, also tend to be organized and managed by village committees. In some cases, this takes the form of communal or sliding-scale payment structures, whereby payments by lower-income villagers are subsidized by those of villagers with higher incomes. In another instance, an installment plan was devised.

While limited, local financing programs are available for grid connection in certain areas. In the case of Monywa, which the Team visited during Phase I Fieldwork, the locally based Zayyarpadeithar Foundation gave one-year loans at 2% interest to 42 villages between March 2012 and June 2013. Loan amounts ranged from 10 lakh to 300 lakh, the maximum amount allowed, with an average loan size of about 160 lakh. These are given to villages within a two-mile radius of the grid. To qualify for the loans, each village is required to have 50% of the loan amount in savings and the village electrification committee itself must serve as a guarantor for the loan. Villages that fail to pay are blacklisted though the foundation has indicated that collections have not proved to be a problem. Given the limited time frame for this loan, however, and the relatively large amount of money it represents for effected villages, this program, while positive in

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[†††††††] Bringing More Electricity for the People of Myanmar, World Bank, September 24, 2013.
[‡‡‡‡‡‡‡] See case studies on Kyaukpyu Township and Za Di Ya Ward.

terms of promoting local grid extension, should be seen as extremely limited. That is because it necessitates the village have a highly structured plan in place to allow quick repayment, rather than a general ability to pay out over time through future cashflow.

In another area in the region, it was reported to the Team that local businessmen loan money to the regional government, which uses the funds to make development loans.

Challenges to grid extension in rural areas

From a national view, the MOEP, currently operating its distribution at a loss, will only take on greater losses as it increases its consumer base. That makes it difficult for the Ministry to facilitate rural connections with their own resources, even if this were mandated as a policy priority. Additionally, on a village and household level, Phase I Fieldwork interviews found that grid connection proved too costly and organizationally complex for most rural populations. It is a particular challenge in low-density areas where populations are spread out over a large territory.

It is important to consider that the further a village is from the national grid, the greater the cost of grid connection. Equally important, villagers lack project management and financial sophistication, which makes planning difficult. In the case of Pathein, for example, several agricultural villages were reported to have lost their initial investment in grid connection as they were ultimately unable to cover auxiliary costs, such as wiring and plugs, which can add up to 50% to the total cost of connection. In May 2014, it was also reported that Karen State experienced unrest as villages were asked to collectively contribute more than 10 million kyat to connect to the national grid.[§§§§§§§] Villagers elsewhere have reported concerns over whether the government will be as responsive to maintenance issues as the private power providers upon which they currently rely.

Beyond economic barriers, topographical constraints can also be a hindrance. Taungyargon, for example, a relatively affluent village in the Pathein region that was, for the most part, able to connect easily to the grid, faced difficulties in certain areas as grid lines could not be run through ravines and other challenging landscapes.

Despite the challenges associated with grid extension, Phase I Fieldwork revealed the extent to which expectations for improved living standards are rising among certain segments Myanmar's population. Villagers near Mandalay, for example, when asked why they were not interested in developing capacity through installation of gen-sets and panels as seen in other areas, cited the belief that off-grid initiatives were not necessary given their belief the government would soon help them connect to the national grid.

Increasing electricity access through grid extension is a matter of balancing the electricity needs of a diverse range of stakeholders within the resources that can be made available. This includes not only rural versus urban populations but also agricultural actors, industrial players, government, the tourism sector as well as other

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[§§§§§§§] Paing Soe, Karenni villagers asked to pay the price to connect to the grid, Democratic Voice of Burma, May 20, 2014 interests. It will require decisions concerning which regions to prioritize, pitting areas inhabited by ethnic minorities, which in some cases continue to represent conflict zones, against disenfranchised and impoverished rural areas and comparatively more affluent and larger urban areas. The latter's electrification issues may be easier to address and prove more attractive to foreign investors and industries, but prioritizing them may be seen as favoring elites over the wider population.

This difficult balancing act was noticeable during Phase I Fieldwork. In Nyaung-Oo, a mostly agricultural village neighboring the burgeoning tourist destination of Bagan, the local pumping station was only able to provide irrigation for about one third of the land in its mandate, in part due to electricity shortages. Although the grid system was unable to meet the region's current electricity needs, demand is only going to increase, perhaps rapidly, as tourism develops, hotels expand and new ones are developed.

In Monywa, a small industrial city about 136 km northwest of Mandalay, township officials reported being required to ration electricity during the dry season, when supply from hydropower is limited and availability of electricity was said to drop by more than half. During the daytime, pump stations and industrial users are given priority, while access is reserved for residential users at night. This differed from some other areas visited, such as Bagan/Nyaung-Oo, where the majority of capacity was reserved for industrial use and tourism, though may be accounted for by the fact this is a city with a far larger population.

In addition to these concerns, simply extending distribution lines will not provide a short- to medium-term solution to rural electrification due to inadequate generation capacity. A 2003 report by Japan International Cooperation Agency estimates if rural electrification were improved 2% annually, an optimistic assumption, it would take more than 40 years for networks to reach the majority of Myanmar's towns and villages.[********]

Off-grid electricity development

Micro-level

Given the challenges of grid extension, in particular for Myanmar's rural population, villagers have begun implementing schemes on a self-help basis. Accounting for overall electricity access, World Bank data states 49% of Myanmar's population had access to electricity as of 2011. This is consistent with a 2009-10 Integrated Household Living Conditions Survey, carried out jointly by UNDP and Myanmar Ministry of National Planning and Economic Development, which states overall access to electricity increased from 38% to 48% in 2005-10. Large differences exist between the poor, with a 28% access rate—up from 20% in 2005—and the non-poor, with 55%. The figures stand at 34% for rural and 89% for urban dwellers.

[********] The Study on Introduction of Renewable Energy Sources in Myanmar, Japan International Cooperation Agency, September 2003

Rakhine State fared among the worst in the UNDP study in respect to access to electricity and household, water and sanitation conditions. Access to electricity stood at 26% in Rakhine, 30% in Ayeyarwaddy, 31% in Magwe and 32% in Bago.[††††††††]

It is likely these statistics, while measuring availability of electricity from all sources, including the national grid, generators and independent projects are primarily focused on grid extension and public programs organized through the MOEP to supply off-grid power through captive hydro and other means. Typically remote households in Myanmar also derive electricity from car batteries, chargers, and inverters—commonly used to convert direct to alternating current—or purchase power from independent or village-owned generators. It is therefore the Team's belief that few villages are totally lacking in electrification access, even if electrification in these areas consists of only one or more solar panels and a few lights or rechargeable batteries, solar lanterns, or other minimal sources of generation.

Solar

Solar energy also holds substantial promise. Myanmar's MOEP reports available solar energy is about 51,974 tWh per year. Solar energy is abundantly available in central Myanmar with a radiation intensity of 5 kWh per square meter per day during the dry season. At present it is mainly being used on an individual scale, primarily through photovoltaic cells, although Phase I Research revealed plans underway to develop solar energy farms to supply the national grid.

Solar panels have been a source of electricity for certain monasteries and schools in Myanmar and were provided to villages in Myanmar's Ayeyarwady Delta following power interruptions due to Cyclone Nargis.[‡‡‡‡‡‡‡‡]

In some cases, off-grid electrification is carried out with the support of NGOs, donors and small- to medium-sized enterprises, in parallel with government initiatives. Proximity Designs, for example, a Yangon-based social enterprise, introduced a solar-powered lantern that sells for about $11, compared to a $60 Chinese model.[§§§§§§§§] In May 2014, ADB, with financing from the Japan Fund for Poverty Reduction, announced $2 million in grants to bring power to 25 off-grid villages in Myanmar, primarily through small-scale solar and biomass systems.[*********]

Regional governments are also supporting micro- and household-level initiatives. In an interview in Monywa in the Sagaing region in Upper Myanmar, the Team learned that 130 villages in the area were reported to have taken advantage of a solar panel cost-sharing program, whereby the regional government pays 50% of a $70 solar panel and

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[††††††††] Integrated Household Living Conditions Survey in Myanmar 2009-2010, Poverty Profile Report, UNDP Myanmar, June 2011
[‡‡‡‡‡‡‡‡] Electricity in Myanmar, *op.cit.*
[§§§§§§§§] Winn, *op.cit.*
[*********] ADB, Japan Grant to Pioneer Off-grid Renewable Energy Access in Myanmar, Asian Development Bank, May 29, 2014.

converter, which are then distributed within villages to individual users. Individual households cannot apply. It was also reported in the Kyaukpyu region that the MLFRD had provided six local villages with solar panels and solar home systems in 2013. In addition, a MLFRD notice was also recently published concerning a $35 million national tender for solar and other energy-related equipment[††††††††††]

In a separate interview during Phase I Fieldwork, conducted with a company named Asia Solar in Yangon that is active in Upper Myanmar, it was reported they and two other firms had won a tender sponsored by the Sagaing government, in which the local government purchased 1,030 “starter” solar kits from each firm. The kits were then distributed to villages in the division. The company did not know the exact details of where the kits were installed.

Asia Solar supplied a 25 W kit, consisting of a solar panel, three bulbs and a box that allows generation by direct current for $73. They also market this kit directly to consumers for $85. According to Asia Solar, the price of the solar kits has fallen from 160,000 kyat roughly 8 or 9 years ago, and is expected to fall further in coming years.

Asia Solar US$74 lighting kit for villagers in Sagaing Division

Solar panels were reported to be used as back-up to generators in some cases, and were also said to power income-generating activities. In Monywa, for instance, a solar panel allowed one household to refrigerate soft drinks and water that could then be sold at a profit.

Solar poses more of a challenge to larger-scale commercial and industrial users. In one case, the manager of a foundry in Mandalay was unable to find the appropriate equipment that would have allowed him to install a powerful enough solar scheme for his operations.

[††††††††††] The New Light of Myanmar, May 29-June 1, 2014

Other challenges include high start-up costs and the need for greater technical knowledge. Energy storage for nighttime use is also a problem with solar electricity.

Like hydro, solar electricity is site specific and dependent on sun intensity among other factors. Solar panels, however, were reportedly used in locations where sun intensity was not optimal, but were said to require more costly configurations. Asia Solar, for example, noted that configurations for equipment sold for use in Shan State, which has less sun intensity than the dry zone of Upper Myanmar, were more expensive.

Hydro

Myanmar has a high potential to provide low-cost renewable alternatives to diesel. The largest source is hydropower, which grew in importance after the World Bank conducted a 1995 study that predicted Myanmar had a potential production capacity of 108,000 MW.[‡‡‡‡‡‡‡‡‡]

The use of hydro-power as an alternative to grid-access was prevalent across Myanmar and was seen by the Team being used as a primary or auxilliary energy source in Mandalay, Kengtung and Pyin Oo Lwin, where it provided cost-effective power for lighting, electronics, television and other uses.

In Pyin Oo Lwin, for example—a tourism destination in the Shan highlands north of Mandalay—the Team interviewed a restaurant owner near a small waterfall that serves as a tourist attraction. This individual was able to power her business using an off-grid, micro-hydro scheme. The restaurant owner reported purchasing a hydro generator ten years ago for $300 and replacing the ball mechanism once per year at a cost of about $15. Additionally, an attendant checks on the generator routinely. The generator supplies all the restaurants' electricity needs 24 hours a day, including several lights, television and a normal size refrigerator.

Mini-hydro Turbine in Waterfall Powering Restaurant w/ Refrigerator, Lights & TV

[‡‡‡‡‡‡‡‡‡] Harnessing Energy from the Clouds, *The Myanmar Times*, August 20-26, 2007

The business owner noted hydro-generators operated by other nearby shopkeepers require more maintenance on a comparative basis, perhaps due to less optimal locations, but still represent a very cost-effective energy source.

A larger and more powerful hydro-generator was seen in a store on Pyin Oo Lwin's main road. It sold for $550 and was said to supply 5 KW, enough to power lighting and television within an average sized village of about 100 households.

Despite the advantages of hydroelectricity, however, it was not as widely used as might be expected in Pyin Oo Lwin and many consumers expressed a growing preference for solar power. This can potentially be explained, in part, by the need for optimal placement within a viable water source. In many cases significant engineering support is also required where damming is necessary with larger installations. Water flows can also vary tremendously as seen in the example above by one restaurant owner whose neighbors incur a higher cost structure due to placement elsewhere in the same small waterfall. Additionally, there is the convenience of installing a solar panel as opposed to a hydro-generator, which can be easily washed away or subject to power surges given variations in currents. These findings emphasize the need for further research to better understand the factors surrounding consumer preferences for solar over hydro, among other resources.

Gasifier/Biofuels

Myanmar is working to develop its biomass resources, consisting of fuelwood, charcoal, agricultural waste, and animal residue.

Biomass Resources in Myanmar

Type	*Quantity*
Rice Husk	4.392M ton/year
Lumber Waste	1.5M ton/year
Bagasse	2.126M ton/year
Molasses	240M ton/year
Livestock Waste	34.421M ton/year

Source: Myanmar Engineering Society

While it is difficult to obtain accurate data given unreported logging, more than 50% of Myanmar's total land area is reported to be forest. This represents approximately 344,232 square kilometers. Myanmar's potential annual yield of fuelwood could be as high as 19.12 million cubic tons.

To preserve forests, Myanmar’s government has undertaken initiatives to substitute use of fuelwood with other biofuels or, in areas near oil and gas fields, LPG. Efforts are also being made to introduce more efficient stoves and appliances to rural households.

These measures are expected to decrease dependence on fuelwood by 46% over a 30-year period.

Myanmar has 1.5 million tons of lumber waste, 240,000 tons of molasses, 2.126 million tons of bagasse, and 34.421 million tons of livestock waste per year. All of these sources can be used for biomass gasification.[§§§§§§§§§] Cost savings makes biomass especially attractive for Myanmar's rural population.

Per year, Myanmar also has 4.392 million tons of rice husk resources, which are most prevalent in Yangon, Ayeyarwady and Tanintharyi divisions as well as Rakhine and Mon States.

The abundance of rice paddy in the Ayeyarwady Delta, makes rice husk gasifiers the preferred alternative to diesel generators in this region. In Myaungmya Township, for example, a hybrid rice husk gasifier managed by the Ministry of Agriculture and Irrigation, with supplemental power from diesel, electrifies 80 households in a nearby village and pumping station and operates at a profit. Electricity generated by the Myuangmya gasifier is reportedly available for five hours per day in the evenings.

In Nayaung, a village visited roughly 45 km northwest of Tachileik in Eastern Shan State, a local entrepreneur powered his rice mill and factory, as well as approximately 100 other consumers in the area, using a rice-husk gasifier, which powers a generator via a dual-use gas and diesel engine.

Although economically viable, the environmental impact of most rice husk gasifiers currently used in Myanmar is not favorable. According to an interview conducted in Yangon with the owner of one of the largest suppliers of gasifier equipment in Myanmar revealed that more environmentally friendly technology is being developed with the help of JICA and other parties. This would, however, add to the cost of the equipment and compliance would have to be monitored. In the absence of such environmental safeguards, it is unlikely that rice husk gasifiers will be endorsed by donors and international agencies, nor should it be seen as a viable energy source given the potential for toxicity and adverse environmental consequences.

Generators

Generator sets, typically fueled by diesel, were the most commonly observed independent electrification scheme seen by the Team in Myanmar.

In the Bagan/Nyaung-Oo region, villagers off the grid tended to operate collectively owned generators and monthly payments were not metered, but varied depending on whether they utilized only lighting or other appliances such as television. One village possessed a communal generator to provide lighting for the village pagoda, streets and school, but not for individual households.

[§§§§§§§§§] ASEAN Countries' Presentation on Renewable Energy Projects and Business Opportunities (Myanmar), Myanmar Engineering Society

In addition to providing primary electrification, independent generators were observed throughout the country to provide back-up power for users connected to the national grid. This is common throughout Myanmar even in the most urban of areas and adds a significant additional cost layer for businesses and individuals who seek a reliable power source. For example, although grid extension initiatives were underway in the Monywa region, only about one quarter of the villages connected to the grid were reported to be fully reliant upon it.

This is important as almost every business person interviewed during the Team's Fieldwork who received access to subsidized power noted their willingness to pay more providing the MOEP could improve the capacity that would allow the removal of this extra cost layer which required the installation and maintenance of back-up generators. Without this ability the incentive structure was reversed in which these business people counted on the availability of subsidized power to compensate for the high costs of diesel and maintenance, operation and installation of this costly equipment.

Back-up generator use was particularly common among commercial and industrial users where a dependable power source is more critical. An interview with Monywa's Industrial Zone Management Board officials revealed that each of the factories within the zone relied on at least one generator to compensate for unreliable electricity supply from the grid. Factories in Pathein also reported the use of back-up generators in the case of black outs.

In Mandalay, a development company has opted for self-reliance as it develops an industrial park, given there is no feed-in tariff or ability for this developer to sell excess power back to the grid. The company therefore seeks to utilize a modular power supply that will power the construction phase of the operation on an as-needed basis. It will then add capacity as tenants are located and move into the facility. This example highlights the pressing need for Myanmar to develop regulation that encourages private sector involvement in the power industry, through mechanisms such as a feed-in tariff, power-purchase agreements and public-private partnerships. That would allow longer-term planning and the ability of entities such as this developer to develop the capacity needed for the longer term, which would be far more economical than adding on periodically, and selling what is presently unneeded back to the national grid or other customers. According to one interview conducted in Yangon with a supplier of rural micro-finance and electricity solutions, $200 million in investments for power generation were held up as of 2013 because of the lack of such legal frameworks.

Although more reliable, the cost of electricity from captive diesel generators is significantly higher than the government-subsidized rates for electricity from the grid.

For industrial users, unreliable electricity was a paramount concern as the national grid did not provide sufficient capacity or reliability, however, the use of diesel generators raised production costs considerably. In some cases, companies reported spending up to 50% of operating costs on electricity. As noted, the need for this reliance contributes to an suboptimal incentive system in which large users—most of whom indicate they would pay more for grid power if it were reliable and enabled them to operate without these auxiliary systems—become dependent on the cheaper grid power to reduce the higher cost of diesel-fueled power accessed through their auxiliary generators.

Challenges of decentralized power

Although desirable to provide a short-term solution on a household or small-scale basis, the sustainability of reliable decentralized power is questionable, particularly if there is no connection to the national grid in the long term. Isolated systems, including those that use solar, hydroelectricity and biofuels are suitable options where demand density is low. They do not require large-scale investment or substantial amounts of hard currency. While operating and maintenance costs are also low compared to projects involving the national grid, administrative and management costs by donors and other institutions seeking to develop numerous sites can be onerous given individual small projects lack the scale that allows effective amortization in comparison with larger projects.

Independent power providers that try to deliver to rural areas face many challenges, including customers unable or unwilling to purchase or install electrification capacity. Marketing to the rural poor is also a challenge.[**********] Other challenges include scarcity of capital, obsolete equipment and machinery, a shortage of adequate physical and human resources and an absence of current information on technical, market and legal issues. There is also a lack of support from the state, especially in technology transfer, credit guarantees and loans. This is an area in which donor assistance could prove vital.

Mini-grids

According to the International Energy Agency (IEA), which advocates efforts to reach universal electrification by 2030, 42% of all new power generation worldwide must derive from mini-grid systems.[††††††††††] The IEA suggests at least 100 kWh of electricity per person per year must be reached to surpass basic home needs, such as lighting, phone charging or television/entertainment use, and to develop sufficient electricity supply for productive uses, such as rice mills, tools, irrigation pumps, and refrigerators.[‡‡‡‡‡‡‡‡‡‡]

The Team defines a mini-grid as an electricity distribution network operating at between 4 KV and 13 KV at the lower end or 26 KV and 69 KV at the higher end, which supplies electricity to a localized group of consumers and which can potentially be connected to the national grid. The development of mini-grids could reduce the cost of grid extension, and can act as an incentive to extend the national grid to remote areas where

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[**********] Entrepreneurship Development in Solar Energy Sector for Rural Area in Myanmar, ARTES/SESAM Alumni Regional Level Workshop, May 2008

[††††††††††] Evan Scandling, Rural Energy Access: The Case for Renewable Energy Mini-Grids, *The Huffington Post*, March 8, 2014

[‡‡‡‡‡‡‡‡‡‡] Ibid.

infrastructure is lacking if suitable regulation and policies are introduced to support and encourage this activity.

Mini-grids can be developed utilizing a variety of different business models. Under a community-based model, a mini-grid system would be owned and operated by the village, which would be responsible for maintenance, tariff collection and management services. The government may retain control over technical and safety standards as well as the provision of subsidies. Utility-based mini-grids, which are said to be the most common type for rural electrification in developing countries, may be run by a government institution, investors or a cooperative. Private sector models vary depending on contracts and other circumstances. In one example given by GVEP International, distribution utilities and electricity cooperatives in a developing country were required to outsource power generation to private companies using a competitive bidding process.

Mini-grids may also be operated using a hybrid business model, whereby a utility or private company may own a mini-grid system, the management of which is handled by a community-based organization. Business models are said to benefit from availability of credit from public agricultural banks; private financing from commercial banks; simplified licensing procedures; unrestricted power tariffs; capital cost subsidies from government; and technical assistance from bilateral donors and NGOs. Education and communication with local communities are also a key component of success for private business models.

Table 1. Advantages and disadvantages of different mini-grid business models

Model	Advantages	Disadvantages
Community	• Increase ownership which improves maintenance • Can be more efficient than bureaucratic utilities	• Communities may lack technical and business skills (e.g. design and installation; tariff setting), leading to higher costs to bring these in • Governance of systems needs to be well managed
Private	• Greater efficiency • May have capacity to offer better operation and management services • May be better able to navigate political interference	• Lack upfront financial support in most cases • Often difficult to find enough experienced companies, so often schemes are run by smaller companies with less capacity
Utility	• Responsibility lies with an experienced organization • Often good links to policy so have better access to legal systems • Their scale means that they may have better access to spare parts and maintenance	• Liberalisation means that they are market driven, so may not prioritise decentralised systems in rural areas • Often inefficient and bankrupt • Often driven by political agendas
Hybrid	• Combine the advantages of the models above, such as the technical expertise of a utility and the financial expertise of the private sector	• Differences in the management systems of each entity can increase transaction costs

Source: GVEP International, The history of mini-grid development in developing countries, Policy Brief, September 2011, citing World Bank, 2008a; USAID/ARE, 2011

In Myanmar, MOEP's off-grid projects rely on hydroelectric plants and diesel generators. Countrywide, the MOEP runs 32 off-grid hydroelectric power plants with a total installed capacity of 33 MW.

During Phase I Fieldwork, the Team visited a government-run mini-grid in Kengtung, a relatively large but isolated township in the Shan highlands, close to the borders of China, Laos and Thailand. Kengtung's size, natural resources and distance from the national grid made it an interesting case study for the use of off-grid hydropower on a scale beyond that of village-level.

MOEP administers two off-grid hydroelectric plants in Kengtung, one of which supplies reliable electricity to local military facilities as well as about 8,000 consumers from nearby villages. During the dry season, it was reported that electricity from the national grid was supplemented by a diesel generator. It was also noted during an interview with the MOEP district officer that upgrading the system's transmission and distribution lines could help the off-grid plant to better meet Kengtung's power needs.

Hydropower Facility in Kengtung

Transformers and cables for off-grid projects are set to national standards, but, like those of the national grid system, are also a source of transmission losses.

The MOEP-run projects observed in Kengtung differed from other small-scale hydro-power schemes visited in other areas, like Pyin Oo Lwin, in that they were not supplementing power from the grid or small-scale generators, nor were they merely supplying niche areas, such as small, isolated and geographically challenging villages or parts of village or individuals where grid connection was not feasible. Considering most parts of Myanmar, including those on the grid, receive a limited number of hours of electricity per day, the off-grid hydropower plants visited in Kengtung appear to be a relatively reliable electricity source for local residents.

Cross-border electrification

Although the Myanmar Electric and Power Enterprise is designated under the State-owned Economic Enterprises law of 1989 as the sole legal provider of electricity, certain areas of the country have been receiving electricity from Myanmar's more developed neighboring countries for years.

Tachileik, a border city situated on an important crossing into Northern Thailand, is one such location and was visited by the Team during Phase I Fieldwork. Similar activity has been reported in Kachin State and Northern Shan State on the China border and Kayin State further south along the Thai border.

Tachileik is a prominent trading center in eastern Shan State, bordering Thailand to the South and located roughly 29 km west of the Laos border. The area is so integrated with its neighbor that the local economy operates on the Thai baht as opposed to the Myanmar kyat. As Myanmar continues to develop and open to foreign travelers, Tachileik holds significant potential for the tourism industry because of its hiking trails, scenic views, and ancient pagodas as well as its proximity to Thailand.

Tachileik initially connected to Thailand's grid in 1995. Because of the availability of electricity in Tachileik, in addition to lucrative trading opportunities, and ability to serve as a gateway to Northern Thailand, the area's economic development has steadily increased over the years. By 2001, the population was reported to have grown to 100,000, about five times what it had been in the mid-1990s.

Border Crossing Between Myanmar-Thailand in Tachileik

The electricity from Thailand is said to provide sufficient power to all of Tachileik's 100,000+ inhabitants. Less than 10% of these are industrial users, which primarily consist of small-scale factories and workshops that produce welding, steel structures and other "installation" products.

The electricity supplied by Thailand is reportedly very reliable with no blackouts, however, there are reported transmission losses of roughly 15% per year, about one third of which may be the result of illegal power tapping. The local electricity committee has proposed increasing electricity supply to Tachileik by upgrading the cables.

Currently, Myanmar's MOEP is responsible for the technical administration of electricity, such as wiring, from the Myanmar side of the border. In addition to the local MOEP office, a local electrical committee was formed and given a permit, renewable on an annual basis, that allows them to assist with electricity operations, including payment collection.

The local MOEP and electricity committee are considering extending the Thai connection outside Tachileik. The area is bound by the nation-wide regulations on grid connection, however, certain aspects of the system, such as switchgears, must also meet Thai standards.

The cost of electricity in Tachileik was reported at approximately 3.25 baht (186 kyat) per kWh for residential users and 7.25 baht (225 kyat) per kWh for industrial users, roughly 5 and 3 times greater, respectively, than subsidized electricity purchased from the Myanmar national grid. It is less, however, than electricity provided by off-grid, independent diesel generators.

Given the relatively high mark-up on this electricity, the return on investment resulting from upgrading or expanding Tachileik's electrification supply would be realized in a relatively short period of time. The Thai energy provider gives a portion of mark-up to the electricity committee, which is a non-profit organization, to cover operational costs.

This situation, however, raises concerns over the area's reliance upon Thailand. Though reliable, the power supply from Thailand is susceptible to political disputes. It was, for example, cut off by Myanmar's government in 2002 due to rising tensions.

If Myanmar's relationship with Thailand were to sour—as it has in the past—or if either government decided to cut off Tachileik's access to Thai electricity for any reason, the area would suffer an immediate and drastic change in living standards and a potential set-back in terms of economic development and tourism revenue.

Likewise, there are concerns about over land ownership and environmental risks of greater energy development in the region. Any negative impact, such as a dam malfunction, has the potential to cause problems between Myanmar and Thailand.

Nonetheless, the Tachileik situation illustrates the economic and social utility of cross-border integration with Myanmar's more developed neighbors and reveals that certain regional arrangements can supersede and supplement national regulation.

Such cross-border understandings, and the development of stronger, though more balanced, relationships with neighboring countries could be a vital component of Myanmar's regional energy and overall economic integration. Arrangements could be developed whereby Myanmar can leverage the capacity of these countries to access, and perhaps ultimately even deliver, additional electrical capacity and, over time, to facilitate the development of a dynamic, regional energy market.

Phase I Fieldwork Conclusions

Phase I Fieldwork helped the Team fill gaps and understand inconsistencies in the exploratory research conducted during development of the initial background report. It also enabled the Team to begin identifying important themes and issues, which will facilitate development of policy recommendations for Myanmar's integrated energy and electricity policy and areas where additional research would prove helpful.

A number of these insights were outlined in the above text, including the importance of regional and local governments in organizing villages' electrification initiatives and payment structures, the need for increased dialogue among the public and private sectors and greater legal clarity on private sector participation in the power industry, and the importance of enhanced international collaboration and cross-border cooperation.

The Team also believed that more structured fieldwork would be of particular importance to gain a greater understanding of the costs and benefits of various energy sources. This was due to the inability of villagers to define their reasons behind stated preferences for different electrification technologies or to assess with any degree of accuracy the variability of installation and operations and maintenance costs.

While there is both a need and clear potential for renewables and energy sources that can be used to supplement the grid as it is expanded to provide additional off-grid supply, there is a definitive lack of information concerning the real cost—monetary and otherwise—of various options. This is important to evaluate the comparative cost of solar, hydropower, gasifiers, grid connection, generators, batteries and other technologies in different parts of Myanmar with consideration given to geography, village size, income level and the various factors that impact effectiveness.

Similarly, given that optimal solutions will likely involve combining different technologies in a manner that at least eventually will promote the connection of remote locations back to the grid, special attention should also be given to evaluate the potential use of micro-grids as a means to extend electricity access in Myanmar.

Phase II Fieldwork Research

Phase II Fieldwork consisted of village-level site visits and other meetings undertaken by KWR and UT between January 2014 and June 2014. This phase enabled deeper examination of the dynamics driving rural electricity supply and demand in Myanmar, and centered on developing a more comprehensive "bottom-up" view through more detailed site visits to specific villages. Special attention was devoted to the development of data on village income and the comparative costs, benefits and feasibility of various electrification technologies, including solar home systems, mini-hyro turbines, generators, gasifiers and grid extension. Finally, steps were taken to facilitate further identification, analysis and refinement of policy recommendations under development for Myanmar's energy and electrification strategy.

After careful planning, in which efforts were made to provide a more comprehensive evaluation of sites in Lower Myanmar, which would then be supplemented in future phases with locations in the North, the following sites were selected: Tha Yet Taw, Kyar Kan Daung, Aung Mingalar Kyun, U To and Me Za Li Ywar Ma in Ayeyarwady Division; War Taung and Za Di Ya in Kyaukpyu in Rakhine State; and Myoma and Mu Du near Dawei in the Tanintharyi Region. Interviews with villagers, field offices of the Myanmar Electric Power Enterprise (MEPE), private power providers and small business owners were supplemented with “exploratory” fieldwork visits to larger, more urban and industrial settings. These included two special economic zones (SEZ), one in Kyaukpyu, which is also the site of a government led-initiative to extend the national grid, and another in Dawei. Another exploratory visit was conducted to a now defunct hybrid-power facility in Chaunghtar, a beach area in the Ayeyarwady region of Myanmar. The facility had been initially developed by the New Energy and Industrial Technology Development Organization (NEDO) of Japan in cooperation with MOEP and MEPE. It was comprised of a hybrid power system incorporating renewable and conventional power generation, including solar photovoltaic panels, Myanmar’s first wind turbine and a diesel generator.

In addition to the Fieldwork research, the Team convened numerous meetings in Yangon, Naypyitaw and other locations inside and outside Myanmar to interact with key stakeholders and individuals who could contribute to the planned research. The Team also participated in a number of events and discussions on integrated energy development in Myanmar, with an emphasis on rural electrification. These included: a) Stakeholder meeting, organized by the Team in coordination with the Union of Myanmar Federation of Chambers of Commerce and Industry, Myanmar Engineering Society, Myanmar Industries Association and Investment and Industrial Development Committee of Myanmar’s National Assembly, which was held in Yangon to gain broader input on rural electricity access from Myanmar's private sector; b) a conference, convened by UT, held at Chulalongkorn University in Bangkok, Thailand on the topic of cross-border power integration and c) Meetings sponsored by the World Bank and Asian Development Bank which took place in Naypyitaw from March 20-22, 2014. These meetings facilitated the exchange of information and helped boost awareness of KWR/UT/ERIA and the ability to contribute to and advance policy discussions concerning rural electrification and integrated energy development in Myanmar.

Phase II Fieldwork Methodology

Basic Assumptions

To make sound recommendations on the feasibility, sustainability and comparative advantages of electricity sources requires a nuanced understanding of the various costs, monetary and otherwise, involved in each source and in each village.

While the Team realized it would not be possible to develop a full detailed costing of different electrification technologies, given the intensive engineering and other resources required as well as the potential for alternative and hybrid approaches, it initiated an effort to gain a basic, approximate understanding of the costs and benefits associated with the five most commonly utilized electrification approaches in Myanmar in each village visited. This includes solar home systems, generators, mini-hydro, gasifiers and grid extension. The options were viewed from a village level and assessed from the perspective of individual villages, rather than a regional or national standpoint.

Demand Assumptions

In respect to the demand side, the Team overlaid Myanmar household income data with projected household electricity goals. Households with the lowest income were assigned a projected wattage of 120, a level noted by the MLFRD as their minimal goal in providing rural electrification access on the household level. Wattage estimates were then determined for four higher income brackets (aspirant = 500 W, emerging = 1,000 W, established = 2,500 W, and affluent = 5,000 W), utilizing categorizations first developed by the Boston Consulting Group and its Center for Consumer and Customer Insight. It is recognized that many households normally defined as "affluent" could have much higher demand capacities over 25,000 W. However, for the purposes of this study, there were no "affluent" category examples even at 5,000 W capacity.

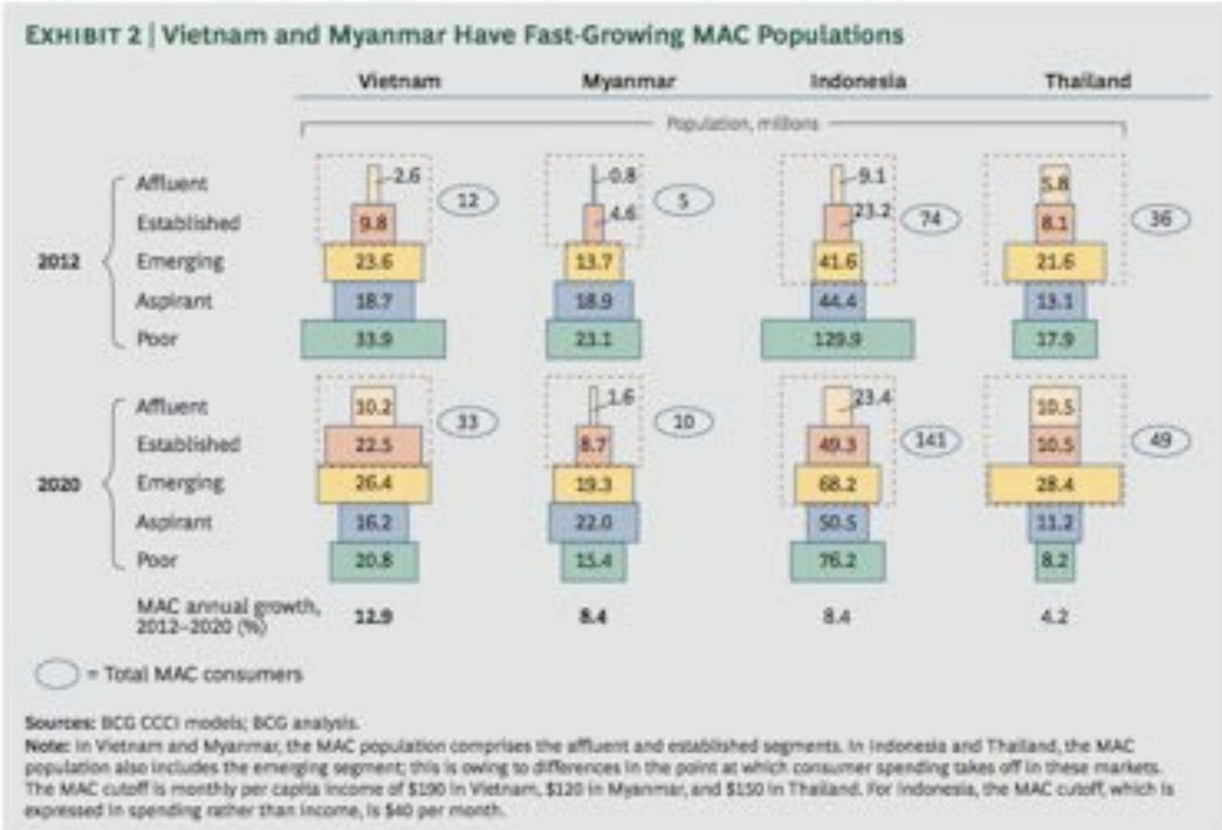


EXHIBIT 2 | Vietnam and Myanmar Have Fast-Growing MAC Populations

Sources: BCG CCCI models; BCG analysis.
Note: In Vietnam and Myanmar, the MAC population comprises the affluent and established segments. In Indonesia and Thailand, the MAC population also includes the emerging segment; this is owing to differences in the point at which consumer spending takes off in these markets. The MAC cutoff is monthly per capita income of $190 in Vietnam, $120 in Myanmar, and $150 in Thailand. For Indonesia, the MAC cutoff, which is expressed in spending rather than income, is $40 per month.

Projected household electrification goals 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 set
Emerging	1,000 W	Lighting, portable DVD player, portable fan, television set, rice cooker
Established	2,500 W	Lighting, portable DVD player, music system, television set, air conditioning, rice cooker
Affluent	5,000 W	Lighting, portable DVD player, music system, television set, air conditioning, rice cooker, microwave, refrigerator, water heater

Source: KWR International

When the Team visited each village, the leadership was asked to give an approximate breakdown by income of the village inhabitants. Few villages in Myanmar have any "affluent" people. There can be a few residents in the second category (established), while the majority of village inhabitants will likely fall into the remaining three (emerging, aspirant and poor). For example, in one village visited in early 2014, the headman broke down inhabitants into three categories. No villagers were truly "affluent"; the richest residents were traders, merchants and property owners, the second group comprised small farmers and property owners, and the third comprised day laborers.

From there, the Team examined further to fit these groups as possible into the five categories and household demand was calculated accordingly. The Team would also ask about other facilities in the village and then calculated a rough projection of the electrical demand required. For example, below is the demand estimate for U To village.

	Percentage	Kilowatt	Demand (KW)
% Poor	80%	0.12	11.52
% Aspirant	15%	0.5	9
% Emerging	5%	1	6
% Established	0%	2.5	0
% Affluent	0%	5	0
Total Household Demand			26.52
Non- household demand			6
	Total Village Demand		32.52

These calculations were derived to project the estimated capacity needed for stand-alone off-grid projects. With grid extension, however, total demand on a village- or township-level is not as much of an issue. That is because within reason, villagers can get what they need from the grid or a larger source (ie hydro or generator, in the case of regional micro-grids) as opposed to village-level projects in which there is a clear finite limit. At the same time, total demand is important for determining the approximate cost of potential electrification schemes. This is necessary to put the costs and comparative advantage of grid extension into context with the other four options examined.

Non-household demand was calculated based on facilities commonly found in villages, with emphasis on monasteries and schools. Although the Team encountered small businesses, such as teashops and small industry in some villages, given the difficulty in assessing their energy demand, and an assumption that the electrification costs for these facilities would likely be underwritten by the owners utilizing captive power sources rather than drawing from village-installed installations, the cost model omits these elements from its non-household demand estimate. This is because this usage would not commonly be included within village mini-grids.

Through consultations with local inhabitants and consultants, the Team made the following assumptions on the average non-household demand required for these facilities: monasteries would consume about 3 KW of electricity, schools 2 KW, and clinics 500 W. In most villages, monasteries host celebrations and religious ceremonies that often use sound equipment. Community wells, requiring electrical pumps, may also be found on monastery grounds. Schools were assumed to consume 2 KW of electricity because they often serve as meeting halls for the village. Additionally, there are a growing number of night classes held for improving literacy among adults. Village clinics do not have any medical equipment that requires electricity. They are often very modest and at minimum have basic lighting.

Technology Assumptions

Every village is unique and the Team's objective is not to use this data as the basis for larger scale forecasts of regions or the country as a whole. It is rather a tool that allows for a more nuanced understanding of the comparative benefits of these various commonly employed solutions, to help define which technology may be best for a respective region and village and to identify commonalities, trends and conclusions.

As a result, mini-hydro has largely been eliminated as a possible electrification solution due to lack of adequate river sources in the respective sites visited. Among the Team's field visits, there was only one town—Myoma—where mini-hydro was deemed feasible, and which was in the process of installing a 100 KW turbine. While the Team has calculated an estimate of $172,552 for a 100 KW installation, the estimate does not account for the dam being constructed for Myoma's project. Developing a meaningful estimate for installation of a dam would require a detailed engineering study. Mini-hydro projects in general require such in-depth civil engineering surveys and studies, as they are site-specific. As noted in prior analysis undertaken by the ADB, such surveys often incur high consulting fees and can cause the cost of electricity generated to become less competitive.[§§§§§§§§§§]

While it is unknown whether the present project in Myoma has undergone such a survey, this mini-hydro plant, as with most, is also dependent on water flows and will only be operational eight months out of the year. For two of those months, it will be reliant on the reservoir. Additionally, these facilities are generally either too large for smaller villages, with very high excess capacity, or insufficient, given weather variability. As a result, as with the case of Myoma, where the facility under development will only supply 100 KW of 420.54 KW in estimated demand, these facilities tend to require auxiliary generation through generators and other sources. For these reasons, as well as the cost of up-front engineering, and the fact there was not a sufficient hydro resource in eight of the nine villages visited, the Team eliminated hydro as a viable source for small-scale rural electrification during this phase of the study.

Based on this assessment of present electricity demand in the locations visited, the cost model focuses on installation costs and includes a one-year estimate of operation and maintenance (O&M) expenses, as this is commonly included in installations in Myanmar. In the case of diesel and other inputs needed for generation, these first year costs include only that needed for testing and installation. Although these estimates

[§§§§§§§§§§] Scoping off-grid renewable energy opportunities in Myanmar, Asian Development Bank, March 2014 should not be interpreted as sufficient to plan actual installations, the Team did its best to generate an assessment in consideration of the most appropriate solution and materials.

The systems priced in the cost evaluations reflect those commonly utilized in Myanmar, albeit outfitted with more proper installation and design. For instance, while the estimated costs for solar are based on home systems, those priced in the Team's cost model include a mounting structure, controller and a battery specifically designated for deep cycle charging. Solar home systems widely used in Myanmar generally have no controller or mounting structure and utilize car batteries that are suboptimal for solar charging. The mounting structure should resolve the issue of improper panel orientation.

Similarly, the cost estimates for the generator and gasifier systems are based on a properly installed mini-grid system with a distribution panel instead of the common practice of improperly positioned distribution lines that have high losses. Additionally, gasifier estimates account for a water treatment system, which, in the Team's experience, most gasifier operators neglect to install.

The cost evaluation also accounts for better quality materials which have more sustainability, though efforts were made to include costs for components that were feasible for Myanmar rather than even higher cost options seen in more developed countries. The solar home systems, therefore, were composed of higher quality parts from Taiwan and China. The panels, guaranteed for ten years, are based on Japanese technology and assembled in Taiwan or India. The controller, maintenance-free battery and inverter are of advanced technology made in China. Like many Chinese manufactured products, there are ranges in quality. As witnessed by the Team, inexpensive, low-quality solar home systems made in China abound in Myanmar. While the initial cost is lower, the quality is generally inferior, resulting in less sustainable installations and a higher real cost over the lifetime of the installation. Therefore, the choice of Chinese-made materials priced in Team's cost analysis is of the higher end.

While the solar home systems priced in the Team's model are admittedly pricier than those generally seen in villages and those readily available in the Myanmar market, in the range of solar PV product price and quality, these units fall in the middle of the spectrum of available products. For a 100 W peak solar power system—including a panel, controller, battery, inverter, mounting structure, panel box and wiring—the cost comes out to 340,000 kyat (approximately $354). At Schneider Electric, where solar PV systems are among the available retail products, the price for only a panel and battery of the same specifications amounts to 320,000 kyat.

Prices for gasifiers, mini-hydro and grid extension are all based on equipment and materials generally used in Myanmar. Some are manufactured in Myanmar but higher technology components will be imported. This will change as the country's capability develops. Generator prices are based on high quality Japanese gen-sets readily available in the Myanmar market[***********].

[***********] See Appendix 1 for summary of equipment costs.

Interest rates were left out of the equation as they vary depending upon the source. Grants and gifts can be obtained with subsidized, single-digit rates, while interest rates can be as high as 30% for certain micro-loans. In addition, loans are still difficult to obtain in Myanmar. It should be noted, however, that interest rates will be an important factor in determining technology choices, as access to lower interest rates may make capital-intensive choices more favorable.

Capital Cost Summary

The table below summarizes the capital costs and first year O&M expenses for solar home systems, gasifiers, generators and grid extension in the villages the Team visited. While there is a separate table for estimated O&M costs for each village, as mentioned above, the figures below include O&M expenses because, as standard practice, Myanmar contractors generally charge and include these fees with installation. For instance, the commissioning of the generators requires a 24-hour fuel test. Fuel costs for this test have been included in capital costs.

Due to the impossibility of accurately designing distribution networks without a more detailed engineering study, distribution networks included in the gasifier and generator capital cost estimates are based on the assumption that households in villages were not widely dispersed and that the terrain is relatively flat. Additionally, the grid extension figures for Aung Mingalar and War Taung islands are based on the assumption that they would use land connections, which results in a far lower charge than would be actually incurred if the requisite sub-sea connections were provided. To the Team's understanding, the Electric Power Corporation's policy generally does not extend the grid to any areas that require crossing bodies of water.

Village Name	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Tha Yet Taw	48	10	9	$34,285	$0	$31,610	$27,485	$411,738
Kyar Kan Daung	72	11	15	$51,738	$0	$34,610	$30,485	$451,760
Aung Mingalar	110	42	24	$79,677	$0	$50,642	$41,006	$1,557,581
U To	120	37	32	$98,026	$0	$51,390	$41,756	$1,381,752
Mesah	96	7	70	$182,418	$0	$77,839	$58,569	$314,886
Za Di Ya	520	2	269	$708,798	$0	$220,130	$177,430	$54,167
War Taung	161	13	41	$121,271	$0	$63,350	$53,714	$557,152
Myoma	600	246	421	$1,044,422	$173,553**	$312,776	$236,171	$9,065,329
Mu Du	700	234	352	$921,938	$0	$250,338	$205,338	$8,544,246

* Estimate for 100 KW system and does not include construction of dam or advanced engineering study

Operations and Maintenance

To develop a more accurate assessment of which technology works best, the Team also examined O&M costs beyond the first year of operations or in the case of fuel which extend beyond the installation tests. By adding in these O&M costs, certain technologies, which may have smaller capital costs, become less attractive due to operating expenses generated over the longer term. A cost assessment would have been incomplete without including these important details. Additionally, for some power-generation options, the original expected lifetime will not be met, consequently requiring replacement after just a few years. Solar household systems are such an example.

Total Estimated Cost - Annual								
Region	Village Name	# Households	Total Demand	Solar	Mini-hydro	Gasifier	Generator	Grid Extension
	Operating Hours			6		3	3	24
Ayerwaddy	Tha Yet Taw	48	9	$110		$5,795	$6,663	$2,878
	Kyar Kan Daung	72	15	$160		$7,178	$9,429	$4,733
	Aung Mingalar	110	24	$240		$9,402	$13,877	$7,717
	U To	120	33	$260		$11,295	$17,662	$10,256
	Mezali	94	70	$220		$20,143	$35,359	$22,126
Rakhine	Za Di Ya	520	269	$1,090		$66,874	$128,821	$84,817
	War Taung	161	41	$350		$13,190	$21,452	$12,798
Tanintharyi	Myoma	600	421	$1,260	$26,280	$102,509	$200,091	$132,621
	Mu Du	700	352	$1,450		$86,345	$167,763	$110,937

Operations and Maintenance Assumptions

The above O&M costs were calculated based on the following assumptions:

Solar

Hired maintenance would be paid $5 to clean five panels per day, twice a year.

(Total number of panels)/ (5 panels per day) * (2 times a year) * ($5 a day)

Mini-hydro

At $26,280 per annum, O&M costs assume the same labor, maintenance and overhead cost for all capacities from 500 KVA and below. This is based on $0.01 per kWh and 60% availability per year.

Gasifier

A gasifier consumes an estimated 0.04667 gallons per kWh and runs for three hours per day with labor costs to be about $10 a day. Price of diesel per gallon is estimated at $4.60.

[[(Total Demand * 0.04667) * ($4.60 – price of diesel per gallon) * (3 hours per day)] + ($10 – daily labor charge)] * 365 days

Generator

A generator consumes an estimated 0.09334 gallons per kWh and runs for three hours per day. An operator overseeing the generator will cost $6.50 per day in labor fees. Price of diesel per gallon is estimated at $4.60.

[[(Total Demand * 0.09334) * ($4.60 – price of diesel per gallon) * (3 hours per day)] + ($6.50 – daily labor charge)] * 365 days

Grid Extension

There are 8,760 hours in a year. Each unit of electricity costs 35 kyat or about $ 0.036.

Total Demand * 8760 * 0.036

Technology Analysis

In addition to examining each technology for each village, the Team also conducted a macro-evaluation of each electrification method for Myanmar as a country. This overall assessment was done according to the following categories:

Capital/financing cost (1=highest cost, 10=lowest cost)	Including system, batteries, installation and land
Energy resource cost (1=highest cost, 10=lowest cost)	Cost of energy resource
Operation & Maintenance cost (1=highest cost, 10=lowest cost)	Includes labor, spare parts and consumables, transportation, overhead
Sustainability/Life-span (1=lowest sustainability, 10=highest sustainability)	Supply chain, reliability, plant/material life cycle, deterioration
Importance of Local Knowhow (1=high importance, 10=low importance)	Technology, installation and O&M overall familiarity
Ease of capacity growth (1=difficult scalability, 10=high scalability)	Ease of scaling-up capacity
Front-end engineering/project management (1=highest upfront cost, 10=lowest upfront cost)	Front-end engineering, consulting & management costs

Ease/Lead time of installation (1=hardest/longest lead time, 10=easiest/shortest lead time)	Civil, mechanical and electrical engineering
Energy resource availability (1=lowest availability, 10=highest availability)	Insolation, fuel, small river systems, rice husks, geographic factors, etc.
Environmental impact (1=severest impact, 10=lowest impact)	Emissions/pollution/contamination concerns

The Team found that evaluating each technology according to the above criteria allowed for a better understanding of which means of rural electrification would be best in the context of existing needs, constraints and resources with overall conditions in Myanmar.

The current policy for rural electrification prioritizes an immediate solution under a limited budget. Thus, these benchmarks help to distinguish solutions that are convenient for the short-term and which account for more sustainable, long-term electrification goals. For the sake of achieving current national policy goals and to provide immediate means of basic lighting, capital/financing cost and ease and lead-time of installation, these are important indicators to consider and balance against the needs, concerns and preferences of specific villages and regions so they can prove successful over the long term.

Electricity Category	Solar Home System	Grid Extension	Hydro - Mini Mini grid	Gen-set HS Diesel Mini grid	Gasifier Gas Engine Mini grid
Capital/financing cost (1=highest cost, 10=lowest cost)	6.33	3.33	1	5.67	4
Energy resource cost (1=highest cost, 10=lowest cost)	9	6	8.67	2.33	5.67
O&M cost (1=highest cost, 10=lowest cost)	6.33	7	4.33	3.33	2.67
Sustainability/Life-span (1=lowest sustainability, 10=highest sustainability)	3.67	7.67	7	5	4.33
Local knowhow (1=minimal local knowhow, 10=high local knowhow)	5.33	6.33	1.67	4	3
Ease of capacity growth (1=difficult scalability, 10=high scalability)	6	8	0.67	6.67	5
Front-end engineering/project mgt (1=highest upfront cost, 10=lowest upfront cost)	5	3.67	2	5.33	4
Ease/Leadtime of installation (1=hardest/longest leadtime, 10=easiest/shortest leadtime)	9	3.33	1	7.33	4.67
Energy resource availability (1=lowest availability, 10=highest availability)	7.67	5	7.33	4	6.67
Environmental impact (1=severest impact, 10=lowest impact)	9	5.33	3.33	3.67	3.67
Total	67.33	55.67	37	47.33	43.67
Average across 10 categories	6.73	5.57	3.7	4.73	4.37
Median across 10 categories	6.33	5.67	2.67	4.5	4.17
St. deviation across 10 categories	1.87	1.74	2.98	1.55	1.2
% of total combined ratings	26.83%	22.18%	14.74%	18.86%	17.40%

These ratings were calculated by having three team members provide their own ratings separately, and then after discussion to allow revisions. The numbers were then averaged to provide the indicators noted above. In this overall technology assessment, solar home systems garnered the highest rating—67.33—due to generally favorable insolation conditions found throughout the country, its short lead-time, low environmental impact and low resource cost. Though overall solar received medium to high scores, it did receive a rather low rating for sustainability on account of the low quality materials generally used in Myanmar.

Following solar is grid extension with a score of 55.67. While grid extension is ideal, because it can supply low-cost electricity presumably for 24 hours and easily accommodate capacity growth, it has much higher capital costs and a longer lead-time. In the short-term, solar power is the best solution as it can immediately be deployed, while grid extension should be viewed as the long-term goal.

The other technology ratings are as follows: gen-set mini-grid system (47,33), gasifier mini-grid system (43.67) and mini-hydro systems (37).

Similar to solar home systems, generators also have a short lead-time. They can be reasonably affordable as villages often combine resources in order to purchase one. Generators are also reliable and familiar to Myanmar. However, concerns related to availability and cost of fuel as well the negative environmental impact led the Team to rate it at 47.33.

Gasifiers, although in theory should have a more positive environmental impact, are given the same mark of 3.67 as generators in that category because of their unfortunate track record in Myanmar. The rice husk gasifiers presently in use do not incorporate a water treatment system and often elicit complaints about smell and tar residue. Moreover, while Myanmar may be a large rice producer, paddy fields are mainly concentrated in the Ayeyarwady Delta region. Therefore, rice husks are not readily available throughout the country and not always free of charge. Operation and maintenance costs—another weight on the gasifier ranking—are also of concern, as most gasifiers require frequent cleanings and labor to feed fuel into the gasifier units.

Mini-hydro may have ranked higher but its application is limited to certain regions where the geography is more accommodating. Furthermore, it may be more difficult to organize from a village perspective. Although hydro is often viewed as an environmentally friendly energy source because it uses renewable resources, this can sometimes be misleading as hydro systems can potentially have an impact on plant and animal life in the water source, and in terms of carbon emissions. The generally high capital cost, long lead-time and in-depth civil engineering required for mini-hydro systems led the technology to have the lowest rating.

Broader Factor Analysis

To supplement these cost evaluations, the Team also assessed each technology solution for each village on a broader set of indicators. These indicators look at factors that affect how each technology fares in the context of each village's resources and constraints. Below, for example, is an example of one such assessment done for the village of Tha Yet Taw.

Item	Category	Electricity Category				
		Solar Home System	**National Grid** Extension	**Hydro** Mini Mini system	**Gen-set** Diesel Mini system	**Gasifier** Gas engine Mini system
1.1	Cash/non-cash (1=totally insufficient, 10= totally adequate)	6.50	2.50	1.00	8.00	4.00
1.2	Population (1=totally insufficient, 10= totally adequate)	9.00	2.50	1.50	7.00	2.50
1.3	Location /Geography (1=totally unsuitable, 10= totally adequate)	8.00	3.50	2.00	7.50	5.00
1.4	Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	3.00	1.50	7.50	7.00
1.5	Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	6.50	6.50	5.00	6.50	4.00
1.6	Cohesion (1=totally insufficient, 10= totally adequate)	9.00	1.50	1.00	4.50	3.50
	Total	46.50	19.50	12.00	41.00	26.00
	Average across 7 categories	7.75	3.25	2.00	6.83	4.33

The first item assessed the village's ability to pay for the respective electrification method, including O&M costs, with cash or bartering of resources.

The second item looked at factors related to the population of the village and those surrounding it. Population size, density and clustering of villages are important determinants. Some installations require a minimum use of energy that a small village may not need. In other cases, such as grid extension, clustering of villages is important as the combined electricity demand would justify the construction of the distribution line and help disperse the costs over a larger group of people.

The third item—location/geography—looked at the proximity of the village to the grid, road accessibility, captive power access, ease of transportation of materials, local siting locations and potential topographical challenges. Some of the villages the Team visited are flooded every year during the monsoon months, while others are in particularly hilly areas. Such factors affect where generation sites are situated and the manner in which distribution networks are established and can lead to higher expenses.

The fourth item, resource availability, is also a key component to the success of off-grid electrification strategies. For grid extension, this indicator looked at the ease of connection to the grid. While the previous category looked at the proximity, this indicator evaluated whether or not connection is feasible. For hydro, the distinction between location and resource availability is that while a village may be near a river source, the river may not hold consistent water levels throughout the year.

The fifth item—local/accessible knowhow—examined a village's ability to handle the design, project management, installation, operation and maintenance and safety demands of each technology. While a village in itself may lack the knowhow, vicinity to larger cities and towns where the expertise is available can suffice. As the Team witnessed, O&M of equipment is a critical issue in Myanmar. Therefore, while a technology may be suitable in other respects, if it involves regular maintenance or some technical training, certain villages may not be equipped to handle them well and may be better off with a different electrification strategy.

Finally, the sixth item, cohesion, recognizes that villages must be self-reliant in securing means of electrification, and cohesion among the community is of great importance. This indicator examines a village’s capacity for leadership, cooperation and planning. With the exception of solar home systems, the other means of electrification require coordination among villagers, especially to deal with the financing of these projects.

Challenges

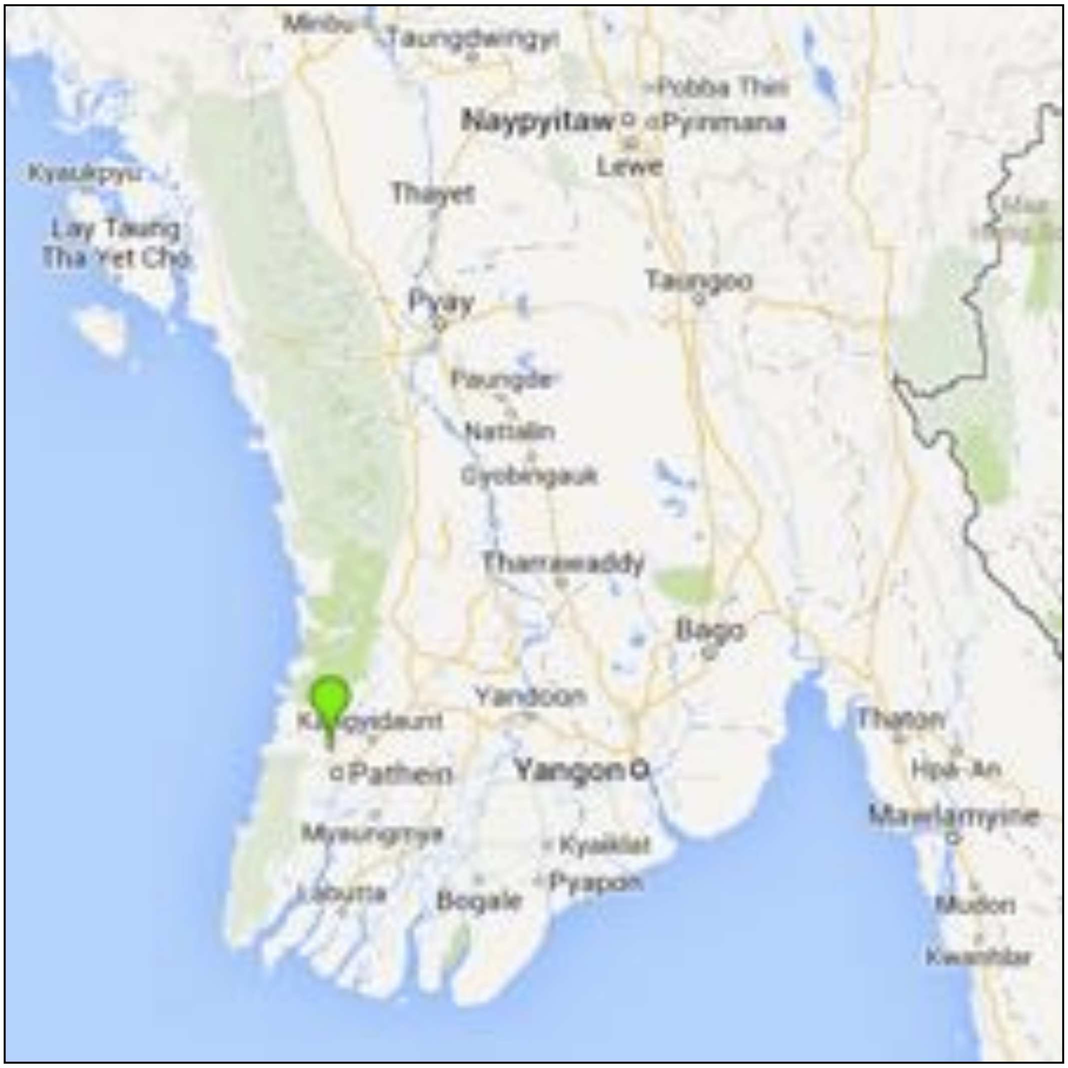
The Team's cost model was based on consultations with local Myanmar experts experienced in transmission and distribution utilizing these different technology platforms. While the Team did its best to consider all factors, the pricing model only provides approximations. Developing an accurate view of installation costs has been a challenge. The Team has found that while typical Myanmar installation costs may be comparatively lower than international standards, this is largely due to local practices whereby safety and maintenance standards are often not considered.

Throughout the course of field visits, the Team encountered a general lack of exercise and regard for safety, maintenance and formal standards. This, however, has not been exclusive to villages and remote areas. Even in Yangon, as explained by a local consultant experienced in transmission and distribution, there are plenty of instances in which switchgear is improperly positioned and transformers and distribution lines are not properly installed. The Team has also witnessed the general disregard for safety, for example observing repairmen dangerously work on distribution lines without proper safety gear. However, with training of professional suppliers as well as electricity users, these issue could be overcome.

As emphasized in the Chaungthar case study, one of the key lessons learned during this phase of Fieldwork Research is that providing state-of-the art equipment for well-intentioned purposes can backfire. Thus in trying to develop the model on what should be as opposed to what is, and keeping in mind that overly advanced technology and equipment would likely face neglect and could not be financed or adequately maintained, the Team settled on striking a balance between what is desirable and what is practically feasible. Inputs are an improvement on existing systems observed by the Team during its field visits, but are by no means too complicated or advanced in quality and design to be utilized in Myanmar and were selected with a regard toward price.

Village Fieldwork Visits

Tha Yet Taw: Satisfied with the Status Quo
Pathein Township



Population	150 -200
Number of Households	48
State/Division	Ayeyarwady
Township	Pathein
Distance from Grid	10 miles
Nearest City with Access to Grid	Pathein City
Coordinates	16.88, 94.698
Main Economy	Fishing and farming
Recommended Electrification Strategy	Solar

Tha Yet Taw	Percentage	Kilowatt	Demand (KW)
% Poor	98%	0.12	5.64
% Aspirant	2%	0.5	0.48
% Emerging	0%	1	0.00
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			6.12
Non- household demand - 1 monastery			3.00
	Total Village Demand (KW)		**9.12**

Tha Yet Taw is a small Buddhist village ten miles outside of Pathein City. Though not especially remote, Tha Yet Taw is not reachable by a typical car or truck. Accessible only by a narrow road, the Team had to hire motorcycles to reach the village. Tha Yet Daw is within the Kyauk Chaung Gyi village tract and surrounded by three other villages, the nearest is Kyar Kan Daung, which the Team also visited.

Taking motorbikes into Tha Yet Daw

Economic Profile

Most villagers in Tha Yet Daw work in both the farming and fishing sectors. Villagers reportedly are only able to plant one crop of rice per year due to flooding during the monsoon months. Villagers report that they farm between February and October and fish between November and January. Fishermen can reportedly earn up to 7,000 kyat per day during the high season when eels are plentiful, while daily laborers engaged in farm work reportedly make 2,000 kyat per day when their services are needed. Alternatively, the Team did encounter a household supplementing its income by making and selling bamboo floor mats, which might serve as the basis for a village-scale cottage industry in the future.

The young child's family sells bamboo mats like the one on which she is resting

On average, villagers report earning about 100,000 kyat per month. There is no value added in their commercial activities beyond the delivery of the underlying agricultural and marine products. Therefore, while one might imagine the village has ready access to rice husks that could be used as a potential biofuel, these crops are forwarded on and sold to processing centers and traders in their raw form so they are not then available for use as a biofuel or other products.

Electrification

According to the village headman, U Tin Aye, villagers could afford to pay about 1,000 kyat to 2,000 kyat per month for electricity. He expressed a preference for electrification through either grid extension or solar.

At nearby Kyar Kan Daung village, which has a small generator and is also profiled in this report, the local pastor offered to extend a line to Tha Yet Taw at a cost of about 100 kyat per day per household, but the villagers declined. According to the pastor, villagers from Tha Yet Taw decided they did not want to spend the money and preferred to set up solar home systems for themselves.

Presently there are only a few households with solar home systems. Panels ranged in size from 80 W to 150 W. Nearly half the village, however, own solar-powered batteries. Those without their own panels pay to charge their batteries. Additionally, those without batteries can rent them by the day. Depending on the size of the battery, a full charge is at least 100 kyat. Outside of lighting, most households with access to a battery also use the power for entertainment purposes. Most own small television sets or small portable DVD players.

In the Team's assessment of potential generation sites, the only communal land available is the assembly hall and nearby properties. However, the land may be too small to accommodate building a gasifier unit. Any associated installation of distribution lines from a potential generation site would have to account for the many trees in the village and the high winds that occur in the monsoon months. Further, the potential generation site and other associated facilities would need to be well elevated to safeguard against seasonal flooding.

Analysis

Tha Yet Daw does not appear to have any plans to electrify the village independently. Unlike neighboring Kyar Kan Daung, the Team found Tha Yet Daw to be loosely organized and less unified as a community. In addition, villagers do not appear to have the income or motivation to finance and successfully organize a village-scale electrification initiative. As a result the Team does not foresee the village as a whole taking any active measures toward electrification at the present time.

Estimated Cost Analysis

Village Name: Tha Yet Taw

Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	48	10	9	$34,285	$0	$31,610	$27,485	$411,738
O&M*	48	10	9	$110	$0	$5,795	$6,663	$2,878

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

This is currently the preferred and existing technology within the village with all installations seen being home systems. Utilizing the assumptions and equipment preferences noted within the model that has been developed[42], the estimated cost of installing solar home units to all households, the local monastery and six solar streetlights is approximately $34,285, or $714.26 per household. The cost per KW is $3,757.30. Annual O&M costs would be approximately $110.

Mini-Hydro

Although Htan Kant Lant creek is only 1,800 feet from the village, water levels are not consistent enough to support a mini-hydro turbine. Therefore this cannot be considered a viable energy source.

[42] Please see prior section, Phase II Fieldwork Methodology, for an explanation of how cost estimates were calculated and the assumptions that were made.

Biomass

A gasifier-based mini-grid system would cost approximately $31,610 to install, or $660.72 per household. The cost per KW is $3,464.21. In terms of capital costs, it is slightly less expensive than solar, but after accounting for annual O&M costs of about $5,795, solar would become more economical in the first year with less maintenance required.

Generator

The Team estimates installation costs for a generator-based mini-grid would be approximately $27,485, or $572.61 per household. The cost per KW is $3,012.15. It is the cheapest option in terms of upfront capital costs, but after accounting for an annual O&M cost of $6,663 it is no longer as competitive.

Grid Extension

With less than 50 households in Tha Yet Taw and its distance from the grid, it is not economical to pay for grid extension. The Team estimates grid connection would cost $411,738 or $8,577.86 per household. The cost per KW is especially high due to Tha Yet Taw's low demand at $45,122.91. Grid extension is not a feasible option.

Broader Factor Analysis

Tha Yet Taw	Solar Home System	National Grid Extension	Hydro Mini-grid system	Gen-set Mini-grid system	Gasifier Mini-grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	6.50	2.50	1.00	8.00	4.00
Population (1=totally insufficient, 10= totally adequate)	9.00	2.50	1.50	7.00	2.50
Location /Geography (1=totally unsuitable, 10= totally adequate)	8.00	3.50	2.00	7.50	5.00
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	3.00	1.50	7.50	7.00
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	6.50	6.50	5.00	6.50	4.00

Cohesion (1=totally insufficient, 10= totally adequate)	9.00	1.50	1.00	4.50	3.50
Total	**46.50**	**19.50**	**12.00**	**41.00**	**26.00**
Average across 6 categories	7.75	3.25	2.00	6.83	4.33

Solar ranks the highest with a score of 46.50, more than twice the scores of national grid extension and hydro and nearly double that of gasifier. Solar is well suited to the village’s small population and electricity demand as well as the village's low level of cohesion. Additionally, after factoring in O&M costs, it is the least expensive option. The village’s apparent lack of leadership and local governance makes it difficult to organize any of the other technologies on a village level.

While a gen-set-based system scores well in all the other categories, cohesion is an obstacle to its use in Tha Yet Taw. The village had declined neighboring Kyar Kan Daung’s offer of electricity from their gen-set as Tha Yet Taw’s residents preferred solar home systems. Tha Yet Taw’s residents appear to have no plans to combine resources for a village generator.

The same issue of organization applies to a gasifier mini-grid system, where cohesion also rates low at 3.5. Overall gasifier ranks third with a score of 26. While Tha Yet Taw does not have a steady supply of rice husks from its harvest, it is possible to purchase rice husks from the local rice mill. Gasifier ranks low on location because of storage and siting issues, as the village floods during the monsoons.

Because of its exorbitant costs, grid extension scores low in all categories except local/accessible knowhow, given the little technical knowledge required once it is installed, with a score of 19.5 overall. Since Tha Yet Taw is just outside Pathein City, technical assistance is accessible from there. While it can be argued this village could attempt to connect in combination with other nearby villages so the high costs could be distributed over a larger population, assessing the ability of villages within the area to join together was beyond the scope of this exercise and therefore all analyses were done from the perspective of the villages that were visited. As a result, grid extension rates low in location/geography and resource availability.

Finally, mini-hydro is simply impractical because of a lack of an adequate river source and ranks last with a score of 12.

Conclusions

Despite the rustic lifestyle of Tha Yet Taw's villagers, existing solar home systems demonstrate their willingness to embrace new technologies. Yet, the residents of Tha Yet Taw appear complacent with their few solar home systems and battery rentals that provide enough power for a couple of lights and a small portable video player.

Electrification efforts will need to be introduced by an outside party, perhaps microfinance organizations or an NGO. Though the physical implementation of a project may not be too difficult, efforts will need to be made to encourage community and development of the local economy.

Recommendations

Mini-hydro and grid extension are immediately disqualified as feasible options due to a lack of a water source and the high cost of grid extension. If the government made an extension to the area a priority, and provided financing, it could be a possibility. Nevertheless, considering the small size of the village and low level of demand, the Team recommends the expansion of solar home systems.

Installation costs of generator, gasifier and solar are relatively in same range – though differences are significant for a poor village of this size. O&M costs reveal that in the first year O&M expenses for gasifier and generator will make up for the higher cost of solar. They also require far more attention and maintenance.

The factor analysis also puts solar first, with a score of 46.5. Generator is not far behind at 41, followed by gasifier (26), national grid (19.5) and mini-hydro (12). However, in combination with O&M costs and the fact that solar home systems provide electricity for twice the number of hours, solar again comes out the clear winner, especially when considering the low level of cohesion in Tha Yet Taw.

Solar would work better for this village in this regard too given its reliance on household units which do not require strong leadership as individual households are responsible for themselves. Also, from the overall technology assessment, solar works better than generators because of its low resource cost and low environmental impact. Further the mounting structures that come with the solar home units would solve problems of improper panel orientation as witnessed by the Team.

It is clear from the range of site visits that were conducted that solar works best in smaller, isolated villages as there are economies of scale for gen-set, gasifier and grid extension which do not exist with solar home systems. This is even more true if the village, like Tha Yet Taw, lacks leadership and cohesiveness.

Interview List

- U Tin Aye - Village Head
- U Han Kyay - Resident
- U Than Aung - Resident
- U Kyaw Lin Aung - Resident
- U Poe Tha Htoo - Resident
- Daw Tin Nwe - Resident
- Daw La Ohn - Resident

Kyar Kan Daung: Benefiting from Leadership and Strong Community
Pathein Township

Population	~300
Number of Households	72
State/Division	Ayeyarwady
Township	Pathein
Distance from Grid	11 miles
Nearest City with Access to Grid	Pathein City
Coordinates	16.872, 94.701
Main Economy	Fishing and farming
Recommended Electrification Strategy	Solar

Kyar Kan Daung	Percentage	Kilowatt	Demand (KW)
% Poor	95%	0.12	8.21
% Aspirant	5%	0.5	1.80
% Emerging	0%	1	0.00
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			10.01
Non- household demand - 1 monastery & 1 school			5.00
	Total Village Demand (KW)		15.01

Kyar Kan Daung is a close-knit Christian Karen village about a quarter of a mile down the road from Tha Yet Taw village. The village is about 11 miles from Pathein City. Kyar Kan Daung is also in the Kyauk Chaung Gyi village tract and shares a similar economic profile to Tha Yet Taw.

Economic Profile

The average income in Kyar Kan Daung is reported to be less than 100,000 kyat per month. The majority of the villagers work as day laborers, some in farm work, while a handful of villagers own a few acres of land. Some villagers also subsist on eel fishing, like the fishermen in Tha Yet Taw. There is no value added in their commercial activities beyond basic production of the commodities themselves.

Electrification

Nevertheless, Kyar Kan Daung is a well-organized community centered around the church and led by the fourth-generation pastor and his wife, Esther Moe. Mrs. Moe, a retired elementary school teacher, has been pivotal in helping to provide basic lighting. Through donations from the Women's Committee of the Christian Society, Mrs. Moe was able to purchase two solar panels, one 150 W and one 300 W, for communal use. In light of its existing presence in the village, Mrs. Moe expressed preference for the technology as a future means of electrification.

Sitting with Mrs. Esther Moe

The panels are located beside the Pastor's house. The house, along with the village church and assembly hall are located at the village center. A number of households have been able to charge batteries using the communal solar panels. A 6-volt battery costs 100 kyat per full charge, while a 12-volt battery costs 200 kyat per full charge. The money collected goes back to the Women's Committee of the Christian Society.

About ten households within the village have been able to afford the cost of batteries. The 6-volt battery costs between 6,000 kyat and 7,000 kyat and lasts for one year; the 12-volt battery costs 30,000 kyat and lasts for two years. In the past, Mrs. Moe and the Pastor tried to provide lighting for the entire village, with a diesel generator, at 100 kyat per three hours of electricity a night but discontinued the service because people could not afford it. Mrs. Moe and the Pastor noted they had also offered to provide lighting for neighboring Tha Yet Taw, but the village declined.

Those unable to afford the cost of batteries rely on candles or kerosene lamps. The Team encountered one clever individual who devised an alternative solution for lighting. He fashioned a device by fitting five AAA batteries into a tube with wires on both ends that connected to a small light bulb. With those five batteries, at a total cost of 500 kyat, he is able to keep his small bulb lit for three hours a night for an entire week.

Households mainly use the solar-powered batteries for lighting. They can purchase a small solar kit, consisting of one solar-powered battery and an 8-inch fluorescent tube light, for 15,000 kyat. The battery will provide approximately three hours of light. For households with school-aged children, the solar kits have been a worthwhile alternative or supplementary source of lighting for studying. A handful of households have been able to afford additional appliances, such as small televisions and portable video players.

In addition to the solar panels, Kyar Kan Daung village also has two diesel generators, one of which, a 10 KVA high speed gen-set, is only three years old. Despite being relatively new, it is not functioning. From a brief assessment, the Team found a cracked cylinder head and a potential lubricant problem. The only available maintenance is in Pathein and the villagers cannot afford to fix the generator.

The working generator provides lighting for the church and assembly area, though only for special events. The site for all social occasions, the assembly hall is well equipped for lively celebrations with a keyboard, lights and sound system. Generally, rural villages are willing to organize and prioritize electrification efforts for local religious establishments. In Buddhist villages, electrification efforts are often focused on monasteries.

Analysis

It is important to note that Kyar Kan Daung is demonstrative of the value and importance of strong local leadership to the development of village cohesiveness and the organization of successful village-scale initiatives. Despite its poverty, due to Mrs. Moe's leadership and the strong Christian community that exists in the village, it has been able to access the little electricity it has. While other villages may have similar leadership, they do not always have the same access to external sources of support as Kyar Kan Daung has from the Christian Society.

For Buddhist villages, former residents or relatives who have done well for themselves often become benefactors. Buddhists often make donations as a means to earn merit. Although Buddhist villages may also have means to external sources of support, it often comes through individuals rather than organized associations.

Estimated Cost Analysis

Village Name: Kyar Kan Daung

Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	72	11	15	$51,738	$0	$34,610	$30,485	$451,760
O&M*	72	11	15	$160	$0	$7,718	$9,429	$4,733

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

Solar is preferred and present in the village though at maximum there are only ten households with solar home systems. Powering the entire village, including the church, school and six streetlights, with solar home systems would cost approximately $51,738 or $718.58 per household. The cost per KW is $3,447.33. O&M expenses would add approximately $160 per year.

Mini-Hydro

The nearest river source to Kyar Kan Daung is also Htan Kant Lant Creek. Though nearby, water levels are not consistent enough to support a mini-hydro turbine. Mini-hydro is therefore not a feasible option.

Biomass

The installation cost of a gasifier-based mini-grid system is estimated to be approximately $34,610, or $481.14 per household. The cost per KW is $2,306.12. Annual O&M expenses would be an estimated $7,178.

Generator

There are presently two generators in the village. One, though relatively new, is not functioning. Installing a gen-set-based mini-grid would cost approximately $30,485, or

$423.41 per household. Although this may appear to be the cheapest option, annual O&M expenses, estimated to be $9,429, must also be factored in. The cost per KW is $2,031.27.

Grid Extension

It would cost approximately $451,760 to bring the grid to Kyar Kan Daung. The installation cost is equivalent to $6,274.45 per household and the cost per KW is $30,101.31. Due to the village's low demand, the annual O&M costs for grid extension, an estimated $4,733, will be less than that for a gasifier system and nearly half of that of a gen-set based mini-grid. Still, grid-extension does not qualify as a feasible option.

Broader Factor Analysis

Kyar Kan Daung	Solar Home System	National Grid Extension	Hydro Mini grid system	Gen-set Mini grid system	Gasifier Mini grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	6.00	2.50	1.50	7.00	5.00
Population (1=totally insufficient, 10= totally adequate)	8.50	2.50	1.50	7.50	5.00
Location /Geography (1=totally unsuitable, 10= totally adequate)	8.50	3.50	2.00	7.50	5.50
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	3.00	1.50	7.50	7.00
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	7.00	8.00	4.50	7.00	4.50
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	4.50	3.00	8.50	7.00
Total	**46.00**	**24.00**	**14.00**	**45.00**	**34.00**
Average across 6 categories	7.67	4.00	2.33	7.50	5.67

According to the factor analysis, solar and generator are the best options for Kyar Kan Daung, with scores of 46 and 45 respectively. Both technologies are currently present in the village and register roughly the same scores across the board. However, considering the state of existing generators in Kyar Kan Daung, solar might be seen as the better option, as it requires less maintenance, which is a clear challenge for the village.

Gasifier comes in third, with a score of 34. Similarly to Tha Yet Taw, Kyar Kan Daung does not have a steady supply of rice husks from its harvest, but it is possible to purchase rice husks from the local rice mill. The same seasonal flooding in Kyar Kan Daung causes the gasifier to score low on location because of storage and siting issues.

Grid extension ranks fourth, with a score of 24, and mini-hydro last, with a score of 14. Without a suitable water source, mini-hydro is not a real alternative in Kyar Kan Daung.

Grid extension is cost-prohibitive due to the village's low income and small population. Although some support is likely to come from the Christian community, it is unlikely to be enough to make grid extension feasible. Furthermore, Kyar Kan Daung's economic base does not warrant the capacity increase grid extension would afford, at least in comparison to alternatives. Kyar Kan Daung also shares the same logistical, economic, and transportation challenges as Tha Yet Taw. The only category in which grid extension scores high is local/accessible knowhow. Situated outside Pathein city, Kyar Kan Daung can easily hire technicians from the city. Overall, grid extension is not an appropriate solution for Kyar Kan Daung.

Conclusions

Though Kyar Kan Daung’s economic profile is similar to that of neighboring Tha Yet Taw, the Team encountered many more households solely reliant on traditional forms of lighting, particularly kerosene and candles, and unable to afford solar-powered batteries. Mrs. Moe believes electrification for her village would be difficult because of cost constraints. Considering the prevalence of rudimentary forms of lighting and the lack of ability to pay 100 kyat per night night for electricity, the Team finds Mrs. Moe’s assessment to be more or less accurate.

Kyar Kan Daung’s communal cohesion is encouraging and the Team believes that with adequate funding, a plan for electrification would not be difficult to implement. With Esther Moe at the helm, the Team is optimistic about any village initiative. The only matter of concern is the ignorance of the importance of maintenance and proper usage of equipment. Educating villagers on these issues will be critical to successful and efficient electrification.

Recommendations

Mini-hydro and grid extension are immediately disqualified due to lack of a water source and cost constraints, respectively. The only way grid extension would be possible is if the government made extension to the area a priority.

The Team recommends expansion of solar home systems. Since Kyar Kan Daung has more households than Tha Yet Taw, solar would be more expensive, but the village is still small enough that economies of scale seen in larger villages are not yet that significant.

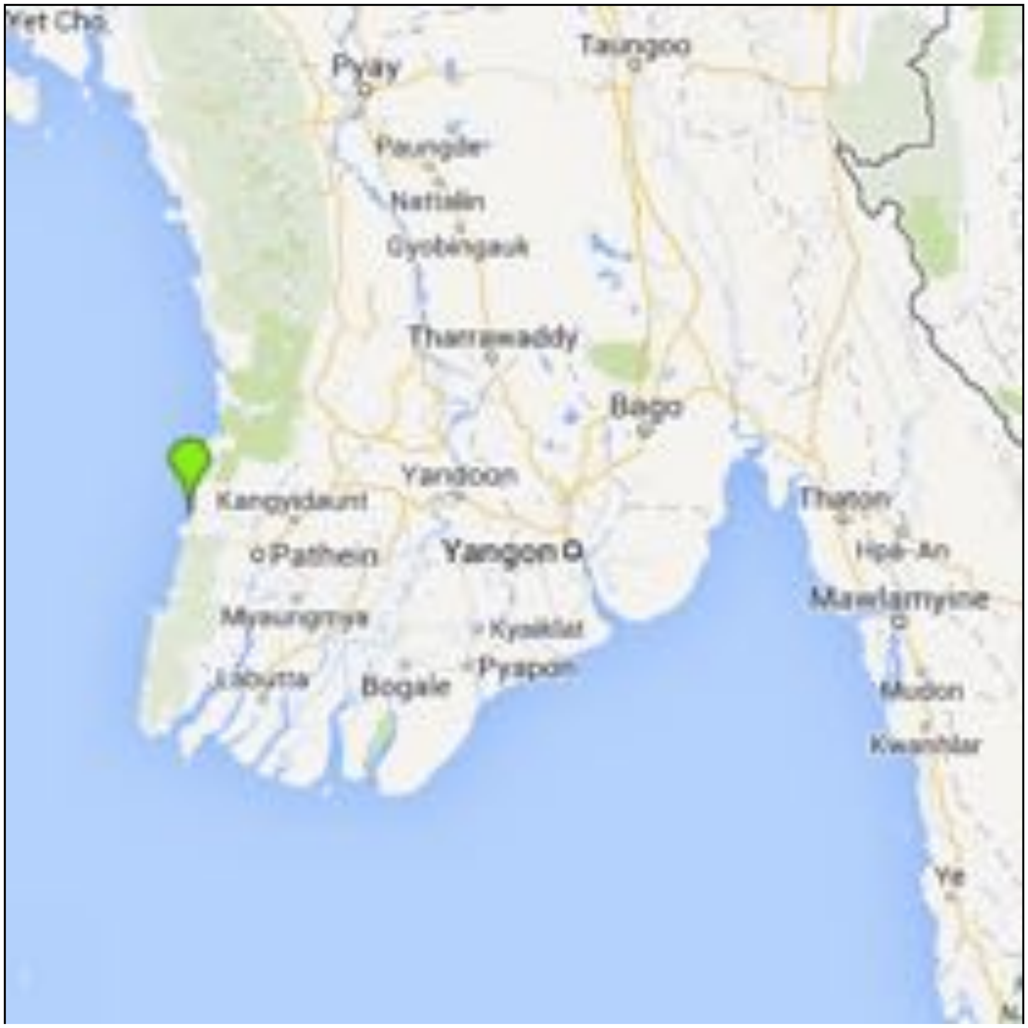
The difference between solar home systems and gasifier- and generator-based systems is nevertheless much greater here. The O&M expenses associated with gasifiers and generators would surpass the extra cost of installing solar home systems after about two years. This does not account for financing costs, which can be as high as 30% in microfinance markets.

While it is less apparent in the factor analysis, given that solar and gen-sets registered scores of 46 and 45, respectively, followed by gasifier (34), grid (24) and hydro (14), the O&M costs further strengthen the appeal of solar home systems. Moreover, solar home systems would provide twice the number of hours of electricity compared to generators. The overall technology assessment also supports solar, particularly due to its low resource costs and neutral environmental impact.

Interview List

- Esther Moe - Pastor's Wife
- Tapalase - Resident
- U Hin Kyaw - Resident
- Rowena - Resident
- Mary - Resident
- U Saw Mu Taw - Resident
- U Saw Kyay Lay - Resident
- Daw Tal Tar - Resident

Aung Mingalar Island: Fishing Village on the Verge of a Tourist Boon
Chaungthar Township



Population	~560
Number of Households	110
State/Division	Ayeyarwady
Township	Chaungthar
Distance from Grid	42 miles
Nearest City with Access to Grid	Pathein City
Coordinates	16.952974, 94.430096
Main Economy	Fishing
Recommended Electrification Strategy	Solar

Aung Mingalar	Percentage	Kilowatt	Demand (KW)
% Poor	85%	0.12	11.22
% Aspirant	15%	0.5	8.25
% Emerging	0%	1	0.00
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			19.47
Non- household demand - 1 monastery & 1 school			5.00
	Total Village Demand (KW)		**24.47**

Aung Mingalar Kyun village is located half a mile across the U To River channel from Chaungthar beach on Aung Mingalar Island. The approximately 60-acre island sits at the mouth of the U To River, on the Bay of Bengal. Aung Mingalar is mostly flat with a set of hills to the southwest. Aung Mingalar Kyun is the only village located on the island and is approximately 42 miles from Pathein City, the nearest access point to the grid.

Economic Profile

Aung Mingalar village has a fish-based economy. Approximately 70% of villagers own their own boat. For those who do not, villagers negotiate a means of access by which they pay a portion of their catch to the owner of the boat. As they are only able to fish six months out of the year, though not continuously, the villagers' source of income is seasonal. During the monsoon months it is especially difficult to fish due to heavy winds. In the months when weather is accommodating, it is reported that villagers are able to earn at least 100,000 kyat and as much as 600,000 kyat per month. When they are unable to work villagers do not engage in any other commercial activity and remain on the island.

Dried Fish

A few villagers supplement their income with small businesses. There are about ten modest shops—selling drinks, snacks and other small goods—set up outside of houses, as well as about five teashops. Many youth on the island work in hotels across the river at Chaungthar beach, though the older generation follows a more traditional lifestyle and relies on fishing and agriculture, which until now has served as the mainstay of the island's economy.

Nevertheless, of the villages the Team visited in the Ayeyarwady region, Aung Mingalar Island is expected to be the most likely to develop and improve within the next few years. Due to its proximity to Chaungthar beach, a popular tourist destination, Aung Mingalar Island is likely to benefit from Myanmar's growing tourism sector. At present, there are no formal tourist activities or guesthouses on the island, but interest is undoubtedly present. Villagers report tourists occasionally come across from Chaungthar to wander or sunbathe on the island's beach.

While the village itself has not taken any initiative to encourage tourism, others, described as wealthy businessmen from Yangon, have been buying hillside lands to build hotels. With tourism as the driver, Aung Mingalar Island is likely to see a more rapid increase in electrification compared to the other villages visited.

Electrification

Currently, a small generator electrifies about one third of the households on the island. U Zin Min Tun, the entrepreneurial village headman, believes electrification is easy for his village. He expressed a village preference for electrification through solar home systems or generators. Formerly a fisherman, Mr. Tun runs a small shop, in addition to providing electricity to 35 households, with his private 15 KW generator. Mr. Tun funded the household wiring and installation fees himself.

U Zin Min Tun's private generator

For their part, households pay according to usage. For electricity sufficient to power a two-foot fluorescent light for three and a half hours per night, households pay 100 kyat per day. For 300 kyat per day, households receive electricity sufficient to power both a light and a small television. Mr. Tun runs his generator from 6 P.M. to 9:30 P.M. every night.

While Mr. Tun believes electrification would be easy, transmission and distribution may be challenging due to the layout of the village. The monastery and schoolhouse—the two communal areas in the village—are at a distance from where most of the households are concentrated. If potential generation were to be sited in either area, distribution costs would increase.

Analysis

With the inevitable growth in tourism, electricity demand will change and increase. While hotels may and likely would have an ability to utilize and finance the development of captive power, other businesses and facilities catering to tourists will grow and likely draw on the village's power source. In any case, a comprehensive electrification plan is desirable but beyond the scope of the Team's analysis at present, given both the difficulties of forecasting growth in the tourism sector and ultimately to assess and finance the development of captive power to service this emerging demand. Therefore as with the other villages visited, the Team assessed demand projections based on current usage.

Estimated Cost Analysis

Village Name: Aung Mingalar								
Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	110	42	24	$79,677	$0	$50,642	$41,006	$1,557,581
O&M*	110	42	24	$240	$0	$9,402	$13,877	$7,717

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

Solar is one of two preferred electrification strategies. There are some home systems present and, similarly to other villages, batteries are charged and rented. Installing solar home systems for the entire village, including the monastery, school and streetlights, would cost approximately $79,677, or $724.34 per household. The cost per KW is $3,256.11. O&M expenses would add about $240 per year.

Mini-Hydro

Aung Mingalar is on a channel of the U To River but there are no smaller river sources on the island itself. Mini-hydro is not an option.

Biomass

Installation costs for a gasifier-based mini-grid system are estimated at approximately $50,642, or $461.32 per household. The cost per KW is $2,069.53. O&M costs would add roughly $9,402 a year.

Generator

The existing generator in Aung Mingalar is poorly installed, raising safety concerns. The Team assessed costs for a properly installed generator mini-grid system. Installation costs would be approximately $41,006 or $372.78 per household. The cost per KW is $1,675.77. O&M costs would add an estimated $13,877 per year.

Grid Extension

The Team's cost estimate of about $1,557,581, or $14,159.83 per household for grid extension, does not account for sub-sea cables that would be necessary for this village and is instead calculated as if this were a land connection. The cost per KW of $63,652.69 is very high due to the village's low demand.

Broader Factor Analysis

Aung Mingalar	Solar Home System	National Grid Extension	Hydro Mini-grid System	Gen-set Mini-grid System	Gasifier Mini-grid System
Cash/non-cash (1=totally insufficient, 10= totally adequate)	7.00	1.00	1.00	8.00	4.50
Population (1=totally insufficient, 10= totally adequate)	8.00	2.00	1.50	7.50	4.50
Location /Geography (1=totally unsuitable, 10= totally adequate)	8.00	1.00	1.00	7.00	3.00
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	1.00	1.00	6.00	4.00
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	6.50	6.50	2.50	6.50	5.50
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	3.00	1.00	7.50	5.00
Total	**45.50**	**14.50**	**8.00**	**42.50**	**26.50**

Average across 6 categories	7.58	2.42	1.33	7.08	4.42

In the broader factor analysis, solar ranks highest with a score of 45.5, although generator is not far behind with a score of 42.5. Aung Mingalar's population, resource availability and location favors solar slightly more than generators.

This is followed by a gasifier-based mini-grid which ranks third with a score of 26.5. Resource availability and location/geography are concerns as there are no rice husks on the island and it is prone to flooding during monsoon months.

Grid extension received a score of 14.5 and mini-hydro 8. Neither are feasible options due to cost, location and, in the case of mini-hydro, resource availability.

Once Chaungthar is connected to the grid, connection to Aung Mingalar Island may be possible, especially if tourism takes hold on the island. Nonetheless, the Team does not anticipate grid extension to happen any time soon, given the island's distance from the grid and the high costs of sub-sea connection, as well as the current level of economic activity on the island.

Conclusions

Unlike Kyar Kan Daung and Tha Yet Taw, Aung Mingalar Island has significant potential for growth. Its proximity to Chaungthar beach is likely to result in a shift from a fish-based economy to a more diverse and productive economy based on tourism that allows for commercial activities all year round instead of six months. The potential for growth necessitates a sustainable electrification method that will accommodate increased demand and allow for expansion of the power generation facilities. At the same time, however, lack of a developed tourism plan makes it difficult to evaluate potential demand with any measure of real specificity.

Recommendations

The Team recommends electrification by solar home systems. Mini-hydro and grid extension are impractical due, respectively, to lack of water source and the high costs associated with connecting a village located far from the grid and with a difficult physical geography. Installation of a sub-sea cables in particular would be extremely expensive.

Given the larger number of households, and the resultant expense for solar home systems, it would take almost three years for the maintenance costs associated with generators to bring the total cost of these systems up to that of solar. This does not include financing costs which could require almost another year if the village were not able to finance for themselves.

Nevertheless, while Aung Mingalar may require added financing costs, the factor analysis supports the use of solar. Additional advantages of solar home systems over a generator-based mini-grid are low resource costs, longer hours, and low environmental impact. In addition, transport costs for bringing diesel and other inputs onto the island, which are probably underestimated in this estimate, are minimized.

The Team also suggests consideration of a pilot project for anaerobic digestion based on animal waste. As many households in Aung Mingalar own pigs, organic waste could potentially be used in anaerobic digestion, although this technology is relatively unknown in Myanmar where biomass generally refers to use of rice husks. Therefore, while it should be possible to purchase feedstock off the island, a readily available and transportable fuel source for a gasifier is unknown.

If successful, however, anaerobic digestion could be expanded to accommodate organic waste generated from hotels and other associated tourist industries that will eventually develop. If successful, this platform could be utilized in other locations in Myanmar.

Interview List

- U Zin Min Tun - Village Head
- U Aung Aung - Resident
- U Nyi Pu - Resident
- Ko Kyaw Shwe - Resident

U To: Public-Private Cooperation and Being in Right Place at Right Time
Chaungthar Township

Population	~500
Number of Households	120
State/Division	Ayeyarwady
Township	Chaungthar
Distance from Grid	37 miles
Nearest City with Access to Grid	Pathein City
Coordinates	16.958711, 94.4764
Main Economy	Fishing and farming
Recommended Electrification Strategy	Generator/Solar

U To	Percentage	Kilowatt	Demand (KW)
% Poor	80%	0.12	11.52
% Aspirant	15%	0.5	9.00
% Emerging	5%	1	6.00
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			26.52
Non- household demand - 1 monastery, 1 school & 1 clinic			5.50
	Total Village Demand (KW)		**32.02**

U To is a fishing village on U To River. Situated at the major bridge crossing and entry point toward Chaungthar beach, it is four miles from this increasingly popular tourist destination and 37 miles from Pathein, the nearest grid connection.

Economic Profile

According to the village headman, U Thein Win, 70% of villagers work as fishermen, while 30% engage in small farming. This consists of cultivating rice, vegetables and fruits. The fishermen, however, only work fourteen days out of the month due to variance in the U To River's water levels. They sell their catch at the Chaungthar market. Like the fishermen on Aung Mingalar Island, they do not engage in any other commercial activities when conditions are not to their favor.

The Team also noticed a few small stores on the main road selling cold drinks and snacks. Shop owners likely profit from the flow of traffic on the road toward Chaungthar. Average incomes are reported to range between 60,000 kyat and 100,000 kyat per month, though living conditions in U To appear somewhat higher than in other Delta villages visited.

Electrification

Similar to the island village, U To has a diesel generator providing electricity. In October of 2013, U To received a 15 KVA high-speed diesel generator from the Chaungthar administration to provide lighting for the bridge. They are able to utilize the leftover power in return for providing necessary diesel and maintenance. This allows U To to provide electricity to its 120 households for four hours per night, from 6 P.M to 10 P.M without having to organize or finance the generator purchase. Additionally, the generator powers 30 streetlights.

U To's generator gifted by the Chaungthar administration

As in other villages, households pay according to their usage: 100 kyat per day for lighting, and 200 kyat per day for lighting and television. The charges essentially cover diesel costs. At 2 gallons per day, fuel costs run between 8,000 kyat and 10,000 kyat per day. Out of 120 households, only 90 contribute to fuel costs. The village head does not collect from the elderly or those unable to pay. As a result, the village roughly generates revenues necessary to cover their costs, not accounting for any necessary depreciation or maintenance.

Of the villages surveyed in the Delta region, U To demonstrated the most initiative in improving quality of life for the entire village. Electricity aside, U To also has plans to build a health clinic in the near future. Granted their electricity access comes at least in part by virtue of being located next to a bridge, generally the Team found U To’s communal unity to be a considerable asset. Their demonstrated resourcefulness indicates the potential for future public-private cooperation in electrification and other areas.

In addition to the electricity provided by the generator, many households also use solar-powered batteries as an auxiliary power source. U Myo Htike and his wife have made a small business of renting solar-powered batteries. He and his family own three 300 W solar panels, two of which he uses for his solar battery business and one for his own household use. The small 6-volt batteries cost 100 kyat per day, while the larger 12-volt batteries cost 500 kyat per four-day use. The smaller batteries are used to power small light bulbs while the larger batteries are used for lighting and entertainment.

It was reported that U Myo Htike and his wife rent about 70 batteries per day combined. This is a substantial amount for a village of this size, with only about 120 households, in which most households already have a generator connection. The desire for this auxiliary power source suggests that the village's electricity demand is likely to grow.

U Myo Htike's wife preparing batteries for rent

Analysis

According to U Thein Win, the preferred electrification strategy would be mini-hydro. There is a stream that runs off of the U To River four to five miles away from the village. However, without a civil engineering study, the Team could not accurately assess whether mini-hydro is actually feasible. Hydro has not been a widely used technology in this area and the village in and of itself is not optimal for a dedicated hydro facility. However, considering the way U To has been able to capitalize on the generator provided by the Chaungthar administration, it is reasonable to believe that the village would be able to organize and facilitate more advanced electrification efforts through alternative technologies in the future.

Estimated Cost Analysis

Village Name: U To								
Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	120	37	32	$98,026	$0	$51,392	$41,756	$1,381752
O&M*	120	37	32	$260	$0	$11,295	$17,662	$10,256

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

Solar-powered batteries are prevalent in the village but solar home systems are not. To install solar home units for all households, the school, monastery, streetlights and future clinic would cost approximately $98,026, or $724.34 per household. The cost per KW is $3,061.40. O&M expenses would add an estimated $260 per year.

Mini-Hydro

An off-stream of the U To River is four miles away. However, actual feasibility for mini-hydro is unknown without a thorough civil engineering study. Therefore, the Team does not consider this to be an option.

Biomass

Installation cost for a gasifier-based mini-grid system is approximately $51,392, or $429.13 per household. The cost per KW is $1,604.98. Annual O&M expenses are estimated at $11,172.

Generator

The high-speed diesel generator currently used is relatively new. The Team finds switchgear and installation to be satisfactory. However, there is no scheduled maintenance for this generator. The Team estimates the village will need a larger generator system in the future to fill village needs as the current capacity is only 15 KW and current demand, according to interviews conducted by the team, is already 32 KW. For a 40 KW system, installation costs are estimated to be $41,756, or $347.97 per household. Though this low compared to other technologies, O&M expenses add an estimated $17,417 per year. The cost per KW is $1,304.06.

Grid Extension

Installation costs for grid extension are estimated to be $1,381,752, or $11,514.60 per household. The cost per KW is $43,152.78. Annual O&M expenses are expected to be $10,092. U To is far from Pathein and the road from Pathein to U To runs through a particularly hilly region. The aforementioned figures assume a simple distribution system without these complications, but the Team expects actual transmission and distribution costs will be inflated by topographic challenges.

Broader Factor Analysis

U To	Solar Home System	National Grid Extension	Hydro Mini grid system	Gen-set Mini grid system	Gasifier Mini grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	7.00	4.00	3.00	8.00	6.00

Population (1=totally insufficient, 10= totally adequate)	8.00	2.50	2.50	8.00	5.00
Location /Geography (1=totally unsuitable, 10= totally adequate)	7.50	3.00	2.00	8.00	4.00
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	1.00	2.50	6.50	3.50
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	6.50	7.00	1.50	8.00	3.50
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	7.00	4.00	8.00	5.00
Total	**45.00**	**24.50**	**15.50**	**46.50**	**27.00**
Average across 6 categories	7.50	4.08	2.58	7.75	4.50

Generators rank first with a score of 46.5, followed by solar (45), though differences are marginal. Both technologies are well suited to the village's population, location and relatively low demand.

Gasifier ranks third with a score of 27, followed by grid (24.5) and mini-hydro (15.5). Low resource availability and the village's lack of interest in a gasifier system make the technology less favorable.

As expected, grid extension ranks low because of high costs. Extending the grid from Pathein will require building transmission lines through a hilly region, which further increases costs. Though villagers mentioned mini-hydro as a possibility, the Team believes further surveys would be needed before determining its viability. As a result, it ranks last.

Conclusions

U To demonstrates reasonably strong leadership and enterprise. This, in addition to the village's geographic advantages, provides a strong basis for future public-private partnerships. Of the villages visited by the Team, U To appears to be the least isolated. Though Aung Mingalar Island will likely benefit from the extension of tourism from Chaungthar, U To also stands to benefit from the increasing exposure it will have to tourists heading toward Chaungthar.

Recommendations

The Team would not consider mini-hydro and grid extension. Biomass is not readily available, eliminating gasifier as an option as well. There is a possibility for anaerobic digestion with organic waste. However, for the time being, villagers do not undertake any fish processing in the village. If that changes, anaerobic digestion might be considered.

Ultimately, the Team recommends a generator system with the use of solar as an auxiliary source. Village factor analysis shows similar numbers for both solar and generators, though generators rate higher which only happened in one other village visited. Additionally, U To has the benefit of having had its generator donated to them by local government authorities, who would presumably also cooperate in an upgrade. This would serve to further differentiate between the already significant cost differences between the installation of a solar or generator platform.

Further, U To possesses more than 100 households, the level at which scale starts to deliver more cost efficiencies for generators and other micro-grid platforms. O&M costs for a generator, at an estimated $17,417, would take approximately three and a half years to bring the total cost of generator use up to that of solar home systems. This is in addition to financing costs which, as noted previously, could be as high as 30% in the case of microfinance, if such an option were available.

Solar home systems are, however, generally more favorable as a technology because of the ease of installation, low resource cost and low environmental impact. Moreover, using solar would allow for twice the number hours of electricity.

In addition, as the present generator was installed less than a year ago and already seems inadequate for current, not to mention future, demand, solar can also potentially play an important role in U To, as it does elsewhere, as an auxiliary electricity source. One can see that already happening given the high number of villagers charging batteries on a daily basis using the solar panels that U Myo Htike has installed.

Interview List

- U Thein Win Village Head
- U Hla Than - Resident
- U Tin Oo - Resident
- U Myo Htike - Owner of solar battery-charging business
- U Myo Htike's wife

Mezali: Primed for Gasification
Nyaungdon Township

Population	~300
Number of Households	94
State/Division	Ayeyarwady
Township	Nyaungdon
Distance from Grid	7 miles
Nearest City with Access to Grid	Sarmaluck
Coordinates	16.944, 95.795
Main Economy	Daily Laborers
Recommended Electrification Strategy	Gasifier or Grid Extension

Mezali	Percentage	Kilowatt	Demand (KW)
% Poor	11%	0.12	1.24
% Aspirant	42%	0.5	19.74
% Emerging	47%	1	44.18
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			65.16
Non- household demand - 1monastery & 1 school			5.00
	Total Village Demand (KW)		**70.16**

Mezali is located in the Ayeyarwady division in the Nyaungdon district and township. The village lies within the Mezali village tract. The tract, composed of eight villages, has an aggregate population of between 3,000 and 5,000 people.

The Myanmar Engineering Society (MES) facilitated the Team's visit to the village. Retired Colonel U Thoung Win, a mechanical engineer, who specializes in bio-fuels, and who serves as chairman of MES's Energy and Renewable Energy Committee, accompanied the Team on this visit.

Economic Profile

Of the villages visited in the Ayeyarwady division, Mezali is the first in which the Team encountered small industry. Situated by the main road is the Ne La Rice Mill, owned by U Ye Kyaw Htut. There are 12 other rice mills in the surrounding areas. The Ne La mill has two sets of milling equipment and two gasifiers powering the machinery. An in-depth review of the rice mill is included below.

Households in Mezali are concentrated about a mile from the rice mill. Within the village, there are three main streets, a local monastery and small schoolhouse. Houses within the village vary more significantly than other sites that were visited and range from poorly thatched bamboo huts built on wooden stilts to modest wooden houses with concrete bases. Along the road toward the main village area are sturdy concrete houses of considerable comfort. One such house belongs to the village head. These households belong to the village's top income bracket, estimated to include about 2% of the village population.

For the village assessment the Team spoke with U Thein Myint, a member of the local Village Electrification Committee (VEC). According to U Thein Myint, the village can more or less be broken down into four income categories: very poor, low income, middle and top. He estimates the village is mostly low and middle income with the remaining falling into the top or very poor categories. Most villagers are day laborers who work at nearby plantations and reportedly earn 3,000 kyat per day. Skilled workers are reportedly able to earn 5,000 kyat a day. Some of the villagers work at the local rice mill.

Electrification

Like U To, Mezali also has a local generator. The VEC presides over the generator. Donated by UNICEF four years ago, the 10 KVA generator provides power to 90 consumer units, including the monastery. The few households that fall into the very poor category do not receive power.

Electricity is provided from 6:30 P.M. to 9:30 P.M. each night. For those three hours, the generator requires two gallons of diesel. In Mezali, electricity payments are broken down into three categories: 100 kyat for lighting only; 150 kyat for use of a television and DVD player; and 200 kyat for lighting, television and a DVD player. Some households own solar panels.

Mezali's version of a streetlight - a fluorescent bulb housed in a plastic bottle

Altogether, the VEC collects 8,500 kyat per day in fees. Diesel expenses run at 7,000 kyat per day. The remaining 1,500 kyat in revenue is used to pay for a local operator and maintenance. The local operator earns 36,000 kyat per month and maintains the generator, however, like most operators in Myanmar he has not had any specialized maintenance training.

The local operator

Gasification at Ne La Rice Mill

Colonel U Thoung Win arranged for the Team to evaluate Ne La Rice Mill's Myanmar-made gasifiers. During the Team's visit, only one of the gasifiers, and accordingly only one of the two mills, was in operation. The Team was able to get an up-close look at the gasifier in the suspended mill. The following report focuses on the suspended gasifier undergoing maintenance.

With Colonel U Thoung Win and Ne La Rice Mill owner U Ye Kyaw Htut

The Ne La Rice Mill has been in operation since 2003. The mill has a capacity of 1,200 baskets of rice per day and operates from 7 A.M. to 6 P.M. Farmers deliver paddy to the rice mill themselves for processing. For every basket of green paddy, U Ye Kyaw Htut charges 200 kyat. (A basket of rice is approximately 49 kg, or 108 lbs.) He sells 50 kg bags of broken or finished rice for 700 kyat each. Broken rice can be used for animal feed. Finished rice can either be eaten or sold.

The former truck engine modified for gasifier use

A 350 horsepower (HP) (261 KW) gasifier unit powers the milling machinery. The gasifier uses rice husks as a feedstock, requiring 16 bushels of rice husk per hour. The gas produced runs through an 8-cylinder generator engine and produces enough electricity to power the mill throughout the day. Altogether, the initial capital investment for the mill was 177.5 million kyat:

17.5 million kyat for the gasifier unit; 50 million kyat for the building; and 80 million kyat for the rice milling machinery. The cost of the gasifier unit includes a 5 million kyat modification, which upgraded the original 6-cylinder engine to an 8-cylinder, 350 HP engine.

The gasifier unit is, in Colonel U Thoung Win's words, of crude, older, mostly Indian technology. The gasifier uses a large truck engine outfitted for gasification. (To be suitable for use as a gasifier generator, the pistons of truck engines are cut and compression ratios are changed.) Colonel U Thoung Win noted that if the gasifier had been built with an engine made specifically for gas production, it would run much more efficiently.

The suspended gasifier

Every four to six months the mill shuts down for scheduled maintenance on the gasifier engine. U Ye Kyaw Htut was trained during the installation of the gasifier and performs the engine upkeep himself. Engine maintenance takes approximately three days. For the mill itself, maintenance is performed every six months and one head cleaning is performed every year. During the time of the Team's visit, the gasifier was in need of a part replacement and U Ye Kyaw Htut was awaiting the finished product from the casting shop in Hlaing Thar Yar.

The broken part used to sit at the base of the furnace

Though the technology is “crude,” the gasifier has managed to power the Ne La Rice Mill for more than a decade. There is, however, one major concern: the gasifier uses a considerable amount of water to cool down the gas. The water, which comes into direct contact with the gas, is then released into the environment without treatment. The Team was able to witness this process at U Ye Kyaw Htut’s other gasifier.

The other gasifier at Ne La Rice mill

Wastewater discharged from the running gasifier

The contaminated water from the above flows directly into the local creek. Though Mezali villagers do not use the creek water, it is likely the polluted wastewater will seep into groundwater. Additionally, the wastewater is highly acidic and is believed to have a pH level of 3. Further, it is estimated that installation of a water treatment component could increase costs by 20% to 30%.

As with most villages in Myanmar, the poor installation of distribution lines in Mezali results in significant electricity losses. During the course of the Team's interview with U Thein Myint about village electricity demand, it was estimated that households paying 200 kyat a day for electricity use approximately 300 W. Altogether, that means the village likely consumes only about 3 KW. Mr. Myint stated, however, that the system is overtaxed and that the generator does not provide sufficient electricity.

As the generator's real output is about 8 KW, the village is experiencing about 5 KW in distribution losses. Proper installation of lines and streetlights could result in a 20% to 30% increase in efficiency.

Analysis

When the village finally received electricity access four years ago, according to a woman the Team interviewed, villagers were jumping for joy. Having been informed of their distribution losses, it remains to be seen whether or not the village will now invest in proper installation. With time, given the diverse income levels, demand load will increase. Granted the higher-income households probably own their own gen-sets, as middle income households drawing from the village generator begin wanting more than three hours of electricity per night, it may incentivize the village to improve its distribution network.

Lastly, the visit to Mezali was notable due to the existence of a VEC, which suggests it is a fairly well organized community and is a promising indicator that future electrification initiatives will have functioning leadership to coordinate and implement.

Estimated Cost Analysis

Village Name: Mezali								
Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	94	7	70	$182,618	$0	$77,839	$58,569	$314,846
O&M*	94	7	70	$220	$0	$20,143	$35,359	$22,126

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

A few households supplement the generator-provided electricity with their own solar home systems. Electrification through solar home systems for all households, the monastery, school and 15 solar lighting systems would cost approximately $182,618, or $1,942.75 per household. Solar is more expensive due to the village's higher demand. The cost per KW is $2,602.85. Annual O&M expenses would be approximately $220.

Mini-hydro

There is no river within the vicinity of the village, only the creek. Though its levels are sure to rise during monsoon months, the creek had very little water when the Team visited. Further, villagers have noted that many creeks have been drying up. Mini-hydro is therefore not a feasible option.

Biomass

Installing a gasifier-based mini-grid in Mezali would cost approximately $77,839, or $829.19 per household. The cost per KW is $1,109.44. Annual O&M expenses would be roughly $20,143.

Generator

The Team estimates that the cost to install a generator-based mini-grid system with a proper distribution system would be approximately $58,569, or $623.07 per household. The cost per KW is $834.78. Though a generator system would have the lowest installation cost, annual O&M expenses are expected to be about $35,359.

Grid Extension

The installation cost associated with grid extension is estimated at $314,846, or $3,349.42 per household. That number could be reduced, however, if Mezali was able to join with other villages in the area. The cost per KW is $4,487.49. Annual O&M expenses are expected to be about $22,126.

Broader Factor Analysis

Mezali	Solar Home System	National Grid Extension	Hydro Mini- grid system	Gen-set Mini-grid system	Gasifier Mini-grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	7.00	3.50	1.50	6.50	6.50
Population (1=totally insufficient, 10= totally adequate)	9.00	7.00	4.00	7.50	6.50
Location /Geography (1=totally unsuitable, 10= totally adequate)	7.50	6.00	1.00	7.50	7.50

Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	5.50	1.50	7.00	8.50
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	7.00	6.50	3.00	8.00	8.50
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	5.50	3.00	8.00	8.00
Total	**46.50**	**34.00**	**14.00**	**44.50**	**45.50**
Average across 6 categories	7.75	5.67	2.33	7.42	7.58

Similar to many other villages, solar and generator scored nearly the same for Mezali. Gasifier also scored high for this village and in fact ranked second with a score of 45.5 after solar (46.5). Generator is third with a score of 44.5, followed by grid extension (34) and mini-hydro at (14).

While solar would generally prove favorable in a village of Mezali’s size, given its fairly small population, Mezali's higher income and demand requirements make solar a more expensive option. Gasifier is actually more favorable in this village because of the abundance of fuel supply. Technical knowhow scores well because there are many gasifiers in operation in this locale. Environmental factors, however, are a real concern.

Grid extension ranks fourth because of high costs. However, in light of the sizable population of the Mezali village tract and its proximity to the grid, grid extension is a potentially viable option if Mezali can join together with other villages in the area. Though Mezali village proper is not on the main road, it is relatively easy to access and only seven miles from the national grid.

Mini-hydro is not an option due to a lack of water source.

According to the factor analysis, Mezali can presumably have its pick of four out of five alternatives. Once cost is factored in, however, the number of viable options diminishes.

Conclusions

The existence of value-added production distinguishes Mezali village from the other villages visited in the Ayeyarwady region. Furthermore, as compared to the other villages, Mezali also demonstrates a greater range of income levels as evidenced by the three-tiered payment categories and varying levels of housing structures. Village electricity demand will be difficult to predict but will undoubtedly grow. Though U Ye Kyaw Htut appears satisfied with his captive power generation and rice mill operations, he could potentially expand his line of business to include power generation and distribution for the entire village. His gasifiers as they are now, however, would not be an appropriate source of generation given the environmental impact.

Recommendations

Mini-hydro is definitely not an option. Solar is suitable but too expensive. The relative cost benefits to solar decline with a larger population as well as higher household demand such as is seen in Mezali. A generator could work as well but O&M costs are high.

Of all the villages visited, biomass has the greatest potential in Mezali. When asked why he did not provide electricity to the village with his gasifier, U Ye Kyaw Htut explained that it was because his gasifier operated during the day, while the village primarily required electricity at night. Furthermore, the gasifiers at his rice mill are at a distance from the village. Nevertheless, with the existing rice mill and ready availability of rice husks, Mezali is primed for gasification-based electrification.

The Team recommends rice-husk based gasification as an interim solution given the combination of available fuel and environmentally conscious facilities, which is priced into the Team’s cost estimate. The only reservation the Team has with gasification is the need for government oversight on environmental impacts, which at present is non-existent. There is a chance that the water treatment systems included in the Team’s gasifier costs, if installed in Mezali, would not be well maintained.

The Team also believes, however, that Mezali village has a strong case for grid extension, despite the factor analysis ranking it fourth with a score of 34. In the first four villages surveyed, demand was low. Here in Mezali, demand is higher and as part of a larger village tract, there is a chance of organizing neighboring villages to contribute to the amortization of costs even if the government does not make this area a priority in terms of grid extension.

Further, the presence of industry within the village tract indicates that there would be a demand base outside of household demand. Grid extension would be the ideal option because, as seen in the technology assessment, its sustainability and ease of capacity growth makes it the long-term goal. As a result it was included as a second recommended electrification strategy.

Interview List

- Colonel U Thoung Win
- U Ye Kyaw Htut - Owner of Ne La rice mill

- U Thein Myint - VEC member

Za Di Ya Ward: The Case for Grid Extension
Kyaukpyu Township

Population	Approximately 2,000
Number of Households	520
State/Division	Rakhine
Township	Kyaukpyu
Distance from Grid	2 miles
Nearest City with Access to Grid	Kyaukpyu City
Coordinates	19.429, 93.514
Main Economy	Fishing and farming
Recommended Electrification Strategy	Grid

Za Di Ya	Percentage	Kilowatt	Demand (KW)
% Poor	23%	0.12	14.35
% Aspirant	58%	0.5	150.80
% Emerging	19%	1	98.80
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			263.95
Non- household demand- 1 monastery & 1 school			5.00
	Total Village Demand (KW)		**268.95**

Za Di Ya ward is administratively part of the Kyaukpyu town area. It is two miles from Kyaukpyu city and three miles from Gon Chein Ward. With a population of nearly 2,000, the ward is large compared with other villages visited by the Team. It has been a clear beneficiary of a grid extension initiative in Kyaukpyu.

With Za Di Ya residents

Economic profile

The local economy includes fishing, agriculture and livestock. Income levels vary in Za Di Ya but average between 80,000 kyat and 90,000 kyat per month.

According to U Hla Aung, the head of the local administration, the ward's income profiles can be classified into three categories. At the top are the merchants and traders, which includes about 100 households involved in importing that are well established in the fish industry. A handful of households within this category have made a profit selling their land amidst rising property prices due to anticipated development of the nearby Kyaukpyu SEZ. It should be noted, however, that while these households are cash rich at the moment, the money made from selling land is not sustainable income and is being rapidly depleted. This tenuous situation has led to a sense of social dislocation and other tensions among the community, which are likely to grow over time.

In the middle income bracket are farmers who own one or two acres of land and sell their harvests for local consumption. Estimated at about 300 households, this group accounts for most residents.

Finally, those considered to be poor are mainly day laborers and fishermen who live and work on a subsistence basis. There are approximately 120 households that fall into this category.

Local business consists primarily of a few small shops—selling drinks, snacks and other small goods—operated out of houses. Small industry also exists and includes a water purification and bottling factory, ASM, which was recently established in November, owing in part to reduced electricity prices.

Although U Hla Aung anticipates that the development of the Kyaukpyu SEZ may generate employment and business for the town, he revealed that many youth, unsatisfied with the lack of local employment opportunities, have left to find work in Yangon or abroad in Thailand and Malaysia. Employment opportunities aside, a dearth of skilled labor, in addition to a lack of properly certified laborers, has been a challenge to local employers.

Distribution lines along the main road in Za Di Ya

In interviewing Za Di Ya's residents, the Team met with one young man who worked at a local bank in Kyaukpyu City. He revealed that he was the only one among his friends with a job. With no local universities or work, these young men sit idle. Indeed, a number of them sat on the sidelines and curiously watched as the Team interviewed residents.

Electrification

Za Di Ya is currently receiving 24-hour electricity from the Kyaukpyu gas-powered mini-grid. Electricity costs are now 35 kyat per unit, the same subsidized tariff rate as in other parts of Myanmar that are supplied by the national grid. In the past, the local Electricity Supply Enterprise (ESE) office supplied diesel generated power, for 500 kyat per unit, which was only available four hours per day between 6 P.M and 10 P.M. Electricity bills reportedly ran between 4,000 kyat and 5,000 kyat per month.

According to U Hla Aung, over half of the households in the ward are electrified, including all houses along the main road (toward Kyaukpyu City), where the distribution line runs. U Hla Aung expects another 150 households will gain electricity access within the next year. The remaining households will be unable to connect to the grid due to either affordability or accessibility constraints. Households must be located within 100 yards of the main distribution line in order to connect.

Twenty-four-hour electricity access at 35 kyat per unit has had a very positive impact on many Za Di Ya residents. Living standards in Za Di Ya are increasing and villagers are buying more appliances such as fans, rice cookers and refrigerators. The electricity has also facilitated activities such as studying and entertainment.

The affordable electricity has also increased commercial activity. U Aung San Myint, who owns an ice-making factory as well as ASM, the water purification and bottling factory, made the decision to expand into the water bottling business because of the consistent and low-cost supply of electricity. Since beginning his business, U Aung San Myint has expanded water bottle distribution outside of Kyaukpyu throughout Rakhine state and plans to grow distribution of his product throughout the country.

Meanwhile, small shops are able to keep longer hours, chicken farms can easily incubate eggs without the additional costs of diesel-generated power and large farms can irrigate lands as needed with an electric-motored water pump.

Moreover, according to one resident who recently returned from Yangon, blackouts in Kyaukpyu are less frequent than in the big city.

Za Di Ya is a rare example of an isolated off-grid area where the government has enacted a measure to establish a mini-grid and provide electricity instead of waiting until the national grid was within reach of the area. Residents of Za Di Ya have only had to pay for their household connection fees; Daewoo International, a South Korean company involved in the construction of a gas terminal and pipeline in the region, financed the costs of building the grid. If not for the gas-generated electricity, the expensive diesel mini-grid system would have remained until the national grid reaches Za Di Ya, on its way to connect to Kyaukpyu City, which is anticipated at the end of 2014.

The exorbitant costs of grid access are typically a significant obstacle for rural areas where income is generally low. Elsewhere in Myanmar, even if a village or town has the financing for grid extension, it must first comply with 24 conditions as per EPC policy. Za Di Ya has been in a privileged position of not having to deal with the onerous conditions and the need to incur heavy up-front costs. While this increases the risk for the MOEP, as a general policy it would allow for more of the population to access low-cost electricity.

Analysis

Za Di Ya Ward has been a fortunate beneficiary of the Presidential directive to electrify and provide electricity at the subsidized tariff rate in Kyaukpyu. The ward is a relatively poor part of Myanmar where residents earn less than 100,000 kyat per month. Without the government mandate, Za Di Ya's residents would not have been able to finance the costs of grid connection on their own, given that it would require organizing themselves to meet the 24 conditions and the costs of financing the entire extension as a group rather than the current practice of allowing individual connections.
Other towns and villages that are not situated near an SEZ are not as lucky. Neither are households located beyond the 100-yard margin of the distribution network. It remains to be seen if and how the policy may be altered to incorporate more households into the grid. However, given reports that funding for the transmission and distribution network came from Daewoo International, EPC and MOEP may not have sufficient funding, or immediate impetus, to adopt a more inclusive policy.

Nevertheless, Za Di Ya is a successful example of grid extension and is demonstrative of the significance of electrification by means of a formalized grid. The accessibility of affordable electricity has increased living standards and stimulated the local economy. The situation here does raise concerns, however, that new commercial activity may not develop at a fast enough pace, or in a broad enough manner, to compensate when the capital gained on property sales runs dry. There are also concerns that tensions may increase between those with access to regular, affordable electricity and those who are still left paying more than 400 kyat per unit. Previously, local residents were angered over price discrepancies between Rakhine state and Myanmar's major cities. The recent electrification initiatives in Rakhine, while well intentioned and responsible for significant social and economic improvements in the area, may, over the short-term, bring this inequality closer to home and fuel more tension moving forward.

Estimated Cost Analysis

Village Name: Za Di Ya								
Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	520	2	269	$708,798	$0	$220,130	$177,430	$54,167
O&M*	520	2	269	$1,090	$0	$66,874	$128,821	$84,817

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

The Team estimates it will cost approximately $708,798 to power all households, the monastery, school and 20 streetlights. This comes out to $1,363.07 per household. Among the technology options, for Za Di Ya solar home systems cost the most at approximately $2,635.41 per KW. Additional O&M costs would come out to about $1,090 a year.

Mini-hydro

The are no rivers or waterways close to the town, only the sea. Mini-hydro is therefore not an option.

Biomass

Establishing a gasifier-based mini-grid would cost approximately $220,130, or $423.33 per household. Cost per KW is the second highest at $818.47. Annual O&M expenses are approximately $66,874. Fuel source and supply, however, is unknown and would need to be secured.

Generator

A generator-based mini-grid would cost approximately $177,430, or $423.53 per household. Cost per KW is moderately lower than the gasifier at $659.71. Additionally, annual O&M expenses would be about $128,821.

Grid Extension

Assuming the Kyaukpyu natural gas-based mini-grid had not been extended to Za Di Ya, the residents of Za Di Ya would have had to pay approximately $260,152 to connect to the national grid. Accounting for the mini-grid, the cost of extending connection to the Za Di Ya households that as yet have been unable to connect or which are located beyond the 100-yard limit is estimated at $54,167 or $208 per household. The cost per KW is the lowest at $201.40.

Broader Factor Analysis

Za Di Ya	Solar Home System	National Grid Extension	Hydro Mini grid system	Gen-set Mini grid system	Gasifier Mini grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	6.50	8.50	1.50	6.50	4.50
Population (1=totally insufficient, 10= totally adequate)	8.00	9.00	3.50	7.50	7.50
Location /Geography (1=totally unsuitable, 10= totally adequate)	7.50	8.50	1.00	7.50	5.50
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	8.50	1.50	7.00	3.50
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	7.00	8.50	2.00	8.00	4.50
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	9.00	5.50	8.00	6.00
Total	**45.00**	**52.00**	**15.00**	**44.50**	**31.50**
Average across 6 categories	7.50	8.67	2.50	7.42	5.25

Grid extension ranked the highest with a score of 52. Since the distribution network already exists, there are no concerns of a long lead-time or high capital costs, which often make grid extension less favorable to other options. Furthermore, as seen in the technology analysis, grid extension is also the most sustainable option as grid infrastructure is built to last for decades.

The cost of connecting to the grid is comparatively low. As a result, under the first category of cash/non-cash, among the all the places visited, Za Di Ya has the highest score for grid extension at 8.5. Za Di Ya's large population and location are also well suited to grid extension.

Solar home systems and a gen-set mini-grid follow with scores of 45 and 44.5, respectively. With respect to Za Di Ya, both technologies received similar ratings in each of the six categories. Since Za Di Ya is close to Kyaukpyu City, there are no issues of fuel supply or lack of local/accessible knowhow and therefore no significant contrasts in scores. Both technologies score high in cohesion because previous use of generators in the town demonstrates the town's ability to organize such a measure and cohesion is not necessary for solar home systems. However, it should be noted that Za Di Ya's relatively high demand and large population make the use of solar home systems very expensive.

As for a gasifier-based system and mini-hydro, cash and resource availability concerns cause both to be rated lower. Hydro came in with the lowest score (15). Aside from a lack of river source for mini-hydro power, Za Di Ya's villagers, with modest average income levels, would not be able to afford the cost of a hydro system capable of meeting the village's energy demands.

Overall, there is a strong case for grid extension in Za Di Ya.

Conclusions

Za Di Ya has experienced eight months with affordable 24-hour electricity. This has resulted in increased living standards and productivity, and the creation of small and medium-sized enterprises. The town is an excellent example of an electrification initiative resulting in economic and social development. The town's energy demand will inevitably grow as more households connect and appliance use increases. The development of the SEZ will add to this by creating opportunities for services, manufacturing and construction.

Nevertheless, unlike other villages in Myanmar, Za Di Ya's residents did not finance the overall electrification effort. Households merely paid a connection fee, a fraction of the costs it took to install the cables, lines and transformers. Furthermore, there are still more than 100 households in Za Di Ya that will be unable to access the grid, not to mention the large number of households, towns and villages that lie outside the 100-yard zone. The Presidential initiative to allocate gas to Kyaukpyu and install gas generators was largely a move to show residents they would benefit from the creation of the SEZ. While the government may have mitigated tensions, the exclusion of residents living beyond the 100–yard zone may lead to strained relations within the community in the future.

Going forward, if the government plans to introduce another mini-grid ahead of extension of the national grid, it should be as inclusive as possible of all residents in a given area and where this is not possible steps taken to address the concerns of those who will be connected over the longer term, possibly through off-grid technologies.

At the same time, however, it will not be possible to include all areas of Rakhine, so auxiliary solutions such as the use of solar or generators is also important as an interim solution.

Recommendations

For residents without electricity, grid extension is the obvious choice. Za Di Ya demonstrates that if costs are born by the government, or a company that operates in the area, grid extension becomes a more viable option. In Za Di Ya this is true not only because of the total investment required but also as the EPC allows individual connection, rather than requiring the entire community to join together to raise the required capital and meet the 24 conditions necessary for grid connection.

If Za Di Ya had not been in this unique situation, it would have had to rely on generators as they did before, when electricity was only available for a few hours a night and was very expensive. For the most part, at that time only businesses and high-income households were able to afford using electricity. Small-scale use of auxiliary solar home units would be the only other alternative, unless a stable fuel source and supply was secured for gasifiers.

At present, estimated demand is relatively low in Za Di Ya but with reliable availability of low-cost electricity, residents have steadily increased their load and economic activity and entrepreneurship has begun to emerge. This typical increase shows the need to plan for the future rather than existing demand.

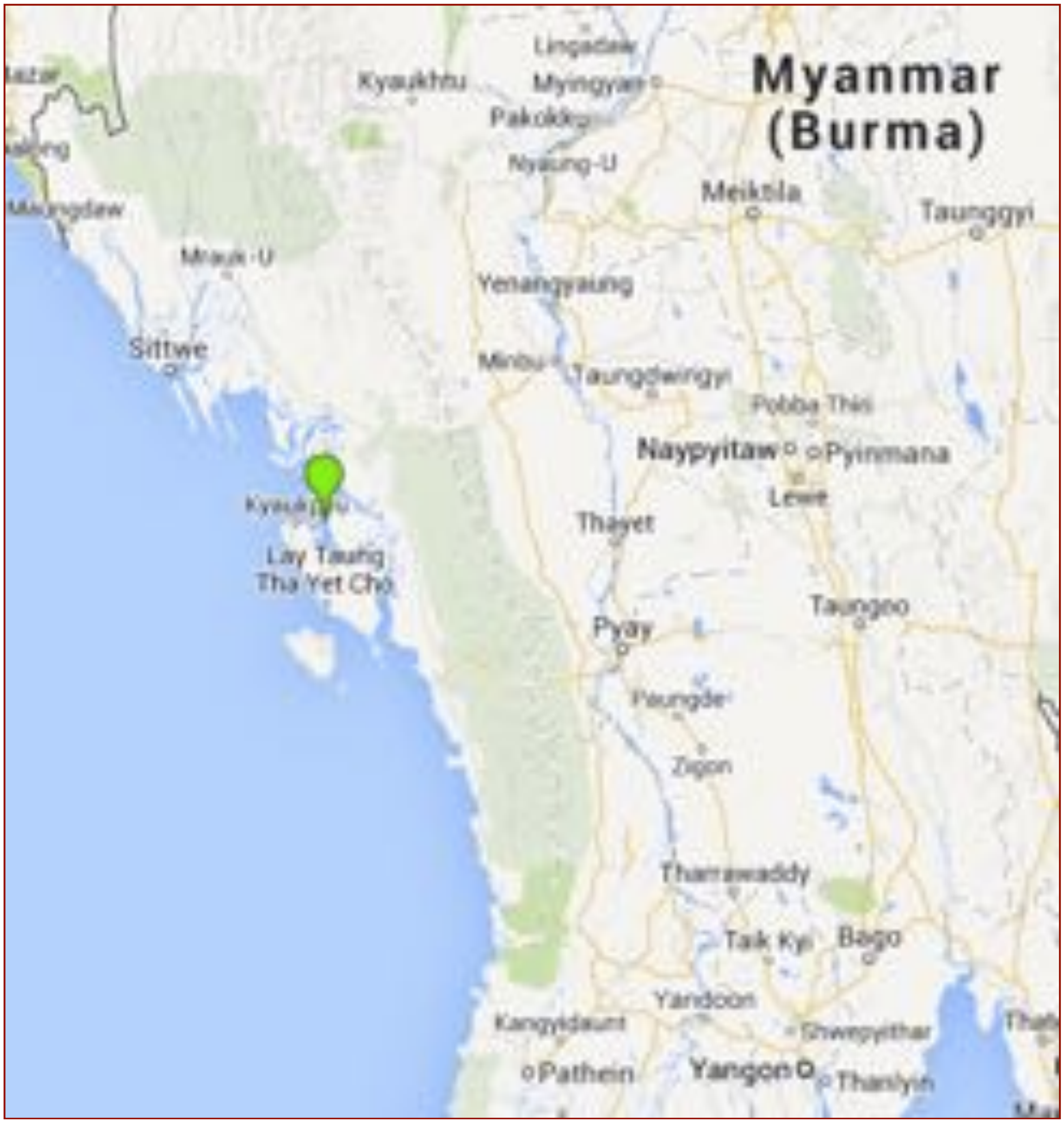
The grid can easily accommodate the need for capacity growth. Additionally, lifespan is not a concern as the grid is built to last for decades. Factor analysis is in accordance with these recommendations as grid extension is ranked first.

At the same time, care must be taken to develop auxiliary solutions as grid extension is in progress, given that it will not be possible to connect the entire state at once.

Interview List

- U Hla Aung – Head of the Za Di Ya administration
- U Aung Tin – Resident
- Shop owner
- Youth from Za Di Ya working in Kyaukpyu city

War Taung: Isolated Island but Resourceful Community
War Taung Village Tract



Population	900
Number of Households	161
State/Division	Rakhine
Township	Kyaukpyu
Distance from Grid	13 miles
Nearest City with Access to Grid	Kyaukpyu City
Coordinates	19.426, 93.686
Main Economy	Fishing and farming
Recommended Electrification Strategy	Solar and Generator

War Taung	Percentage	Kilowatt	Demand (KW)
% Poor	80%	0.12	15.46
% Aspirant	15%	0.5	12.08
% Emerging	5%	1	8.05
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			35.58
Non- household demand - 1 monastery & 1 school			5.00
	Total Village Demand (KW)		**40.58**

War Taung is among the villages that will not benefit from the grid extension plans for Kyaukpyu Township. Because the village is located on a small island about an hour from Kyaukpyu City, establishing a grid connection would require costing underwater cables. The Team arrived by fishing boat and was escorted by U Tun Thway, who had taught in the local elementary school years ago.

The Team with War Taung villagers

Economic Profile

The local economy in War Taung is centered on agriculture and fishing. Villagers grow mostly cashews, fruits and vegetables. The village also grows one crop of rice per year for local consumption. Not all of the villagers own boats, but those who do are able to sell their catch in Kyaukpyu.

Some of the farmland lies on the edge of the island. Villagers have built barriers to protect their fields, but on occasion seawater seeps through and renders the land unable to produce crops. Villagers acknowledge the need for a proper barrier, preferably made of concrete.

During the visit, the Team noticed many idle youths. As in Za Di Ya, many villagers have left to find work in Thailand or Malaysia. An estimated 50 people have reportedly left War Taung to work abroad.

The village headman, U Maung Ba Khin, estimated the village's average household income at roughly 30,000 kyat per month. This is lower than in any other village visited, though when examined on a purchasing-power-parity basis the village could be considered as having a much higher living standard than would seem justified by this income. The availability of fish and agricultural crops enables villagers to enjoy a lower cost of food. Income alone, therefore, does not accurately portray War Taung's economic condition. In fact, the village appeared to be far more prosperous than villages that reported income levels that were two to three times higher.

Though he could not provide an accurate estimate, the headman was able to provide the Team with an idea of how income groups could be classified. He estimated there are about 50 households that are considered poor, 30 households that are living comfortably and 70 that are somewhere in the middle.

Electrification

War Taung has two private diesel generators that connect a total of 70 households. The first generator is an 18 HP (13 KW) engine, providing electricity to 30 households. The generator has been in use since October 2012. The second generator is a 25 HP (18 KW) engine and provides electricity to 40 households. The owner bought it for 4 lakh two years ago in Kyaukpyu City.

18 HP (left) and 25 HP (right) generators

Electricity is provided between the hours of 7 P.M. and 9:30 P.M. For lighting only, households pay 2,000 kyat a month. Households that also own televisions pay 5,000 kyat to 6,000 kyat per month for electricity, depending on the size of the television set. U Maung Ba Khin approximates 25 households have televisions. Though the generators are private, he revealed that due to diesel costs, their owners are not making any notable profit from providing the service.

In addition to the diesel-generated electricity, a few households (U Maung Ba Khin estimates seven) in War Taung own solar home systems. One of these households, which also ran a small shop out of the house, paid 250 lakh for its solar home system and has had it for two years. The size of the solar home system is reportedly 200 W though the family was not too certain of its specifications other than the dimensions of the panel (4 feet). The household uses the solar home system for television and lighting. During heavy rains, the household manages with a battery and flashlight. In circumstances where rains have been heavy and persistent, the household takes its batteries to Kyaukpyu for recharging.

When asked about perspectives on the low-cost electricity from the grid that is available in nearby Kyaukpyu City, U Maung Ba Khin asserted that villagers do not expect grid extension for War Taung. He indicated that government officials have made it known to the village that the government would not be able to afford extending the grid to their island. The government has, however, promised either solar or diesel generators as a means of electrification for the entire village. Though it would depend on village consensus, U Maung Ba Khin believed the village would prefer solar power because of concerns with the fuel, operation and maintenance costs associated with diesel generators.

In contrast to Za Di Ya, War Taung, due to its relative self-reliance and isolation, as well as the villagers' understanding that grid extension to the island is not feasible, may be less susceptible to any social tension that may arise from uneven grid extension initiatives in the region.

Analysis

Despite the lack of employment opportunities and the island's distance from Kyaukpyu, the Team noticed that many of the residents of War Taung do not appear to be struggling or suffering from abject poverty. Unlike, for example, villagers from Kyar Kan Daung or Tha Yet Taw near Pathein, War Taung's access to more resources appears to have made its villagers better off. This can be seen in the fact that 25 households are estimated to have televisions, with electrification and Skynet (cable) charges that would require a major share of the income estimated by the village leader.

Furthermore, there appears to be considerable communal unity in War Taung. During a tour of the village, the Team observed a number of villagers digging a channel to prevent flooding during the monsoon season. The coordinated effort to protect the village and practice of consensus-based decision-making leads the Team to believe that the village headman would be able to rally War Taung residents to organize a village-scale electrification initiative should there be sufficient benefits.

Estimated Cost Analysis

Village Name: War Taung								
Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	161	13	41	$121,271	$0	$63,350	$53,714	$557,152
O&M*	161	13	41	$350	$0	$13,190	$21,452	$12,798

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

The Team estimates that supplying solar units for all 161 households, a monastery, school and ten streetlights would cost approximately $121,271. At $753.24 per household, this is high and, relative to the village's income, would be difficult to finance. The cost per KW is $2,988.37 and additional O&M costs would come out to about $350 per year.

Mini-hydro

Though the channel the villagers are digging might be wide enough to accommodate a small hydro turbine, water levels are only existent during the rainy season. It therefore would not be cost effective to install a turbine. There are no other river sources that could provide mini-hydro power.

Biomass

The Team estimates a gasifier-based mini-grid would cost $63,454, or $394.12 per household. This figure also assumes that War Taung has a flat terrain. Due to slight variations in elevation on the island, the cost of installing a distribution network may in fact be higher. Cost per KW is $1,563.64. Annual O&M expenses would be about $13,190.

Generator

There are presently two generators in the village. The existing distribution system is poor. Installing a larger generator to meet the village's needs with a better distribution system is estimated to cost $53,714, or $333.63 per household. Cost per KW is $1,323.63. Additional O&M expenses would amount to roughly $21,452 per year.

Grid Extension

If War Taung were not an island, connecting to the grid would cost approximately $557,152, or $3,460.57 per household. in reality, however, extending the grid from Kyaukpyu to War Taung would require installation of sub-sea cables, the cost of which is not included in the aforementioned figure. Sub-sea cables would compound the already high costs of grid extension which villagers cannot afford. Further, with War Taung's low demand, cost per KW is high, estimated at $13,729.38. Additional O&M expenses would be about $12,798 per year.

Broader Factor Analysis

War Taung	Solar Home System	National Grid Extension	Hydro Mini-grid system	Gen-set Mini-grid system	Gasifier Mini-grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	6.50	1.00	1.00	6.50	4.50
Population (1=totally insufficient, 10= totally adequate)	7.50	1.50	1.50	7.50	6.50
Location /Geography (1=totally unsuitable, 10= totally adequate)	7.50	1.50	1.00	6.50	5.50
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.50	1.00	1.00	5.50	5.00
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	7.00	8.00	2.50	7.50	4.50
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	6.00	5.00	7.50	6.00
Total	**44.50**	**19.00**	**12.00**	**41.00**	**32.00**
Average across 6 categories	7.42	3.17	2.00	6.83	5.33

According to the factor analysis, solar home systems, scoring 44.50, ranked the highest. Solar is well suited to War Taung's relatively small population, low demand and the island's fair amount of isolation. Its ease of installation and low O&M costs also make it a favorable solution.

A generator mini-grid system follows with a score of 41. This technology scored lower because of the need to transport fuel and parts from Kyaukpyu to War Taung island. In contrast to solar home systems, where transport only plays a role in the installation process, generator use will require frequent deliveries of fuel and the occasional maintenance overhaul. Though travel to Kyaukpyu City may be frequent, the need for consistent transport of materials leads the technology to be ranked lower in availability and location/geography.

Gasifier technology ranked lower because of concerns both with fuel supply and local knowhow. Although rice is grown for village consumption, villagers in War Taung have described difficulties in maintaining their rice crop, which would jeopardize consistent and sufficient access to rice husks, and therefore fuel for gasification. The Team also believes that, should a gasifier be installed, residents may not be able to adequately maintain it, which may have negative environmental effects.

Mini hydro-power is unfeasible and grid extension too costly. Both face challenges of resource availability as the island does not have any river source and the sub-sea cable connection requires significant effort and capital. Consequently, the ratings reflect that neither is a feasible option.

Conclusions

Though employment and income-generating activities may be limited in War Taung village, there is potential for employment in nearby Kyaukpyu. Villagers from War Taung often travel to and from Kyaukpyu for supplies and other services. Though they understand that grid extension will not be available to them, Kyaukpyu's around-the-clock electricity access may motivate War Taung residents to launch a village-wide electrification effort.

War Taung would likely require financial support and especially technical support in order to install a better distribution network. Nonetheless, having witnessed their ability to cooperate and organize, the Team believes the village would be able to manage a village-scale electrification initiative.

Recommendations

The Team recommends the use of both solar home systems and generators. The technology analysis shows that, while both have short lead times, solar, because of its resource availability and low O&M costs, is the better option. Further, due to the low energy demand, it is not as costly to use solar home systems as it is for other villages of a similarly large population.

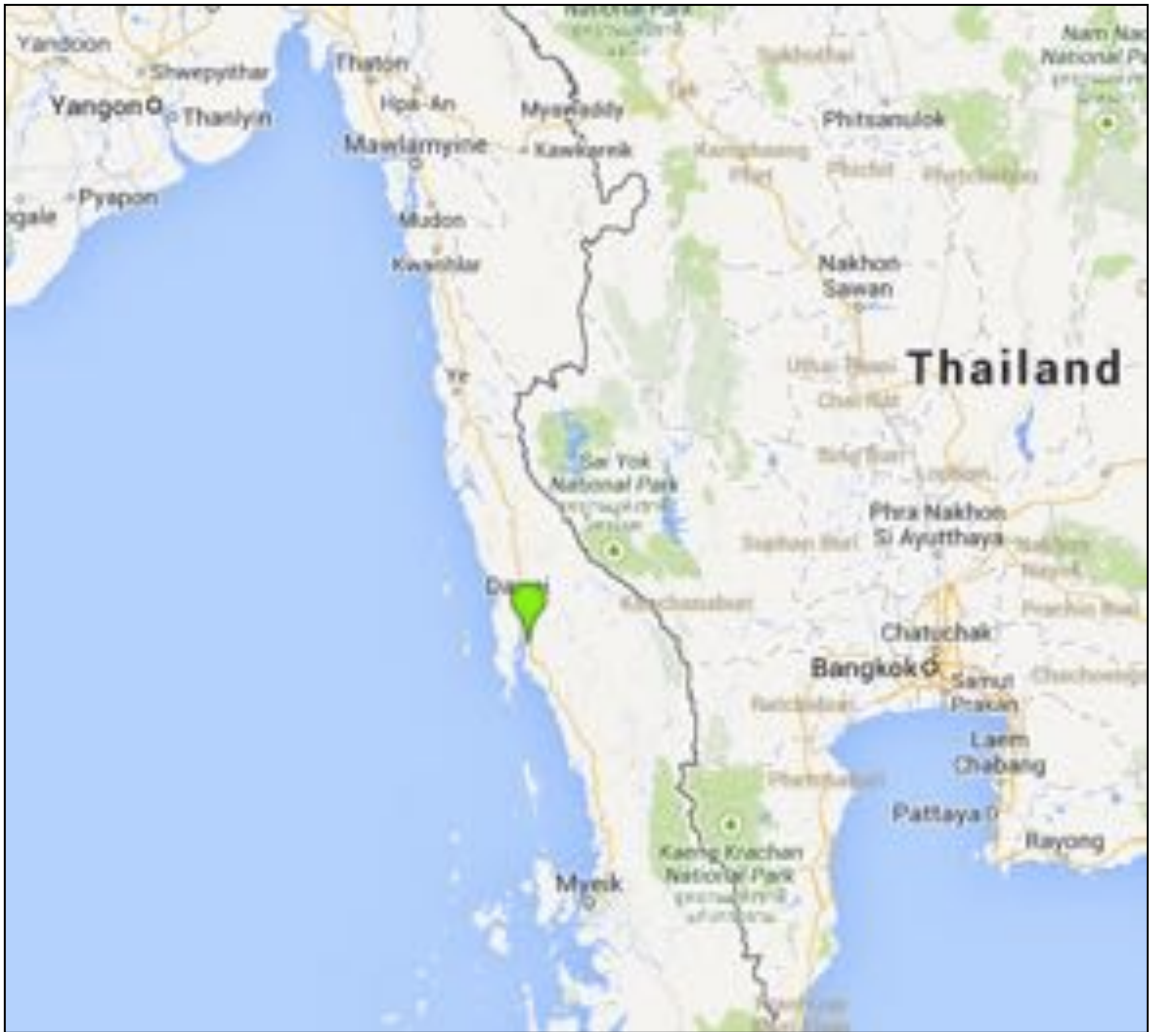
It would, however, take three to four years to pay for solar with financing, and these added costs makes using solar as the primary energy source cost prohibitive. Therefore the Team recommends a combined solution which would call for utilizing generators with the use of solar as an auxiliary source of electrification.

As in Aung Mingalar, the Team believes War Taung would be a good location for a pilot project using anaerobic digestion of waste from livestock and the fishing industry. If the pilot is successful, the Team would recommend anaerobic digestion as an additional supplementary source and a platform that could also potentially be used elsewhere in Myanmar.

Interview List

- U Maung Ba Khin – Village Head
- Small retail merchant with solar panels
- Owner of generator (1)
- Owner of generator (2)
- Host

Myoma Ward: Prosperity with 24-Hour Diesel-Generated Electricity
Tha Yet Chaung Township



Population	3,000
Number of Households	600
State/Division	Tanintharyi
Township	Tha Yet Chaung
Distance from Grid	246 miles
Nearest City with Access to Grid	Mawlamyaing
Coordinates	13.860, 98.265
Main Economy	Agriculture; Migrant Labor
Recommended Electrification Strategy	Generator (short-term)

Myoma	Percentage	Kilowatt	Demand (KW)
% Poor	7%	0.12	5.04
% Aspirant	60%	0.5	180.00
% Emerging	31%	1	186.00
% Established	2%	2.5	30.00
% Affluent	0%	5	0.00
Total Household Demand			401.04
Non- household demand - 5 monasteries, 2 schools & 1 clinic			19.50
	Total Village Demand (KW)		**420.54**

Myoma ward is in Tha Yet Chaung town and is considered a part of the urban area. It is 17 miles from Dawei City, the site of a planned SEZ, the development of which is now stalled. The main road that runs from Dawei to Myeik all the way down to Kawthoung, Myanmar's southernmost point, runs through Myoma.

Economic Profile

This road runs from Dawei through Myoma down to Myeik

Most residents of Myoma are engaged in agriculture and its main crops are rubber, betel nut and durian. Many of the younger residents have left to work in Thailand. According to U Tint Win, the township administrator, approximately 10% of the village population (about 300 people) work outside the village, including in Thailand, Myeik and

Dawei. These workers tend to return to Myoma during the monsoon season after seven to eight months outside.

There are also a number of small businesses in Myoma, including a car workshop, motorcycle shop, game center, bakery, steel furniture shop and about ten teashops. Most of the businesses were established since the availability of regular 24-hour electricity. According to U Tint Win, people from neighboring areas come to Myoma to work.

Myoma's proximity to Thailand plays a strong role in the local economy, which is boosted by cross-border trade and remittances. Anticipation of the Dawei SEZ, the plans for which include a large deep-sea port, industrial zone and highway to Thailand, has already driven up land prices and travel to the area. It is expected that certainty over the Dawei SEZ's future, as well as other regional integration plans, will further drive Myoma's economic growth.


Small businesses (steel furniture shop (left) and motorcycle shop (right) in Myoma

Income levels in Myoma are high compared to other villages and towns the Team has visited. Income ranges from 1.5 lakh (150,000 kyat) per month to as much as 10 lakh (1 million kyat) per month. U Tint Win breaks down distribution of these income levels as follows: approximately 7% of the population earns less than 1.5 lakh, 60% of residents earns about 1.5 lakh; 25% earns about 3.5 lakh; 6% earns about 4.5 lakh; and 2% earns about 10 lakh per month. The 2% earning 10 lakh per month includes plantation owners and teachers who are hired for private tutoring. Indicative of the relatively higher levels of income, many residents in Myoma own satellite dishes.

Electrification

Myoma ward receives 24-hour electricity access from a set of generators in nearby Maw Shi Kone Ward. Their electricity provider is Phoe Thee Cho Co. Ltd. (PTC), a private company working in conjunction with the EPC. PTC is present in villages and cities throughout the Tanintharyi region.

The local PTC office

There are two generators—one 350 KVA and one 150 KVA generator—located in Maw Shi Kone. U Kyi Lwin, the operator, says the villages consume approximately 20 gallons of diesel per day. The two generators provide electricity to four adjacent wards: Myoma (600 households), Maw Shi Kone (200 households), Kyaukmyaung (400 households) and Pan Daw (400 households).

Generators at Maw Shi Kone

According to U Thit Lwin, out of the four wards, Myoma consumes the most electricity. Besides having a larger population, Myoma's apparent position as the central point for businesses among neighboring areas likely contributes to the higher loads.

Myoma has had 24-hour electricity access since November 2013. PTC charges 490 kyat per unit of electricity. The township administrator estimates that of 600 households, 560 have electricity. The remaining 40 are either elderly or cannot afford the electricity, although PTC does provide free electricity to certain low-income households. Before PTC, a local private company provided Myoma with electricity from 6 P.M. to 11 P.M. at a rate of 600 kyat per unit.

U Win Naing's electricity bill

The Team spoke with U Win Naing, owner of the only car workshop in town. U Win Naing moved to Myoma from Dawei seven years ago. He and his family have been happy about the service provided by PTC, although they would prefer grid access as it would be considerably cheaper. U Win Naing's household has the typical television and lighting appliances, but also a fan, water pump and electric iron. His household electricity bill for the month of April was 23,930 kyat.

Myoma will also be receiving mini-hydro generated electricity. The 100 KW mini-hydro project, headed by U Hla Htun, is currently under construction. The turbine will reportedly be able to run eight months out of the year. During six of those months, the creek in which it is built will have consistent flow from rainwater. In the remaining two months, the turbine will rely on a reservoir, which is also being built. According to U Thit Lwin, the 100 KW generated will only fulfill 10% of the town's electricity needs.

Mini-hydro site

Analysis

Myoma's reported incomes are considerably higher than in other villages and towns that the Team has visited. Since the availability of 24-hour electricity access, economic activity is flourishing, even at the cost of 490 kyat per unit. Lower electricity costs would likely encourage even greater growth among Myoma's small businesses, which will also benefit from the proximity to Thailand and the Dawei SEZ when it is constructed. With government plans to extend the national grid to Kawthoung, Myoma is likely to receive grid access within the next few years, as transmission lines will need to pass through the town.

Estimated Cost Analysis

Village Name: Myoma

Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	600	246	421	$1,044,422	$172,552**	$312,776	$236,171	$9,065,329
O&M*	600	246	421	$1,260	$26,280	$102,509	$200,091	$132,621

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for generator mini-grid systems, 24 hours for hydro mini-grid systems, and 24 hours for grid extension.

** Estimate for 100 KW system and does not include construction of dam or advanced engineering study

Solar

Powering the entire town with solar home units will cost an estimated $1,044,422, or $1,740.70 per household. In addition to the 600 households, independent solar units will power five monasteries, two schools, one clinic and 20 street lights. The steep price is due to the town's higher electricity demand and large and more affluent population. Further, solar home units will only supply six to eight hours of electricity as opposed to the 24-hour access to which the town is now accustomed. The cost per KW is $2,483.53. O&M would add approximately $1,250 per year. Altogether, solar is too expensive of an option.

Mini-hydro

A 100 KW mini-hydro system is currently under construction. This however, will only supply 25%, at best, of Myoma's electricity needs and will only be operational eight months out of the year. According to U Hla Htun, there are reports that a river further up on the hill could produce up to 10 MW year round. At the time of the Team's visit, however, surveyors had yet to examine the site. If there is potential for a secondary site, the 10 MW could also feed into the local grid. The Team estimates the current 100 KW project roughly costs $172,552, or $287.59 per household. This figure includes household connections but does not account for the dam and reservoir under construction.

Biomass

The Team estimates a gasifier-based mini-grid to cost $312,880, or $521.47 per household. The cost per KW is $744. Additional O&M costs add an estimated $102,509 a year. Though rice husks are reportedly available, sufficiency of supply is unknown and there are no storage facilities. The Team also has its reservations about the environmental impact.

Generator

Myoma is currently using diesel-generated electricity. Residents enjoy the 24-hour access but electricity costs remain high even after the switch to PTC. Assuming Myoma were without access to PTC's services, the Team estimates the cost of installing a generator-based mini-grid to be $236,171, or $393.62 per household. The cost per KW is $561.59. Additional O&M costs would be approximately $200,091 per year, however, this assumes the generator operates three hours per day as opposed to the 24-hour electrification Myoma is currently receiving.

Grid Extension

The Team estimates grid extension to cost $9,065,329, or $15,108.88 per household. This figure is extremely high because it is dependent upon distance from the national grid, which presently reaches Mawlamyaing, more than 200 miles away. This figure should be seen as exaggerated, however, as it assumes a straight connection between the closest extension point and the village, with no interim connections along the way, which would help to reduce and amortize the costs over a wider population. The cost per KW is $21,556.40. Additionally, annual O&M costs are estimated to be $132,621.

Broader Factor Analysis

Myoma	Solar Home System	National Grid Extension	Hydro Mini-grid system	Gen-set Mini -grid system	Gasifier Mini-grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	8.00	7.00	6.50	9.00	7.50
Population (1=totally insufficient, 10= totally adequate)	7.50	8.00	6.50	8.00	7.00
Location /Geography (1=totally unsuitable, 10= totally adequate)	8.00	3.00	5.00	8.00	6.50
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.00	3.50	6.00	7.00	4.50
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	7.50	8.00	4.50	8.00	5.00
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	5.50	5.00	8.00	6.00
Total	**46.50**	**35.00**	**33.50**	**48.00**	**36.50**
Average across 6 categories	7.75	5.83	5.58	8.00	6.08

According to the factor analysis, a generator mini-grid, with a score of 48, is best suited to Myoma's needs and conditions. This is in accordance with Myoma's current means of electrification. The existing grid demonstrates Myoma's finances, location, local know-how and cohesion are all well-suited to a generator-based mini-grid system.

Although solar ranks second with a score of 46.5, due to the town's relatively high income levels and resource availability, capital cost analysis reveals it is too expensive and inferior to the alternatives. On account of the considerable amount of estimated electricity demand, solar home units are very costly for Myoma.

A gasifier system comes in third with a score of 36.5, followed by national grid (35), and lastly hydro (33.5). The biggest concerns with a gasifier system are resource availability and the technical capacity needed to deal with a gasifier's environmental issues.

As for grid extension, Myoma's distance from the national grid in Mawlamyaing is the biggest hindrance. Once the national grid makes its way down into the Tanintharyi region, grid extension will be a more attractive option.

Finally, Myoma is the only site of which the Team visited where mini-hydro is feasible and a facility is currently under construction, which will supply part of its energy needs. As a result out of all the villages, hydro scores the highest in Myoma.

Conclusions

Twenty-four-hour electricity has already proved valuable in Myoma. Access to new electricity sources, including hydro, has ignited economic activity in a short period of time even though it comes at a relatively high price. The Team finds it reasonable to believe that productivity and economic activity will increase substantially once electricity costs are lowered, and that the area's growth—both in terms of economic activity and electricity demand and capacity—is likely to accelerate with or without access to the national grid.

If the planned Dawei SEZ and ASEAN highway moves forward, the Team expects Myoma to develop even more rapidly. Electricity demand will also grow with it. In the meantime, new businesses will likely continue to grow in Myoma and PTC will need to add additional capacity to meet electricity demand.

Recommendations

The Team recommends continuing with generator use as a short-term measure while waiting for grid extension, given Myoma's high level of demand and existing infrastructure. Once the national grid reaches Dawei, it will make its way through Myoma as it moves on to Myeik and Kawthoung. If the river site on the hill is sufficient, the Team also recommends integrating additional mini-hydro capacity into the generation mix.

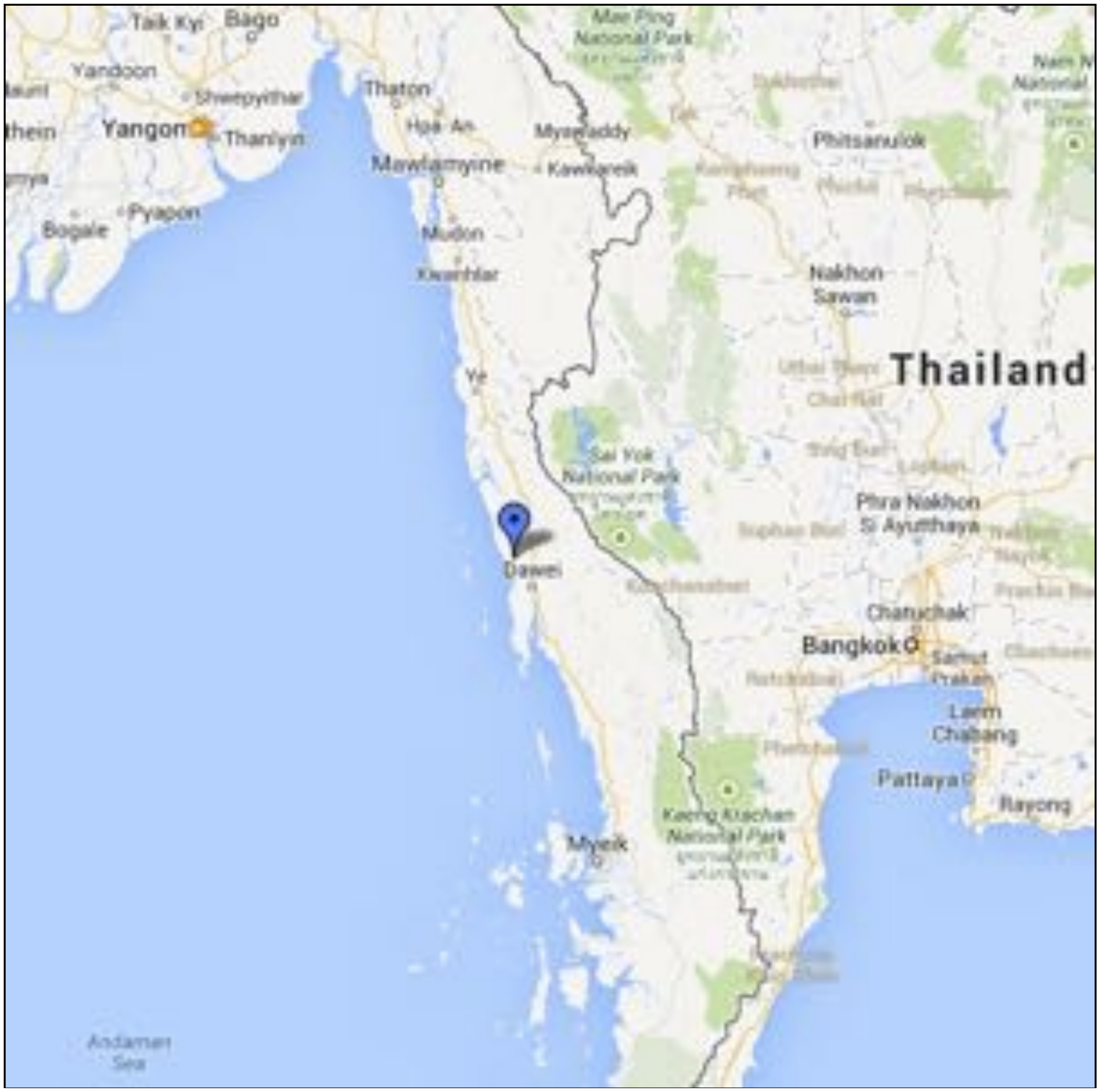
The factor analysis supports the recommendation of generator use with a score of 48. According to the broader technology analysis, the generator also works well because it can easily accommodate capacity growth, which will be important in Myoma where demand is already high and expected to increase.

The Team recommends national grid for the long term. In this particular situation, the government's policy goal of extending the national grid into the Tanintharyi Region was a factor that could not be accounted for in the analysis. Hence its score of 35.

Interview List

- U Win Naing – Owner of local car workshop, Myoma resident
- U Thit Lwin – Administrator for Myoma ward
- U Kyi Lwin – Operator of PTC-owned generators in Maw Shi Kone
- U Hla Tun – Owner and manager of mini-hydro project in Myoma
- U Thit Lwin – Myoma ward Head Administrator

Mu Du Village: Stuck in the Middle as a "New" Myanmar Emerges
Ye Phyu Township



Population	2,700
Number of Households	700
State/Division	Tanintharyi
Township	Ye Phyu
Distance from Grid	234 miles
Nearest City with Access to Grid	Mawlamyaing
Coordinates	14.24, 98.083
Main Economy	Agriculture; Migrant Labor
Recommended Electrification Strategy	Generator

Mu Du	Percentage	Kilowatt	Demand (KW)
% Poor	17%	0.12	14.28
% Aspirant	71%	0.5	248.50
% Emerging	12%	1	84.00
% Established	0%	2.5	0.00
% Affluent	0%	5	0.00
Total Household Demand			346.78
Non- household demand - 1 monastery & 1 school			5.00
	Total Village Demand (KW)		**351.78**

Mu Du village is located 12 miles from Dawei City. According to the Dawei Development Project plans under Italian-Thai Development Company (ITD), the area of Mu Du will become a part of the heavy industrial estate. If and when the Dawei SEZ moves forward, inhabitants of this reportedly 200-year-old village will have to relocate. ITD had already built housing for the relocated residents, however, for the time being, while the Dawei SEZ plans remain on hold, villagers remain in Mu Du.

Economic Profile

Mu Du's economy is mainly agrarian. Crops include rice, peanuts, rubber and cashew nuts. Some farmers also grow watermelon and other fruits. Most villagers do not have significant land holdings. There is, however, a handful of rubber plantation owners that own hundreds of acres of land.

Outside of agriculture there are not many other employment opportunities in Mu Du. The Team learned that nearly one third of the village residents, mostly youth, works abroad in Thailand. One woman sent five of her six children abroad to find work.

Incomes in Mu Du reportedly range between 200,000 kyat per month and 500,000 kyat per month. Based on the significant number of migrant workers, it appears the reported incomes are largely based on remittances from family members abroad. Plantation owners fall in the upper end of the income range and represent an estimated 1% of the population. Around 11% fall in the middle, earning approximately 300,000 kyat per month, with the vast majority of the population at the lower end.

Income is inconsistent for some of the population. A farmer growing watermelon, for instance, can earn 2 million kyat selling his crop but that income would have to last until the next crop season.

The local economy has stagnated due to the Dawei SEZ plans. Residents report that government officials informed them they should not plant any new trees because the village would be razed for the industrial zone. That was more than three years ago when it was first announced the Dawei SEZ would go forward. Since then, villagers have suspended any activities that would prove futile if this move went forward. This includes house and building repair.

Residents are, however, optimistic about the industrial zone despite the disruption it has and will cause. For one, they are hopeful for employment opportunities. The aforementioned mother of six expressly told the Team that she would have her children return to work in Myanmar if the Dawei SEZ created local jobs. One resident said he was willing to make the sacrifice for the good of the country. Another reported that while he's disappointed he cannot plant new crops on his land, he believes the Dawei SEZ will develop the region. Although ITD had accounted for new housing for relocated households, there has been minimal compensation for lost farmland.

Electrification

There are two private generators providing electricity in Mu Du. About 500 households are electrified. Electricity is provided from 6 P.M. to 9:30 P.M. daily and costs 4,000 kyat per month for lighting and between 7,000 kyat and 8,000 per month for television and lighting. There are 400 households paying for both lighting and television while the remaining 100 households only pay for lighting.

About six households in the village own solar home systems. One household has a 145 W peak solar home system which it has been using for three years. The village has expressed a preference for generator-powered or solar electricity.

Villagers are familiar with PTC's services. U Aung Toe, the village administrator estimates that at least 500 households in the village could afford PTC's services. However, with the village expected to be relocated for the industrial zone, it is reasonable to believe PTC has decided not to seek approval or to make the costly investment of building transmission and distribution lines in Mu Du.

Analysis

When U Aung Toe reports to officials at the township level every month, he brings up the issue of the Dawei SEZ and asks for any news on when the project will go forward. The township authority assures that the Dawei SEZ will happen but has no answers as to when. After nearly four years, Mu Du's residents continue to live under the assumption that their 200-year old village will eventually be flattened to make way for an industrial estate. They have foregone activities and investments that are aimed at the long term. Accordingly, villagers may be unwilling to initiate anything more than a provisional electrification project.

Estimated Cost Analysis

Village Name: Mu Du								
Type of Cost	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Installation	700	234	352	$921,938	$0	$250,338	$205,338	$8,544,246
O&M*	700	234	352	$1,450	$0	$86,345	$167,763	$110,937

* Assumes daily operations of 6 hours for solar home systems, 3 hours for gasifier mini-grid systems, 3 hours for gen-set mini-grid systems and 24 hours for grid extension.

Solar

Due to high demand and a relatively large number of households, the cost of supplying solar home systems to the entire village is estimated at $921,938, or $1,317.05 per household. This figure includes solar units for the monastery, school and 20 streetlights. The cost per KW is $2,620.78. Additional O&M expenses would cost approximately $1,450 a year.

Mini-hydro

Yay Hla Chaung River is about half a mile away from the village though it is not clear whether this represents an adequate resource even if the village were willing to bear the expense. Therefore, as with other villages that did not have a proven hydro resource, the cost of hydro for Mu Du was not estimated.

Biomass

The Team estimates a gasifier mini-grid to cost $250,442, or $357.77 per household. The cost per KW is $711.93. Annual O&M expenses would be approximately $86,345.

Generator

The village is currently using diesel-generated electricity. To install a new generator-based mini-grid would cost approximately $205,338, or $293.34 per household. The cost per KW is $583.71. Additional O&M expenses would be about $167,763.

Grid Extension

The Team estimated it would cost $8,544,246, or $12,206.07 per household to extend the grid from Mawlamyaing all the way to Myoma. The cost per KW is $24,288.61 and O&M expenses would add approximately $110,937 per year. While this figure would be reduced given that additional villages, including Myoma, would be connected, it would not make sense here in any case, given that the population would ultimately be relocated.

Broader Factor Analysis

Mu Du	Solar Home System	National Grid Extension	Hydro Mini-grid system	Gen-set Mini-grid system	Gasifier Mini-grid system
Cash/non-cash (1=totally insufficient, 10= totally adequate)	7.00	2.00	1.00	7.50	6.50
Population (1=totally insufficient, 10= totally adequate)	8.00	5.00	2.50	8.00	7.00
Location /Geography (1=totally unsuitable, 10= totally adequate)	8.00	2.00	1.50	7.50	4.50
Energy Resource Availability (1=totally insufficient, 10= totally adequate)	7.00	1.00	1.50	7.00	5.50
Local / accessible knowhow (1=totally insufficient, 10= totally adequate)	7.00	7.50	3.00	8.00	4.50
Cohesion (1=totally insufficient, 10= totally adequate)	8.50	4.00	4.00	7.00	4.50
Total	**45.50**	**21.50**	**13.50**	**45.00**	**32.50**
Average across 6 categories	7.58	3.58	2.25	7.50	5.42

According to factor analysis, solar, with a score of 44.5, and generators, with a score of 45, are the best options for Mu Du. The village's location, availability of resources, cohesion and local knowhow are well suited to both technologies. However, due to the village's high demand, not to mention imminent relocation, capital costs reveal that solar is too expensive.

Gasifier could be an option but the regular availability of fuel is unknown. Cohesion is also a challenge. Activities that involve investment for the long-term have ceased in Mu Du due to their impending move. Villagers would not be willing to plan, organize or pay for a gasifier mini-grid.

The same can be said for grid extension and mini-hydro, both of which have long lead times and high capital costs. Neither is suitable for Mu Du's situation as villagers would not be willing to commit to such large investment projects.

Conclusions

Mu Du is in a difficult position. Economic activities and opportunities are limited. Villagers must weigh investments and projects against the possibility that may be been done in vain once residents are forced to leave the village. Any recommended electrification strategies will have to be temporary. As a result, solar, mini-hydro and gasification are all deemed unfeasible as neither would be worth the time and investment needed for installation.

For Mu Du, the best solution is to continue use of generator power, as it is a sufficient method of electrification for the short-term.

Recommendations

The Team recommends that Mu Du continue using generator power, as there is no incentive to plan or pay for expensive, long-term solutions given the uncertainty over how long residents will remain in the present location.

Theoretically, solar home systems could work well in Mu Du as the equipment is not fixed and could easily be transported if and when villagers leave for new housing. However, whether or not this future housing situation will be suitable for this transfer is unknown.

While the findings of both the factor and technology analyses favor solar more than generators, due to Mu Du's unique situation, benefits of solar power are less applicable. In addition, Mu Du's larger size would probably make solar home systems too expensive an alternative even if they were not faced with the need to relocate.

Interview List

- U Aung Toe – Village administrator
- Assistant to U Aung Toe
- Local resident
- Household owner of solar panels
- Mother of six, with five abroad in Thailand

Exploratory Fieldwork Visits

Chuangthar: A Mismatch of Well-Intentioned Design

Chaungthar is a coastal village and resort in Myanmar's Ayeyarwady Delta, located approximately 155 miles west of Yangon and 35 miles west of Pathein, Myanmar's fourth largest city. An already crowded beach destination, Chaungthar is positioned to grow as tourism to the region and to Myanmar as a whole takes off. Rapidly rising electricity demand, driven by tourism and population growth, will also be pressured by the needs of local agriculture and fisheries as well as industrial development initiatives in nearby Pathein. Unfortunately, the region's appetite for renewable energy projects, wind in particular, was stymied due to the failure of a project, sponsored by Japan in cooperation with the Myanmar government, which combined solar photovoltaic (PV) panels, a wind turbine and a diesel generator. A well intentioned and costly gift, the hybrid-energy system ultimately proved unworkable in Myanmar due in part to a mismatch of advanced technology and limited local technical capacity.

Overview

Situated in Myanmar's Ayeyarwady Delta, overlooking the Bay of Bengal, Chaungthar's local economy has been traditionally based on fishing and agriculture, including rice and coconut products. Income in surrounding villages was reported to be in the range of 100,000 kyat to 600,000 kyat per month and fluctuates depending on the season. (See Aung Mingalar and Za Di Ya reports.) Some residents are said to supplement income by running small storefronts, selling beverages and snack foods. The region's hotels, which profit from a growing tourism industry, have also employed local youth. Chaungthar has benefited from a large-scale investment in the region's transportation sector under the previous Myanmar government, which included the construction of a network of roads and bridges connecting the Ayeyarwady Delta region to other major cities in Myanmar.

Strong emphasis on infrastructure development, combined with Myanmar's tourism boom, has seen Chaungthar become a popular beach destination among locals and foreigners alike. The township has seen an increase in visitors and settlers, with some areas seeing a nearly five-fold increase in population over the past decade. Chaungthar has also seen a subsequent increase in electricity demand.

U Thant Zin, an MOEP-assigned electrical engineer in Chaungthar, estimates that the entire Chaungthar district would need 10 MW of power to provide 24-hour electricity to the area's villagers and hotels. He notes that the existing system of power generation—relying on diesel-based generators—is costly and expressed great interest in renewables.

Development of a Hybrid Power System in Chaungthar

About 15 years ago, Japan's NEDO, in cooperation with MOEP and MEPE, sponsored development of a hybrid power system facility in Chaungthar, Pathein. With a blend of renewable and conventional power generation, the project featured solar PV panels, a wind turbine and a diesel generator. This was also Myanmar's first wind power project.

The site selected for the power generation system was in Chaungthar beach, facing the Bay of Bengal, a promosing area for wind power. After surveying in 2000, construction began in 2001. Technicians held a yearlong wind survey and installed the wind system between January and March of 2003. The project was online later that year.
Built with top of the line equipment, systems and design, the project, estimated to have cost as much as USD 5 million[43], was seen as a successful demonstration of bilateral cooperation and a generous gift on behalf of NEDO.

Wind system installation

Technical Specifications

[43] Ministry of Electric Power, http://www.oilseedcrops.org/wp-content/uploads/2013/06/Ministry-of-Electric-Power-Myanmar-Wind-Power-Resources-Survey-2012-.pdf

Equipment	Specification
Solar Photovoltaic	80 kW output 12in series x 56 in parallel (672 modules) Inclined angle 17°
Solar Battery Module	Polycrystalline silicone solar cell 25.7 V 4.67A 120 W
Inverter	Self-exciting voltage inverter by IGBT (Insulated Gate Bipolar Transistor) 80 kW Input DC 308.4 V Output AC 210V
Wind Power	40 kW output: 3-blade up-wind type Diameter 15 m, Hub Height 21 m Rated wind velocity 11 m/sec, Cut-in wind velocity 2 m/sec, Cut-out wind velocity 25 m/sec
Generator	Permanent-magnetic synchronous generator 43 kW 42 poles with step-up gear of 1:4.6 adjustable speed type
Diesel Generator	Engine: 4- cycle water-cooling type 60 kW
Storage Batteries	Load-leveling type, valve control type, stationary lead battery, capacity 1000Ah Unit battery 2V x 204 cells
Ballast Load	3 units of ice flakes making machine Refrigerant R404a of hydro fluorocarbon Capacity of Refrigeration unit – 2 tons Consumed energy: 8.3 kW/unit

Source: NEDO project brochure

Challenges of the advanced technology

From the beginning after the facility was installed there were reported concerns about output from the wind turbine. The location of the turbine proved problematic, and several people interviewed have suggested it was not assembled at the intended site. Rather it is said that technicians had planned for the turbine to be situated on a hill about half a mile away. However, that site was on private property but the owner then denied use of the area for the project. Nevertheless a decision was made to proceed and the ultimate location of the wind turbine, and therefore the project at large, generated far less wind. The hybrid system operated from 2003 to 2011. The turbine only operated intermittently but by 2008, wind power was discontinued.

Further, NEDO installed three ice-making machines as a ballast load. With a predominant fishing economy, installing ice machines was both practical and sensible. Nevertheless, locals did not take to the small ice cubes produced by the machines; they preferred large blocks given they melted less quickly. Consequently, ice making was also abandoned.

Systems Failure

The most striking mismatch was that of technology and capacity. This became acute in 2011, when a problem with the solar PV systems transformer control caused issue with the DC breaker. The breaker, which automatically switched on, was reported to have failed. Noting the explicit warning on the equipment not to operate manually, employees heeded the warning and left it alone. There was none among the operators that understood the exact source of either the glitch or how to fix it. Thus, solar was also discontinued and thereafter, only the generator was in use.

The DC breaker

The Chaungthar project involved highly advanced equipment. However, system operations were automatic and purportedly easy to maintain. As described in a pamphlet detailing the project, the advantages of photovoltaic generation included “Simple system configuration [and] easy maintenance.” Accordingly, the Team finds it reasonable to believe that NEDO hoped to preempt any major challenges in operation and management with automated systems. An automatically run power system was prudent, especially given the lack of advanced technological systems and equipment in Myanmar. Indeed automation seemed to circumvent the need for intensive training in operations and maintenance. Nevertheless, systems did fail and local operators were not equipped or capable of repairing the problem.

According to U Aung Thaung, a MOEP employee overseeing the site since the project began, sometime about a year ago, a technician from NEDO came to inspect the solar equipment. The technician indicated that the problem was with the program logic control and that it could be fixed in Singapore. Though he did not provide an estimate, it was presumed to be too expensive to repair and the issue continued to be neglected. Consequently, it was only last year that MOEP officials at the site learned what exactly had gone wrong.

MOEP electrical engineer U Thant Zin pointing to the source of the failure

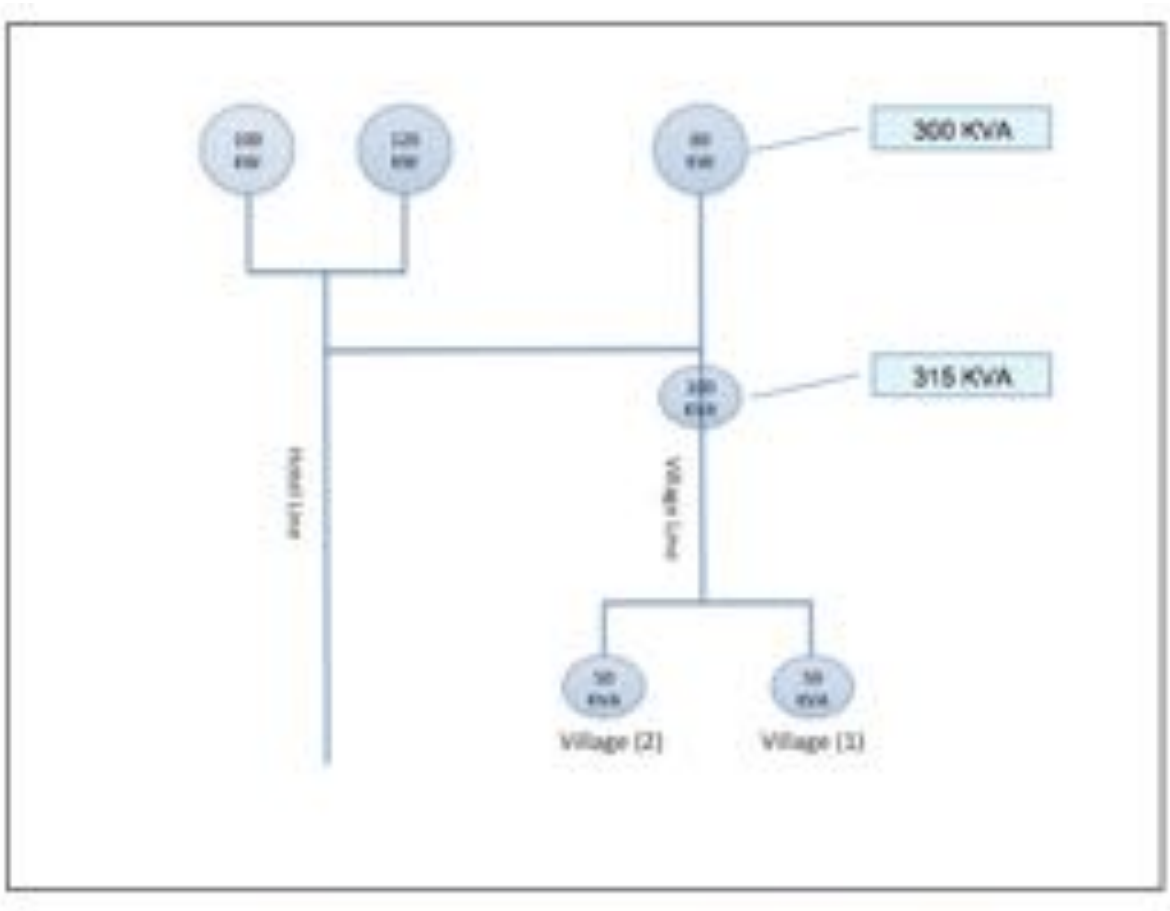
Population Growth

NEDO's hybrid system was expected to supply power to two villages in the Chaungthar Township. Two diesel generators provided the electricity used in the hotels.

According to U Thant Zin, in 2005, there were approximately 55 households in each of Village (1) and (2). The 60 KW diesel generator remaining in use provided them with sufficient power. It was however expensive: the generator consumed 35 gallons of diesel a day and cost 35 lakhs (about $3,500) a month. Since then, Chaungthar has developed into a tourist attraction and beach area and the population in the villages has grown nearly five times. The villages now have a combined total of 500 households.

The new 300 KVA Italian generator

To meet added demand in the villages, MOEP purchased a 300 KVA Italian made generator in April 2012. The generator consumes 13 to 14 gallons of diesel per hour. Where there had been a 100 KVA step-up transformer, they put in place a 315 KVA transformer. The 50 KVA step-down transformers near each village were replaced with 200 KVA transformers. The 60 KW generator, the last remaining NEDO-provided equipment, was moved last year to Shwe Taung Yan village, where it provides electricity to about 40 to 60 households.



Chaungthar Township electrification plan (see appendix for original diagram)

As for the power provided to the hotels, output has fallen dramatically. The original 100 KW Japanese Yanmar generator only produces 30 KW while the 120 KW Czech Skoda generator produces an output between 20 KW to 30 KW. In Chaungthar, MOEP-provided power only runs for a few hours a night, between 6:30 P.M. and 9 P.M. Regardless of the decline in output, hotels have long needed to finance their own power generation. Most own generators, and larger hotels have at least two. Hotels also face heavy fuel expenses and as a result some limit guest use of electricity to after sundown.

Looking Ahead

With service and repair, the NEDO project site can again serve as a renewables-based generation site. At present, the site is dormant. Since wind and solar operations have ceased, MOEP has left the equipment untouched and is not reported to have plans to bring back online. The local MOEP engineer states that the Ministry does not have the budget to repair the control system. Yet from what the Team has gathered, there is no real determination to make use of the equipment either as a generating source or as a valuable research opportunity. This seems unfortunate as the asset is there and has already been financed. Therefore, with a few relatively simply repairs, it could be easily utilized.

With the right resources and determination, the hybrid power generation site can be revived. Upon visiting, the Team saw that for the most part, much of the solar and wind equipment have remained intact. Indeed, the control panels in the wind tower looked relatively new. A few solar panels have been damaged though most appear functional, albeit in need of some cleaning. Once the solar control system is fixed or replaced, the solar generating facility could once again be utilized. Additionally, modifications could be made to the turbine, such as increasing the elevation of the turbine to capture more wind. However, any plans to reintroduce the use of facilities must include training for maintenance and repair.

Brush growing on the abandoned panels

An additional byproduct of the failure of the Chaungthar wind project appears to be that many individuals in Myanmar now express reservations over wind power and one frequently hears that wind power is not a viable option. Myanmar has a long coastline and other areas that are often considered suitable for this technology, and whether or not the nation proves an ideal environment for wind-powered projects, the potential for wind power should not be dismissed based upon the fallout of this one project alone.

Conclusions

With billions of dollars currently being invested in Myanmar's energy sector by World Bank, ADB and other international actors, the NEDO project offers several lessons for donors and other foreign participants seeking to help electrify Myanmar:

The critical need for operations and maintenance training

NEDO's project was so advanced, including the use of automated systems, it seemed to have provided for most contingencies. System automation decreased the likelihood of a local untrained operator committing human error. It also diminished the need for intensive training. However, the developer did not appear to have foreseen the potential for systems failure. And in Myanmar, where even technical engineers are unfamiliar with such advanced systems and finding in-country technicians and parts to repair such systems is difficult, this spelled the end of a tremendous accomplishment as it appears that no provision was made either by NEDO or MOEP for long-term care and maintenance.

Chaungthar is perhaps demonstrative of a theme the Team has encountered over and over again on its field visits, which is that most people in Myanmar have yet to embrace the wisdom of routine maintenance. The condition of equipment is deemed fine until it stops working. The most important lesson to be learned is that simply providing equipment or technology is not enough, no matter how simple or advanced. Instruction on equipment usage, maintenance and repair are fundamental. Further, accounting for local input could help avoid potential dissatisfaction or concerns.

The need for local input in developing sustainable electrification schemes

While one could not likely have foreseen the tremendous growth that the area has enjoyed due to its emergence as a tourism center when the project was first contemplated, and it is unknown why it was first selected, in retrospect it illustrates the importance of long-term planning and the need to contemplate the prospect of future growth rather than the installation of projects based upon existing rather than potential demand.

Going forward, it would be advisable for future electrification projects to incorporate greater local involvement. This is not limited to considerations of local energy opportunities and needs, but applies to the availability and importance of local know-how and participation if the community is to be expected to manage and care for the resource over the long term. As for the future of this hybrid project, optimally, consensus among government ministries will allow for its use as an energy research center and perhaps even a re-launch of operations so that this valuable asset can be utilized.

The importance of donors and international cooperation

Despite its ultimate failure, the NEDO project was a very generous gift to the people of Myanmar, especially considering it came years before solar PV became cost competitive. The state-of-the-art project offered the potential for the development of renewable energy and increased electrical capacity on a scale that would not otherwise have been possible. Had the project been a success, it would have opened possibilities for greater economic and social development in the region, and for replication of the project in other parts of Myanmar.

Interviews

Chaungthar

- U Aung Thaung - MOEP Employee
- U Thant Zin - MOEP Electrical Engineer

Tha Yet Taw

- U Tin Aye - village head
- U Han Kyay - Resident

- U Than Aung - Resident
- U Kyaw Lin Aung - Resident
- U Poe Tha Htoo - Resident
- Daw Tin Nwe - Resident
- Daw La Ohn - Resident

Kyar Kan Daung

- Esther Moe - Pastor's Wife
- Tapalase - Resident
- U Hin Kyaw - Resident
- Rowena - Resident
- Mary - Resident
- U Saw Mu Taw - Resident
- U Saw Kyay Lay - Resident
- Daw Tal Tar - Resident

Aung Mingalar

- U Zin Min Tun - Village Head
- U Aung Aung - Resident
- U Nyi Pu - Resident
- Ko Kyaw Shwe - Resident

U To

- U Thein Win village head
- U Hla Than - Resident
- U Tin Oo - Resident
- U Myo Htike - owner of solar battery charging business
- U Myo Htike's wife

Mezali

- Colonel U Thoung Win
- U Ye Kyaw Htut - owner of Ne La rice mill
- U Thein Myint - VEC member

Kyaukpyu: Accelerated Grid Extension with Launch of New Special Economic Zone

Kyaukpyu City is a port city in Rakhine state, about 400 kilometers (250 miles) northwest of Yangon. While fishing has traditionally dominated the local economy, its role has diminished in recent years. Now, with the development of a Special Economic Zone underway, launch of the Myanmar-China pipeline and the prospect for other projects, land prices and expectations for job creation are rising. Rakhine State has also been the site of social unrest over high electricity prices, reportedly as high as 1,200 kyat per unit, despite the abundance of natural resources in the region. A recent government initiative to lower electricity prices has spurred commercial activity, as locals within proximity to the mini-grid are able to access affordable, 24-hour electricity that is necessary to operate and grow small-scale industry. The Team visited the site of the SEZ as well as Kyaukpyu City center and other locations in the area. The Kyaukpyu region highlights the importance of rural electrification initiatives in driving social and economic development. It also emphasizes the potential risk of exacerbating inequality and social unrest as certain locales achieve electricity access while nearby neighbors remain unconnected.

Overview

Kyaukpyu is located in Rakhine State in western Myanmar and shares a border with Bangladesh to the northwest. Situated on the Bay of Bengal, Rakhine state comprises most of Myanmar's western coastline. The state has 3,860 villages with a population of 2.61 million. Its natural resources are substantial. Several oil and gas projects are underway with involvement of foreign and local companies.

According to government reports, Rakhine is the second poorest region in Myanmar, after Chin state. Rakhine is also the site of recent unrest between the local Muslim and Buddhist populations. This has taken a toll on the local economy and raised concerns about the state's reputation as a safe and stable place for business and investment.

MLFRD statistics suggest more than 1,000 of Rakhine's villages are electrified, equivalent to an electrification rate of 26%. Electrification in Myanmar, however, may mean 24-hours of electricity, such as that found in Kyaukpyu, a few hours of electricity accessed through a generator, solar panel or gasifier, or a few light bulbs powered by small solar units. The cost of electricity in Rakhine has traditionally been among the highest in Myanmar, with prices reported at between 400 kyat and 1,200 kyat per unit from private providers, compared with the subsidized tariff rate of 35 kyat per unit for household use of electricity from the national grid.

PTC, one such private company involved in generation and distribution that also operates in Tanintharyi region, sells electricity provided by diesel-powered generators at

460 kyat per unit. It provides electricity in Sittwe, (with 8,000-metered customers), Kyauttaw (2,000-metered customers), and Thandwe (4,000-metered customers). The price discrepancy between the subsidized tariff rate and that offered by providers such as PTC, combined with economically and socially disruptive resource extraction by foreign companies, has caused many local residents to speak out against their exclusion from reaping the benefits of their local resources.[44]

To address inequities and to allow the local population to share in the benefits of local energy resources, President Thein Sein pledged to provide lower the cost of electricity to Rakhine State by installing a 50 MW gas turbine in the region.[45] Twenty percent of the natural gas produced from the Daewoo-led Shwe project in Kyaukpyu, or 100 million cubic feet of gas, is allocated for domestic use, while the other 80% will be sent to China.[46] Twenty million cubic feet of gas a day is specifically allotted for Kyaukpyu's use, a move that has resulted in significant reductions in electricity prices.[47] Temporary gas generators provided by British firm Aggreko and managed by Parami Energy, a local company, currently supply low-cost electricity to Kyaukpyu with the allotted gas while the 50 MW power plant is constructed.

Kyaukpyu is a port city located on the northern tip of Ramree Island in Rakhine state, about 400 kilometers (250 miles) from Yangon. Kyaukpyu is also the site of a SEZ under development.

According to the local administration office, the city of Kyaukpyu, comprised of ten wards, has a population of 19,857. Kyaukpyu Township has a population of 161,998, although estimates vary.[48] About two-thirds of the township's population is located across the water from Kyaukpyu City.

A Rapidly Changing Local Economy

Kyaukpyu's economy has traditionally relied on fishing, an industry that has been in decline for the past decade, allegedly due to overfishing, dynamiting and other destructive practices. It was further hindered by the devastating impact of Cyclone Giri in 2010 and more recently by ethnic conflict. One former fisherman that was interviewed explained that after the cyclone destroyed his gear and equipment, he gave up the business after more than two decades.

Besides fishing, agricultural products in Kyaukpyu include rice, coconuts and cashews.

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[44] Nyein Nyein, Arakan residents push for more benefits from state's resources, *The Irrawaddy*, August 19, 2013
[45] Kay Zin Oo, Thein Sein Pledges Cheaper Electricity for Rakhine State, *Mizzima*, October 4, 2014
[46] Juliet Shwe Gaung, Shwe gas to power Rakhine State: minister, *The Myanmar Times*. Volume 31, No. 611. January 23-29, 2012
[47] Maung Tintone and Kay Zue, Arakan national conference calls for Rakhine to get 50% of oil and gas revenues, *Mizzima*, April 30, 2014
[48] These figures do not reflect the recent census. Nor do they account for displaced Muslim population.

Kyaukpyu is also the site of significant oil and gas resources. South Korea's Daewoo International in a consortium with Myanmar Oil and Gas Enterprises, India's GAIL and ONGC Videsh Ltd., Korea Gas Corporation and other companies are operating the Shwe gas pipeline and onshore terminal. Most of the project's more than 420 billion cubic feet of Shwe gas is sent to China, while 20 million cubic feet is allocated for Kyaukpyu. The China National Petroleum Corporation (CNPC) oil and gas pipelines delivering gas and crude oil from the Middle East to Yunnan are also situated in the Kyaukpyu area on Maday Island. Maday Island has a deep-sea port to receive oil and gas tanks from the Middle East.

Shwe Onshore gas terminal

With plans for the development of an SEZ in Kyaukpyu, the Team expects the local economy to change rapidly. In the interim, because electricity has become available 24-hours a day in certain areas and its cost per unit has dropped substantially, there is also potential for small and medium-sized enterprises to flourish.

Despite recent advances, challenges exist to Kyaukpyu’s rapid development. Local businessmen point out that lack of skilled labor is of prime concern. Daewoo reportedly had to bring welders in from Singapore due to lack of certification on the part of local welders. One businessman reported an assignment where he had taken on a job that required certification at a local wage rate and he had to bring in a worker outside which eroded all this profit. There are also concerns that while construction of the SEZ will provide employment opportunities for locals, these jobs will mainly involve hard labor and will only last for as long as construction is ongoing.

Furthermore while Kyaukpyu is no longer limited by the availability and cost of electricity, SMEs will still face other infrastructure challenges, as will industries in the SEZ. During the construction of Kyaukpyu's gas facilities, Daewoo provided a crane to assist with deployment of the generators that were brought in on a barge from Yangon. More recently, however, when a turbine was delivered to meet increasing demand, one month passed before it was able to be installed due to the lack of a proper crane.

A lack of well-built roads is another notable infrastructure challenge. In the Team's discussion with local businessmen, they mentioned they have voiced this concern to government officials. Nevertheless, local businessmen are optimistic about the future of the region, particularly given the decline of electricity prices in and near the city center.

Chinese built port on Maday Island

Bringing Affordable and Reliable Electrification to Off-grid Kyaukpyu Township

According to U Kyaw Thu Soe, the head of the local administration office, of the 261 villages in Kyaukpyu Township, up to 35 villages have electricity access, though definitions of "electricity access" within Myanmar can vary, and he counts among these 13 villages that have been given solar home systems by the MLFRD. The Ministry provided six villages with panels and solar home systems last year.

Solar home system

Team with U Kyaw Thu Soe at the township administration office

Until recently, Kyaukpyu operated on a diesel mini-grid. Under this system, electricity was reported to have cost between 400 kyat per unit and 1,200 kyat per unit, and the diesel input to run the generator cost roughly $60,000 per month. During that time, only 2,100 meters were installed, as only businesses and high-income households were able to afford electricity.

At present, the city and 17 villages are receiving 24-hour electricity from the Township's mini-grid, powered by gas generators with an installed capacity of 4.5 MW. The facility went online on September 14, 2013 and is expected to be connected to the national grid by the end of the year. The remaining five villages are powered by local diesel-generators.

Aggreko gas generators

The current gas-powered generators are operated by Parami Energy, a Myanmar firm, which, through a reported agreement with the government, receives gas free of charge from Myanma Oil and Gas Enterprise. The facility operates four gas generators from Aggreko, a public company from the UK. These include three 1 MW generators and one 1.5 MW generator. The initial installed capacity was 3 MW, however, due to increasing demand, and an additional 1.5 MW was added in March 2014. In September the initial load was only 1.2 MW. According to Parami Energy, the peak load, which occurs between 6 P.M. and 7 P.M., is currently 3.1 MW to 3.2 MW.

The Team visited the gas generator facility and met with the site manager, U Aung Kyaw Soe, and his team. There are a total of 14 employees operating the facility in shifts, 11 of which are employees of Parami Energy and three from Aggreko. The staff monitors the load and switch on generators as needed. Generators take approximately three minutes to turn on but if they have been resting for a long period of time, they need a longer period of time to warm up.

With U Aung Kyaw Soe and his team

Aggreko/Parami are operating on an 18-month contract that will end once the construction of a MEPE 50 MW gas power plant is completed. The 50 MW plant will be built in the Kyaukpyu area and is expected to feed into the national grid in September 2014. According to U Zaw Zaw, an electric engineer at the EPC office, the national grid should reach Taunggok and Thandwe in lower Rakhine state in May 2014 and An, a city 121 miles to the north of Kyaukpyu, in August 2014.

Once Aggreko/Parami's contract ends, the company will hand over the gas generation facility to MEPE. However, it is believed the Aggreko/Parami contract may be extended because, as of May 2014, construction for the 50 MW plant had reportedly not yet begun and it appears only the substations had been built.

Construction of Kyaukpyu's transmission lines and distribution network from the generating facility began in February 2013. It was reported that government policy is to provide electricity from the gas-powered mini-grid to villages within 15 miles of Kyaukpyu city. However, this only applies to villages inland on Ramree Island and not to villages across the inlet on the mainland, despite the fact that they are part of Kyaukpyu Township. The required sub-sea cabling and logistical difficulties would make grid extension very costly for those areas, which for the most part are accessible only by small boats.

Current policy allows for households up to a 100 yards from a 11/0.4 kV distribution line along the main road of Ramree Island, which runs along the shoreline, to apply for grid access on an individual basis. This is significant as in most places in Myanmar EPC requires any village seeking to gain grid access to meet 24 conditions and then to fund the extension themselves as a group rather than by individual household as here.

With U Zaw Zaw at the local EPC office

Costs of installation, wiring and connection fees, including the cost of a digital meter (90,000 kyat, compared to the 65,000 kyat analog meters) and service cables (45,000 kyat), are reported to cost a total of approximately 200,000 kyat. Households purchase cables on their own, according to specifications that EPC provides. Meters are produced in Myanmar and cables are purchased from local distributors.

It was also noted that Daewoo International, the main shareholder in the Shwe Project, provided funding for the distribution infrastructure, including cables, posts and 61 transformers. (The Daewoo-operated Shwe Project gas terminal is located in Kyaukpyu.) Two local companies were commissioned to build the network in Kyaukpyu: Ivory Naypyitaw Ltd. and West Yoma Man Daing. A local company carried out electrical installation.

With the regular availability of inexpensive electricity, villagers have begun to adapt their electricity consumption habits. The load has steadily increased as villagers have been able to afford the use of more appliances, especially rice cookers and refrigerators. At the same time, one woman in a nearby village noted she still cooks with firewood even though an electrical power source would be safer and more efficient. In fact, U Zaw Zaw reveals that during occasional power outages, villagers, instead of residents living in the city proper, are the first to call his office and complain.

Another effect of the electrification has been rising property prices along the distribution line. The Team learned of instances where properties are reported to have increased more than three times in value. Households beyond 100 yards may apply for permission to connect their households, according to one official, and EPC officials will consider these applications on a case-by-case basis.

Distribution lines along the main road

It was also acknowledged there were a few instances of households with grid access privately extending a line to their neighbors who live beyond the 100-yard parameters. However, it was reported that efforts were being made to prevent households from privately profiting from electricity sharing activity.

As of April 2014, the number of metered households has increased more than three fold to 6,664. Despite this increase, the staff at the local EPC office has remained the same, though there are plans to hire. The EPC currently has six employees devoted to meter reading. Each meter reader makes two visits to households a month: one for reading and the second for distributing electricity bills.

Kyaukpyu Special Economic Zone

Myanmar's former military government announced plans for a SEZ in Kyaukpyu in 2009. In addition to the SEZ, there are plans to build a deep-sea port, power plant, an international airport and a highway and railway system that will connect Kyaukpyu to Yunnan Province in southwest China.[49] The highway and railway system will run parallel to oil and gas pipelines built by CNPC.[50]

The SEZ will comprise 1,000 acres of land and cost an estimated $277 million for the first phase.[51] The siting of the SEZ has yet to be finalized as the initially designated site was found to be within kilometers of a mud volcano.[52] However, the government recently chose CPG Corporation of Singapore to consult and manage the project. The consulting firm was hired for US $2.4 million.[53] CPG Corporation is tasked with finding and attracting investors and companies that will develop infrastructure for the zone.[54] The firm will also assist in dealing with land issues.[55] They will have until November to find developers for the zone and in early July hosted road shows in Yangon and Singapore to present the project.

Many expect the Kyaukpyu SEZ will have a substantial portion of Chinese investors, given the heavy presence of Chinese in the area due to the new pipeline and oil and gas projects. Local businessmen have expressed concern at the prospect of Chinese dominated investors. They hope for a more diverse group of foreign investors instead.

Kyaukpyu's SEZ will be governed by the national SEZ law. To lure investors, the Parliament passed this law in January 2014 exempting both local and foreign SEZ investors from income tax for up to seven years.[56] The law also stipulates incorporating local skilled labor at graduating levels.

Separate from CPG Corporation's role, a management committee will run the Kyaukpyu SEZ[57] and will be responsible for setting wages and ensuring that local skilled labor is utilized according to the law.

Conclusions

Kyaukpyu is a unique example of off-grid households given the ability to access government-subsidized electricity rates on an individual basis through a project enabled by foreign investors. It illustrates the following:

Electricity's effect on economic growth

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[49] Gwen Robinson, Myanmar plans its own 'mini Singapore', *The Financial Times*, February 8, 2013
[50] Survey commences on railway to China, *Eleven Myanmar*, June 5, 2014
[51] Nyan Lin Aung, Singapore firm wins Kyaukpyu consultancy, *Myanmar Times*, March 17, 2014
[52] Kyaukphyu SEZ to move out of mud volcano effects, *Eleven Myanmar*, June 7, 2014
[53] CPG to invite Kyaukphyu SEZ developers, *Eleven Myanmar*, March 5, 2014
[54] Shibani Mahtani, Myanmar Envisions Trading Hub at Deep-Sea Port, *The Wall Street Journal*, May 20, 2014
[55] Nyan Lin Aung. *Op.cit.*
[56] New Law Offers Tax Incentives for Special Economic Zones, *Eleven Myanmar*, January 28, 2014
[57] Aung Shin, Contracts move forward for third 'gigantic' SEZ, *Myanmar Times*, September 15, 2013

A government-led electrification initiative in one of the country's poorest states demonstrates that regular access to affordable electricity can positively impact economic and social development. With the diesel-based mini-grid in Kyaukpyu has come rising property prices, greater use of electronic appliances and the potential for both large-scale industrial development and smaller-scale commercial activity. Business owners in surrounding villages that have been able to connect to the Kyaukpyu mini-grid have reported being able to expand operations and lower production costs. (More in Za Di Ya report.) This could prove vital to Kyaukpyu and surrounding areas given the decline of traditional industries, like fishing, and the overall low level of economic and social development in Rakhine State.

The impact of foreign investors and public-private partnerships

The mini-grid in Kyaukpyu is made possible by a government directive that prioritizes affordable electricity access for Rakhine State, as well as the involvement of Daewoo, a foreign company with an interest in long-term business operations in the region. Unlike in other villages, Daewoo provided a significant amount of the equipment required for grid connection and households in Kyaukpyu and surrounding areas are able to connect to the mini-grid on an individual basis, as opposed to relying on other households' capacity to connect. The apparent efficacy of this model demonstrates the potential for public-private partnerships in Myanmar and suggests the government should consider how emerging legislation, as well as the existing 24 Rules on Grid Connection, may facilitate individual grid connections and private sector involvement in electrification, particularly in rural or underdeveloped areas of the country.

Potential for Social Discord

Solving some of the region's problems has raised other challenges, namely the potential for affordable and reliable electrification in parts of Rakhine State to exacerbate inequality within the region. Electricity access in the Kyaukpyu area was improved so as to appease the locals who were unhappy over the discrepancies in electricity cost and availability between Rakhine State and major cities including Yangon. With the government's policy of connecting households within 15 miles of Kyaukpyu and 100 meters from main line, while leaving surrounding areas without grid access, inequality has been brought closer to home and the discrepancies in electricity access and affordability—not to mention the resultant impact on living standards and economic development—will become more apparent.

The impact of the Kyaukpyu SEZ may exacerbate this potential social discord. Locals have expressed concerns that the SEZ, dominated by foreign investors and with significant emphasis on integration with China, will only bring jobs to the region that are temporary and involve hard labor. Likewise, the benefits of rising property prices do not guarantee sustained income. This places even greater urgency on the government to develop more comprehensive off-grid rural electrification strategies for areas that are too difficult to access and/or whose populations cannot afford to connect to the national grid. Coupled with investments in infrastructure, vocational training/certification and other areas that would benefit local development, these programs could help bring more equitable develop to Rakhine State and, in the process, mitigate potential social unrest.

Interview subjects

Kyaukpyu

- U Tun Thway – Director of Uprose Japan General Trading Co., Ltd.
- U Aung Kyaw Soe – Site Manager for Parami Energy
- U Ba Lat – Former EPC engineer
- U Khin Maung Cho – Director of Cho Professional Supply
- U Zaw Lin Cho – Executive Administrator of Professional Supply
- U Kyaw Thu Soe – Head of the Kyaukpyu Administration office
- Assistant to U Kyaw Thu Soe
- U Zaw Zaw – EPC Electric Engineer
- U Aung San Myint – Head of ASM Water Purification and Bottling Company
- U Hla Aung – Local businessman in Kyaukpyu city
- U Tun Nu – Head of Kyaukpyu City development company
- U Ba Khin Pyu – Owner of Hotel Kyaukpyu

Villages

- U Hla Aung – Head of the Za Di Ya administration
- U Aung Tin – Resident of Za Di Ya
- Shop owner in Za Di Ya
- Youth from Za Di Ya working in Kyaukpyu city
- U Maung Ba Khin – Village Head of War Taung village
- Small retail merchant with solar panels
- Owner of generator (1) in War Taung village
- Owner of generator (2) in War Taung village
- Host in War Taung village

Dawei: Utilizing Public-Private Partnerships to Allow Successful Electrification

Dawei is the capital of the Tanintharyi region. It is about 230 (273 km) miles from Yangon and a six-hour drive from Bangkok. It is perhaps best known for the presence of a planned Special Economic Zone, the development of which began in 2008, led by Thai investors, and is now stalled. Average income in this region is relatively high, reported at roughly three times the national average, and there is a shortage of labor due in part to opportunities in nearby Thailand.

While the grid has not yet made its way to Dawei, there are plans for grid connection in the near future. In the meantime, households and businesses in the district reported regular, 24-hour access to electricity, provided by public-private partnerships, albeit at a cost as much as ten times or more above subsidized government rates. There were also plans for more, and existing, local distribution of electricity generated in Thailand. Despite some challenges caused by the uncertainty of the Dawei SEZ, the area highlights a number of important themes for electrification, including the role of private electricity providers and value of regional integration with Myanmar's more developed neighbors.

Overview

The city of Dawei has a population of 150,033 and 14,742 households.[1] The local economy includes fishing, trade and agriculture. In areas outside the city, locals farm betel nut, rubber, cashew nuts and rice. Dawei is also a site for coastal trade with its river port frequently unloading goods from Yangon and the Malay peninsula.

The region’s proximity to Thailand allows for a number of locals to migrate across the border to find work. There are reportedly a number of people in and around Dawei that work in Thailand for most of the year and return during the monsoon season.

Dawei is also the first proposed site for a SEZ in Myanmar. The plans include a large deep-sea port, industrial zone and highway to Thailand that is expected to be integrated into larger regional development plans. Though progress on the economic zone has stalled, many local and Thai businessmen have bought land around the zone for investment and development, leading to a rise in land prices.[58]

Dawei’s local hotel industry has slowly been growing in anticipation of the SEZ as well as rising tourism in Myanmar. Since completion of a road between the economic zone and the Thai border in October 2013, Dawei has seen a steady flow of tourists and business travelers.[59]

The Tennasserim hills along the Thai border are rich in mineral deposits, especially tin and tungsten. Prior to 2012, the area was largely inaccessible and dangerous due to the

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[58] Paul Vrieze and Htet Naing Zaw, Dawei awaits its destiny, *The Irrawaddy*, February 22, 2014
[59] Ibid.

presence of the Karen National Union. Since the signing of a ceasefire in 2012, a number of mining firms have shown interest in the area.[60]

According to one local hotel owner, even if the SEZ does not happen, he believes that tourists and many mining prospectors visiting Dawei, where licensing applications are handled, will sustain the industry as will the region's close links with Thailand.

Income in the region is higher than in most of Myanmar with average monthly income at about 3 lakhs, compared with about 2 lakhs in Tachileik, another border zone adjacent to Thailand, and 1 lakh overall for Myanmar. Given greater opportunities for employment in neighboring Thailand, Dawei faces a shortage of labor—and a shortage of skilled and/or properly certified laborers—which has driven up the daily wage to approximately 6,000 kyat for day labor, which is much higher than in other parts of Myanmar.

Electrification

From 1957 to 2005, the EPC provided diesel-generated electricity to the entire Tanintharyi region. Electricity was priced the same as it was in other parts of the country. In 2005, EPC could no longer afford the price of diesel. Cities began relying on local electrification companies that bought fuel and supplied electricity through government-owned generators.

Phoe Thee Cho (PTC), a company that began as a competitor to EPC, began to expand its services after 2005. In cooperation with EPC, the company now operates in nine cities using private generators and the transmission network built by EPC. In the course of expansion, PTC has also built and installed transmission and distribution lines.

PTC supplies 24-hour electricity to Dawei city. The city has 12,000 metered customers. According to U Khin Lay, the chief engineer of the Electricity Supply Enterprise for Tanintharyi Division, metered customers in Dawei of the lowest income on average spend around 10,000 kyat a month for electricity. The average household pays around 30,000 kyat a month, while high-income households spend an estimated 90,000 kyat a month.

Commercial users can pay as much as 2,500,000 kyat and 3,000,000 kyat (25 to 30 lakh) a month. In the past, some commercial users tried operating their own generators but due to high maintenance and operating charges, they are opting to rely on PTC's services instead. Still, electricity charges are high. One local businessman, U Kyaw Win, owner of the Palè Eikari Hotel, estimates that electricity costs account for one-third to one-half of operational costs among local businesses.

While the region is able to sustain these high electricity costs due to its strong economy and high average household income, PTC has recognized that its rates are out of reach

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[60] Paul Vrieze, Dawei village to sue Thai mining firm over environmental impacts, *The Irrawaddy*, March 17, 2014

for some residents. The company provides electricity free of charge to monasteries and very poor households. As a result, it has avoided the public outrage seen elsewhere, including in Rakhine State, over high electricity costs.

Dawei City has a total of 30 generators with an installed capacity of 9 MW. The city uses 4.5 MW at peak load. Fourteen of those generators are at the EPC office compound. All townships in the Dawei district have their own standby generators. Electricity costs approximately 470 kyat per unit in Dawei.

Generators at the EPC office compound

To add capacity and reduce dependence on diesel generators, there are plans to install a combined cycle gas plant in Kanbauk, about 50 miles north of Dawei, with gas from the Gulf of Mataban. Andaman Power Utility (APU), a Thai firm, signed a memorandum of understanding with the Department of Electric Power to study and develop a 500 MW plant.[61] According to APU, the development of 500 MW capacity will depend on the availability of gas. The initial phase will be a 20 MW to 30 MW capacity plant.[62]

The electricity generated from the combined cycle plant is intended for Dawei City. Transmission and distribution lines are currently being built. According to U Khin Lay, once the gas plant is online, electricity costs in Dawei should drop by half, to about 235 kyat per unit. This is still, however, far above the subsidized tariff rate of 35 kyat to 50 kyat per unit. Electricity production is expected to start in October.[63]

The natural gas plant in Kanbauk will eventually feed into the national grid. Plans have been made to extend the national grid down into the Tanintharyi region. The grid presently reaches Mawlamyaing, about 230 miles (370 km) north of Dawei in Mon state, and is expected to reach Dawei between 2015 and 2016. There are also plans to

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[61] Chairman Message from Andaman Power and Utility. http://www.apu.co.th/chairman.html

[62] There are differing reports on the initial capacity of the plant: the APU's website states the first phase will install a 20 MW plant while the EPC reports that it will be 30 MW.

[63] Mega Coal-Power Plants Planned in Myeik, Bokepyin, *Eleven Myanmar*, May 16, 2014

extend the grid down to Kawthoung, at the southernmost tip of Myanmar, by 2020. According to U Khin Lay, the grid extension will be financed by a loan from India.

Successful Public-Private Partnerships in Dawei District

Since 2005, cities and towns that had previously been receiving electricity from the EPC began to rely on local companies for electricity services. The local companies bought diesel fuel and supplied electricity, using government-owned generators. Private generating companies pay EPC a fee of 10 kyat for every unit of electricity it sells.

Dawei Township

As previously mentioned, PTC, a private company, operates in Dawei in cooperation with EPC. PTC's consumer base has increased five-fold since It began operation in 2002 and the company plans to expand to provide services to more villages. Additionally, PTC has negotiated an agreement with PEA, a Thai utility, to provide electricity to the Mawthoung and Tiki villages on the Thai border. Transmission lines on both sides of the border have been built. Only the cables running across the border remain to be established. Thai-generated electricity will cost 6 baht per unit, or 180 kyat per unit in Mawthoung and Tiki villages.

To operate in Tanintharyi, PTC renews its contract with EPC annually. The company has a staff of 110 employees, 30 of whom are meter readers. Meters are read on the first of every month and bills are issued on the third.

In the process of expansion, PTC has grown more efficient as a utility provider. In the past, it used government-owned generators. The generators were inefficient and consumed a significant amount of diesel. As a result, according to U Khin Lay, in its early years, the company operated at a loss. Since then, PTC uses highly efficient generators which it replaces every year. Moreover, in building new distribution lines, the company uses more expensive insulated cables to minimize distribution losses.

Outside of Tanintharyi region, PTC also operates in Rakhine state. PTC supplies electricity to households in Sittwe (8,000 meters), Kyauttaw (2,000 meters) and Thandwe (4,000 meters) at 460 kyat per unit.

According to U Aung Thu, when the national grid arrives in Dawei, PTC will relinquish its operations and the government will be responsible for distribution though he remained confident that they would be able to define a future role for PTC in the sector.

One of U Tin Myint's generators

Launglon Township

PTC's collaboration with the EPC is but one example of public-private cooperation in the Dawei district. In Launglon Town, the Team met with two private operators supplying electricity to the town of 3,000 people.

U Tin Myint works with the EPC to provide diesel-generated electricity to residents of Launglon Town. In the past, at the advice of the Tanintharyi Regional Commander, he also made an effort to operate a rice-husk gasifier for one year. Noticing that trees and fish near the gasifier began to die and after frequent complaints from villagers about the smell, U Tin Myint abandoned the gasifier and continued with the use of diesel generators.

Currently, U Tin Myint operates three generators with a total capacity of 400 KW (one 50 KW, one 150 KW and one 200 KW). The generators consume 37 drums of diesel a month (or 1,850 gallons—each drum holds 50 gallons). U Tin Myint charges consumers 600 kyat a unit. For every unit he sells he pays the EPC 10 kyat.

Switches for separate transmission lines

U Win Min Aung also supplies electricity to the town. Instead of diesel generators, he runs a rice husk gasifier. U Win Min Aung's gasifier seems not to have provoked the same complaints, though this may be because U Tin Myint's generation site is closer to the center of town. The gas generated from the gasifier powers two generators—one 200 KW and one 100 KW. He has been providing electricity to the town's residents since 2000. His customers are charged according to usage: for 1 to 10 units of consumption he charges 550 kyat per unit; 10 to 50 units, 500 kyat per unit; 50 to 100 units, 450 kyat per unit; and for 100 units and above he charges 400 kyat per unit.

The gasifier runs on 350 bags of rice husks a day. Each bag (about 7 kg) costs 80 kyat to 120 kyat. U Win Min Aung suspends the gasifier once a day between 11:30 A.M. and 1 P.M. to change the filter. However, every three to four months, the generator engines break down and requires repair.

Electricity generated from U Win Min Aung's gasifier runs on a transmission line separate from the EPC's line. The majority of the households in town own two meters and have a switch that allows them to use one provider instead of the other.

Daw Than Kyi Htwe and her husband run a small teashop in Launglon. To have 24-hours of continuous power they installed two meters. Much of their income goes toward paying their electricity bills. Last month, their bills totaled 68,500 kyat.

Daw Than Kyi Htwe's meters: the one on the right is EPC

According to Daw Than Kyi Htwe, although one source is cheaper than the other, power from the gasifier fluctuates and a regulator is needed. Furthermore, electricity from the EPC is consistent, whereas U Win Min Aung's gasifier breaks down from time to time. At the time of the Team's visit, the gasifier had been shut down for repair for a few days.

In Min Yet Village, also in Launglon Township, U Zaw Moe supplies electricity to 1,000 households within a five-mile radius of his house, where he runs his 250 KW generator. U Zaw Moe has been operating since 2005, when he applied with the EPC to provide electricity. Similar to other private operators, he pays the EPC 10 kyat for every unit he sells.

U Zaw Moe's hydro turbine

In the past he also generated electricity with a 40 KW hydro turbine. The turbine could only operate three months out of the year during rainy season. After four years with high maintenance costs, U Zaw Moe gave up on using hydropower.

At present, he relies on his generator, which he has had for three years. The generator runs from 10 A.M. to 1:30 P.M. and from 6 P.M. to 10:30 P.M. everyday. It consumes one drum of diesel (roughly 50 gallons) per day.

U Zaw Moe says his customers consume a total load of about 100 KW with each household averaging a consumption rate of 12 kWh. He charges his customers 600 kyat per unit. Installation and meter fees, not including cable costs are 100,000 kyat. The costs of cables depend on the households' distance from the distribution line.

Overall, Dawei has been unique in that a number of private operators, in cooperation with the EPC, have been allowed to participate in generation, transmission and distribution. This is the first region in which the Team has encountered successful public-private partnerships in electrification. Dawei's success could potentially serve as a model to other regions in Myanmar though higher income and prices in this area give it characteristics that make it different from other areas and therefore needs to be recognized.

Special Economic Zone

Initial Plans

After years of discussion, the governments of Myanmar and Thailand signed a memorandum of understanding in 2008 to develop an SEZ in Dawei. On November 2, 2010, both governments signed a deal with Italian-Thai Development Public Company Ltd. (ITD) allowing ITD to develop and operate the planned zone of 250 sq. km.

Development plans included the building of a deep-sea port, power plant, industrial zone and a railway and highway link to Thailand's Kanchaburi Province.[64] As part of the agreement ITD had a 75-year concession over heavy industries and a 40-year concession for light industry.[65] The heavy industrial estate would include a steel mill, oil refinery, petrochemical facility, ship-building yard and fertilizer factory.

The infrastructure for the project's initial phase was estimated to be $8 billion.[66] According to ITD, the first phase of construction would take five years and the entire project would be built in three phases over a period of a decade.[67]

There were high hopes for the project. Envisioned as a part of the ASEAN connectivity project and development of the Southern Economic Corridor, the industrial zone and especially the Dawei deep-sea port, which would be able to accommodate large tankers of up to 300,000 tons, would transform the region. It would allow goods produced and received in Dawei to be transported overland into Thailand and other parts of ASEAN and conversely from Thailand out to markets in India, Middle East and Europe bypassing the Straits of Malacca.

Setbacks

In 2012, it became clear that ITD was facing obstacles in completing the proposed plans. Early in the year, citing environmental concerns the Myanmar government stopped plans for 4,000 MW of coal power plants.[68] In July 2012, Max Myanmar, ITD's main local partner backed out from the project leaving ITD to find investors to replace Max Myanmar's 25% share in the project.[69] A Myanmar energy minister revealed that two other SEZs would likely be developed earlier than Dawei.[70] Thereafter, there were reports of ITD struggling to secure financing from investors.[71]

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[64] Kyaw Lwin Oo, Myanmar seeks new Dawei SEZ partners, *The Asia Times*, December 3, 2013
[65] An Industrial Project that Could Change Myanmar, *The International Herald Tribune*, November 26, 2010
[66] Ibid.
[67] Ibid.
[68] Myanmar scraps coal-fired power plant in Dawei, *Reuters*, January 9, 2012
[69] Myanmar tycoon says pulling out of Dawei project, *Reuters*, July 4, 2012
[70] Ibid.
[71] Italian-Thai seeks investors to replace Max Myanmar in Dawei, *Reuters*, July 6 2012

In November 2013, the Myanmar and Thai governments signed a framework agreement creating a special purpose vehicle (SPV)—the Dawei SEZ Development Co.—to oversee the Dawei project. Both governments hold a 50% share in the SPV.

Dawei as a part of plans for the Greater Mekong Sub-region

The Myanmar and Thai governments signed a series of MOUs restructuring the project.[72] The first created the SPV, which would be registered in Thailand. The agreement also indicated that special purpose companies (SPC) would be created to manage specific projects and the SPCs would be registered in Myanmar. The SEZ was reduced to 196 sq. km.

The second MOU revoked ITD's concession. Finally the third guaranteed that new investors for the ports and road would reimburse ITD an estimated 6 billion baht ($189 million) that it had already invested. ITD's completed infrastructure work would undergo a due diligence assessment, to be funded by ITD. The due diligence report will produce a more accurate figure of how much ITD will need to be reimbursed. Furthermore, ITD would be allowed to bid on projects in the future.

Local Impact

The originally planned SEZ encompassed the Nabule village tract and Ye Phyu township. There are conflicting reports as to the number of villages affected. The ITD-built exhibition hall indicates 15 villages and 4,173 households would be affected. News

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[72] Chatrudee Theparat, [NESDB sounds alarm over Dawei project](), *The Bangkok Post*, April 19, 2014

articles report between 16 to 18 villages.[73] Nevertheless, under the revised plan, only six villages are to be affected.[74]

The Team visited one of the villages to be relocated. According to residents in Mu Du, housing at the resettlement site has already been constructed. They will remain in their village until the plans for the SEZ begin again and officials ask them to leave. (More in Mu Du case study.)

Relocated villagers will be compensated for their loss of land. According to a deputy minister of social welfare, relief and resettlement, altogether compensation will amount to 340 billion kyat, about 33 billion of which has already been paid by ITD to villagers.[75] There are, however, reports of land confiscation and inadequate compensation. According to some farmers, officials have offered farmland that locals claim to be infertile or unsuitable for their crops.[76]

As for local employment opportunities, the zone's focus on heavy industries, instead of light industry such as manufacturing, is not expected to require a large work force.[77] Under ITD's management, the workers employed for construction activities were mainly migrant laborers from Thailand or upper Myanmar.[78] At the same time it should be recognized that given better opportunities in Thailand, there is generally a shortage of labor in Dawei, with the average wage for a day-laborer being approximately 6000 kyat per day. This is far higher than other areas of Myanmar.

Present Status

Although Dawei was the first proposed economic zone in Myanmar, it now looks likely that it will be the last to be developed.[79] Since taking control of the project, the Myanmar and Thai governments have been pushing for Japanese investment. However, Japan has indicated it will first focus on developing the Thilawa SEZ.[80] Furthermore, Japanese firms have suggested they will wait until basic infrastructure in Dawei has been established. This presents a dilemma for the SEZ as developing the necessary infrastructure will require investment that may not take place unless development of the SEZ is assured.

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[73] Ei Ei Toe Lwin, Dawei SEZ sparks concern amid promises, *The Myanmar Times*, December 3, 2012
[74] Kyaw Hsu Mon, In Dawei, ITD Projects Suspended, Not Terminated: Minister, *The Irrawaddy*, December 3, 2013
[75] Ibid.
[76] Kyaw Phyo Tha, Rice paddies in Dawei confiscated for housing, *The Irrawaddy*, October 28, 2013
[77] Soe Lin Aung, Workers in Dawei, *New Mandala*, September 4, 2012
[78] Ibid.
[79] Myanmar tycoon says pulling out of Dawei project. *Op.cit.*
[80] Japan to focus on Thilawa SEZ before Dawei, *Eleven Myanmar*, February 2, 2014

Gas plant site

The Team was able to visit the zone, including the visitor center and exhibition hall built by ITD. The exhibition hall features the original proposals for development, including details on resettlement construction, a LNG terminal, and water resources development for the industrial zone. With ITD no longer in control of the project, It is unknown whether future development will follow ITD's plans.

The Team was also able to visit a gas-fired power plant commissioned by MaxPower (under Navigat Group).[81] The plant's 1 MW GE Jenbacher engine runs on liquefied natural gas (LNG) supplied by LNG Plus, a Thai firm. LNG Plus, in an agreement made with ITD on December 3, 2012, was responsible for the transport and installation of the plant at ITD's construction site.[82] The re-gasification facility was built in Thailand and transported to Dawei over land.

The plant has been idle, however, since December 2013, when ITD suspended its operations pending the due diligence assessment. Two factories operating nearby do not meet the minimum 450 KW load needed and instead use diesel-generated power. The facility was built to accommodate two more engines, which were to be installed in May 2013. Upon the Team's visit, there was only one gas engine on site.

The present status of the Dawei project is unclear. Reports on the opening date for tenders for the initial phase, including the construction of a two-lane highway, port, industrial zone and other infrastructure, have been inconsistent. There are reports that tenders were to be opened at the end of March while more recent news reports mention a July tender.[83] According to certain sources in Yangon, the recent coup in Thailand may negatively affect the SEZ, given its association to the former Thai government.

The Myanmar government has reportedly brought in strategy consultancy Roland Berger—which handled the 2013 telecommunications tender to great international

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[81] Navigat Group, MAXPOWER successfully commissioned 1 MW Power Plant in Dawai, Myanmar, Company Press Release, Jun 24, 2013

[82] LNG Plus International, Completed Projects: Dawei Gas-Fired Power Plant, accessed June 15, 2014: http://lngplusinternational.com/dewei-gas.html

[83] Somluck Srimlee, Italian-Thai Development Subsidiary to raise, *The Nation*, May 2, 2014

acclaim—to devise a strategy for the SEZ moving forward. Multinational accounting firm Ernst and Young has also been reported to have been hired to conduct the due dligence assessment.

ITD, in a joint venture with Rojana industrial Park, has announced that it will bid for the initial phase. Nevertheless, it remains to be seen when and if the Dawei SEZ will go forward.

Conclusions

The Dawei region illustrates the importance of components necessary to crafting effective electrification strategies:

Public-private partnerships

Working in partnership with the local EPC, private power companies in the Dawei region have been allowed to distribute electricity to commercial and residential users, at first using government generators. These private distributors have been able to bring 24-hour electricity access to certain villages when government agencies were no longer able to afford to do so. In some cases private companies also brought expensive upgrades to make generators and cables more efficient and the technical know-how to properly maintain equipment. They have also been able to provide free electricity to certain consumers who would otherwise not be able to afford the high rates. This is an important lesson for country-wide power distribution. While the MOEP operates at a loss, upgrading aging infrastructure with newer and better-maintained equipment is a crucial component of improving energy access and cost-efficiency nationwide. Public-private partnerships in this region could serve as a model for regulating Myanmar's independent power providers, whose role in recent years has been said to be in a state of flux.

Vibrant local economy

Household income of the villages in the Dawei area were relatively high compared to other villages surveyed thus far by the Team. The robust economic activity in this area makes it possible for households and businesses to afford higher than average electricity rates that would otherwise be—and are, in areas such as Rakhine states—crippling and out of reach. The ability to sustain regular access to electricity, and pursue new sources of electrical capacity, has ignited economic activity and accelerated the area's growth.

Effective local government

These first two themes would not be present in Dawei without the strong leadership of the Tanintharyi Region's Chief Minister U Myat Ko. As in other parts of Myanmar, effective local governance in Dawei has played an important role in the region's economic and social development. More specifically, its ability to bring reliable and sustainable electricity to households and businesses is fueling economic activity and has led to the rapid establishment of new storefronts and the subsequent addition of electrical capacity from new sources. The local private power provider, PTC, credited its ability to effectively deliver power to its communication and relationship with the local government.

Regional integration

The visit to Dawei also underscored the potential benefits of regional integration, particularly for border areas. Thai companies are involved in local electricity distribution, and an agreement between a Thai utility and a Myanmar private company will allow for the distribution of Thai-generated electricity to a local village at a rate that is significantly lower than what is currently on offer. Workers from Thailand and elsewhere have migrated to the Tanintharyi Region to benefit from relatively high day-labor wages, while cross-border trade, as well as remittances sent by locals who had found work in Thailand, also boosted the villages' household income and contributed to the region's economic vitality. By the same measure, where the Thai-Myanmar relationship and long-term development plans lack clarity, such as over the future of the SEZ, broader development initiatives, including electrification plans, have been stalled. While some villages neighboring the SEZ are currently unable or unwilling to make long-term plans without knowing the fate of their land, clarity concerning the next steps for the SEZ and how the Myanmar and Thai actors will collaborate would allow the province to achieve substantial development progress.

Interview Subjects

Dawei

- U Myat Ko – Chief Minister of the Tanintharyi Region
- U Khin Lay - Divisional Engineer of the Electricity Supply Enterprise for Tanintharyi Division
- U Aung Kyaw San – EPC engineer
- U Kyaw Win – Owner of Palè Eikari Co. Ltd. and Palè Eikari Hotel
- U Aung Thu – Manager at PTC Co. Ltd.
- Navigat Group employee

Launglon

- Daw Than Kyi and her husband– Owners of a teashop in Launglon town
- U Tin Myint – Private electricity provider cooperating with EPC
- U Win Min Aung – Independent Power Producer in Launglon – through rice husk gasification
- U Zaw Moe – Independent Power Producer in Min Yet Village

Conclusions and Next Steps for Phase III Fieldwork

The extensive and in-depth Phase II Fieldwork research undertaken by the Team culminated in the development of a framework by which the feasibility of various electrification options can be assessed according to the realities of the villages in which they would be utilized. This will be supplemented within the next phase in which additional site visits will be conducted to other areas of Myanmar.

Many other actors involved in helping to develop Myanmar's energy and electricity sectors are drawing on international norms and experiences in making their recommendations. While this is important and instructive, most of these entities lack the time and resources needed to conduct the more in-depth analysis of the specific needs of Myanmar's various and diverse villages and regions which are evaluated in this study. The analytical framework developed by the Team can therefore be used by other stakeholders seeking to evaluate commonly used electrification options, such as solar home systems and generators, in Myanmar's rural populations. This analytical framework can also be extended to analyze technologies that have yet to be introduced in Myanmar, such as aneorobic digestion, which may prove amenable to local conditions in certain areas of the country. In addition, they can be used to provide and draw insight into important policy themes and issues that need to be addressed moving forward.

Next Steps Toward a Comprehensive Electrification Strategy for Myanmar

Conclusions and Recommendations for Third Phase Fieldwork to be Carried out in July-December 2014

Building on this, the Team plans to conduct more in-depth analysis of its findings to produce conclusions and recommendations based on its observations and calculations. This will comprise macro-level conclusions and recommendations concerning the development of Myanmar's rural energy and electricity operations as well as technology-specific conclusions on the costs, benefits and recommended applications of solar home systems, mini-hydro, gasifiers, generators and grid extension.

Further Engagement with Stakeholders

Continuous engagement will be maintained with stakeholders as an important component of this intiative, both from a perspective of sharing the Team's insights and ensuring the data conforms to the findings of other stakeholders and realities on the ground. The Team will continue to convene and participate in meetings both within and outside Myanmar, bringing together other policymakers, practitioners, academics, private sector actors and international donor agencies working toward the development of Myanmar's energy and electricity sector.

The team plans to share these findings with a select group of these stakeholders and once the data and findings have been sufficiently reviewed, the Team will refine this document into a research report which can be released as a publicly available report.

In addition to conferences and stakeholder meetings, the Team will continue to engage Myanmar's policymakers, to promote coordination and discussion of key issues concerning energy and electrification in Myanmar. This includes tangible issues, including: electricity policy; renewable promotion policy; environment and energy policy; energy efficiency and policy; energy technology and human resource development; energy infrastructure; and energy access in rural areas and energy poverty.

Greater Geographic Diversity

Given the importance of the village-level analysis, and the insights gleaned from the fieldwork visits to villages surrounding Kyaukpyu, Dawei and the Ayeyarwady Delta, the Team plans to supplement these analyses with more geographically diverse case studies. For example, a key focus of planned Phase III research will be to develop a better understading of the China-Myanmar energy relationship and site visits are planned for Muse, which is located on the China-Myanmar border and a few surrounding villages. Undertaking village-level analysis in Chin State in Myanmar's far north would also offer insights on the country's poorest state and how sharing a border with India may affect the area's electrification strategy, if at all. Other areas for potential research include Kachin State, if conditions allow, Myeik or Kyauthoung, on Myanmar's southernmost tip, or other areas which are deemed a priority after discussions with the MLFRD and other entities in Myanmar. Fieldwork visits to these regions would add significant depth to the Team's research and help prepare a more comprehensive vision of how to best electrify a country as diverse as Myanmar.

The latter visits would be of particular importance, given reports of cross-border cooperation in electricity development along the Myanmar-China border. The Team has witnessed such cooperation between Myanmar and Thailand, both in eastern Shan State and in more southern sections of the Myanmar-Thai border, and believes these relationships can inform Myanmar's national energy policy as well broader plans for ASEAN integration. Observing more examples of cross-border energy partnerships, and evaluating the pros and cons of such arrangements, will help develop and refine recommendations and can lend further support to the efforts being undertaken by the University of Tokyo and Chulalongkorn University in studying cross-border electrification strategies.

Areas for Additional Research

In addition to supplemental geographic focal points, the Team believes there are additional themes that would benefit from greater examination and analysis. While largely beyond the scope of planned Phase III research, these potentially include:

1. **Community relations and public information** to inform rural populations of the benefits of electrification, the costs involved and the alternatives available to grid extension
2. **Prioritization of maintenance and operations**, including training and the development of relevant certification programs, which would lead to more efficient, more reliable and safer electricity supply
3. **Appropriate legislation on tariffs and feed-in tariffs** in order to make electricity supply more sustainable as the number of people connected to the national grid expands
4. **The development of a Rural Electrification Act** and supporting legislation, designed specifically to meet the economic and social development needs of Myanmar's rural population
5. **Public-private partnerships in the energy sector** given the number of parallel, independent electrification projects that are ongoing, with the help of donor organizations and private sector actors
6. **Regional Integration**, including best practices learned from cross-border electricity agreements between Myanmar and its more developed neighbors
7. **The interaction of policy and implementation**, as rural electrification is as much a political issue as an economic one and will require considerable coordination among ministries, as well as among local, regional and national entities
8. **The feasibility of solar farms** as opposed to solar home systems, as the former help reduce the per capita costs of solar electrification

APPENDIX I

Cost Analysis Data Summary

Summary Table

		Tha Yet Taw	Kyar Kan Daung	Aung Mingalar	Mezali	U To	Za Di Ya	War Taung	Myoma	Mu Du
Village Profile	Number of Households	48	72	110	94	120	520	161	600	700
	Distance from National Grid (miles)	10	11	42	7	37	2	13	246	234
	% Poor	98%	95%	85%	11%	80%	23%	80%	7%	17%
	% Aspirant	12%	5%	15%	42%	15%	58%	15%	60%	71%
	% Emerging	0%	0%	0%	47%	5%	19%	5%	31%	12%
	% Established	0%	0%	0%	0%	0%	0%	0%	2%	0%
	% Affluent	0%	0%	0%	0%	0%	0%	0%	0%	0%
	HH Demand (KW)	6.12	10.01	19.47	65.16	26.52	263.95	35.58	401.04	346.78
	Non HH Demand (KW)	3	5	5	5	5.5	5	5	19.5	5
	Total Village Demand (KW)	9.12	15.01	24.47	70.16	32.02	268.95	40.58	420.54	351.78
Cost Estimates (USD)	Solar	34,284.58	51,737.50	79,677.08	182,618.13	98,026.04	708,797.92	121,271.09	1,044,421.88	921,937.50
	Mini-hydro	0.00	0.00	0.00	0.00	0.00	0.00	0.00	172,552.08	0.00
	Gasifier	31,610.25	34,610.25	50,641.50	77,839.42	51,391.50	220,129.79	63,349.83	312,775.63	250,338.13
	Generator	27,485.25	30,485.25	41,006.08	58,568.58	41,756.08	177,429.81	53,714.17	236,171.46	205,338.13
	Grid Extension	411,737.50	451,760.42	1,557,581.25	314,845.83	1,381,752.08	54,166.67	557,152.08	9,065,329.17	8,544,245.83

Village total cost/ KW demand								
Region	Village Name	# Households	Tot. Demand (KW)	Solar	Mini-hydro	Gasifier	Generator	Grid
Ayerwaddy	Tha Yet Taw	48	9	$3,757.30	$0.00	$3,464.21	$3,012.15	$45,122.91
	Kyar Kan Daung	72	15	$3,447.33	$0.00	$2,306.12	$2,031.27	$30,101.31
	Aung Mingalar	110	24	$3,256.11	$0.00	$2,069.53	$1,675.77	$63,652.69
	U To	120	32	$3,061.40	$0.00	$1,604.98	$1,304.06	$43,152.78
	Mezali	94	70	$2,602.85	$0.00	$1,109.44	$834.78	$4,487.49
Rakhine	Za Di Ya	520	269	$2,635.41	$0.00	$818.47	$659.71	$201.40
	War Taung	161	41	$2,988.37	$0.00	$1,561.07	$1,323.63	$13,729.38
Tanintharyi	Myoma	600	421	$2,483.53	$410.31	$743.75	$561.59	$21,556.40
	Mu Du	700	352	$2,620.78	$0.00	$711.63	$583.71	$24,288.61
	Average	269.44	137	$2,983.67	$45.59	$1,598.80	$1,331.85	$27,365.88
	Median	120.00	41	$2,988.37	$0.00	$1,561.07	$1,304.06	$24,288.61
	St. Dev.	258.78	163	$439.02	$136.77	$906.21	$812.68	$20,552.54

Total Village Cost / Households								
Region	Village Name	# Households	Tot. Demand (KW)	Solar	Mini-hydro	Gasifier	Generator	Grid
Ayerwaddy	Tha Yet Taw	48	9	$714.26	$0.00	$658.55	$572.61	$8,577.86
	Kyar Kan Daung	72	15	$718.58	$0.00	$480.70	$423.41	$6,274.45
	Aung Mingalar	110	24	$724.34	$0.00	$460.38	$372.78	$14,159.83
	U To	120	32	$816.88	$0.00	$428.26	$347.97	$11,514.60
	Mezali	94	70	$1,942.75	$0.00	$828.08	$623.07	$3,349.42
Rakhine	Za Di Ya	520	269	$1,363.07	$0.00	$423.33	$341.21	$104.17
	War Taung	161	41	$753.24	$0.00	$393.48	$333.63	$3,460.57
Tanintharyi	Myoma	600	421	$1,740.70	$287.59	$521.29	$393.62	$15,108.88
	Mu Du	700	352	$1,317.05	$0.00	$357.63	$293.34	$12,206.07
	Average	269.44	137	$1,121.21		$505.74	$411.29	$8,306.21
	Median	120.00	41	$816.88		$460.38	$372.78	$8,577.86
	St. Dev.	258.78	163	$483.32		$148.96	$112.74	$5,310.00

Operations & Maintenance

Total Estimated Operations & Maintenance Cost - Annual

Region	Village Name	# Households	Total Demand (KW)	Solar	Mini-hydro	Gasifier	Generator	Grid Extension
	Operating Hours			6	24	3	3	24
Ayerwaddy	Tha Yet Taw	48	9	$110		$5,795	$6,663	$2,878
	Kyar Kan Daung	72	15	$160		$7,178	$9,429	$4,733
	Aung Mingalar	110	24	$240		$9,402	$13,877	$7,717
	U To	120	32	$260		$11,172	$17,417	$10,092
	Mezali	94	70	$220		$20,143	$35,359	$22,126
Rakhine	Za Di Ya	520	269	$1,090		$66,874	$128,821	$84,817
	War Taung	161	41	$350		$13,190	$21,452	$12,798
Tanintharyi	Myoma	600	421	$1,260	$26,280	$102,509	$200,091	$132,621
	Mu Du	700	352	$1,450		$86,345	$167,763	$110,937

Number of panels in each village
55
80
118
129
111
542
173
628
722

Per Hour Estimated Cost - Annual

Region	Village Name	# Households	Tot. Demand (KW)	Solar	Mini-hydro	Gasifier	Generator	Grid Extension
	Operating Hours			6	24	3	3	24
Ayerwaddy	Tha Yet Taw	48	9	$18		$1,932	$2,221	$120
	Kyar Kan Daung	72	15	$27		$2,393	$3,143	$197
	Aung Mingalar	110	24	$40		$3,134	$4,626	$322
	U To	120	32	$43		$3,724	$5,806	$420
	Mezali	94	70	$37		$6,714	$11,786	$922
Rakhine	Za Di Ya	520	269	$182		$22,291	$42,940	$3,534
	War Taung	161	41	$58		$4,397	$7,151	$533
Tanintharyi	Myoma	600	421	$210		$34,170	$66,697	$5,526
	Mu Du	700	352	$242		$28,782	$55,921	$4,622

Solar

(Total number of panels)/ (5 panels per day) * (2 times a year) * ($5 a day)

Mini-Hydro

(500 KW) * (8,760 hours per year) * (60% availability) * ($0.01 per kWh); This figure is the O&M cost for a 500 KW hydro system but is actually the minimum O&M cos for 100 KW because it takes the same amount to manage both facilities

Gasifier

[[(Total Demand * 0.04667) * ($4.60 – price of diesel per gallon) * (3 hours per day)] + ($10 – daily labor charge)] * 365 days

Generator

[[(Total Demand * 0.09334) * ($4.60 – price of diesel per gallon) * (3 hours per day)] + ($6.50 – daily labor charge)] * 365 days

Grid extension

Total Demand * 8760 * .036

Note: Only Myoma had river resources needed for mini-hydro. Cost estimate does not include dam and reservoir development.

Tha Yet Taw

Village Name	Tha Yet Taw	MMK TO USD rate	960
Number of Households	48	Cost of Diesel (Kyat/ liter)	980
Distance to grid (miles)	10		
Non-household demand	1 monastery	3	

		Percentage	Kilowatt	Demand
% Poor		98%	0.12	5.6448
% Aspirant		2%	0.5	0.48
% Emerging		0%	1	0
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				6.1248
Non- household demand				3
			Total Village Demand (KW)	9.1248

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
35% Poor (Poverty) - 100W Off-grid Solar Power System	17	Solar 100Wp + Controller+Battery+Inverter+++	340,000	5,712,000	5,950
63% Poor - 150W Off-grid Solar Power System	30	Solar 150Wp + Controller+Battery+Inverter+++	435,000	13,154,400	13,703
2% Aspirant - 500W Off-grid Solar Power System	1	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	1,156,800	1,205
% Emerging - 1000W Off-grid Solar Power System	0	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	-	0
% Established - 2000W Off-grid Solar Power System	0	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	-	0
% Affluent - 3000W Off-grid Solar Power System - Monastery	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	6,730,000	7,010
The solar street light system	6	Solar 100Wp + Controller+Battery+Pole+++	360,000	2,160,000	2,250
Transportation Costs	3	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Cost	2	(for one trip -25 men-day)	500,000	1,000,000	1,042
Operation and Maintenance Cost	4	(for one trip 10 men-day)	300,000	1,200,000	1,250
TOTAL				32,913,200	34,285

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Gasifier		15 KW			
Gasifier unit - downdraft, open-core throatless	1		1,000,000	1,000,000	1,042
Water Pump, pipes and valves	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	1		1,000,000	1,000,000	1,042
Generator - duel fuel engine - 15 KW	1	3,200,000	4,160,000	4,160,000	4,333
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	56	Cable + Main Board + Braker + Lighting +++	120,000	6,720,000	7,000
Transportation Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*2*		500,000	1,000,000	1,042
Connection Fee per household Cost	*3*	(for one trip -25 men-day)	500,000	1,500,000	1,563
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	500,000	1,000,000	1,042
TOTAL				30,345,840	31,610

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Generator					
Generator (kW)		15 KW			
Generator Power by 15 KW	1	Silent Type, 3 Phase (Starter)	3,200,000	3,200,000	3,333
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	56	Cable + Main Board + Braker + Lighting +++	120,000	6,720,000	7,000
Transportation Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*2*		500,000	1,000,000	1,042
Connection Fee per household Cost	*3*	(for one trip -25 men-day)	500,000	1,500,000	1,563
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	500,000	1,000,000	1,042
Total				26,385,840	27,485

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 50KVA transformer	1	11-6.6/0.4KV, 50KVA transformer		8,160,000	8,500
Switch Gear / Distribution Panel	1			3,840,000	4,000
(50m length)	322	Total 16,100 meters		340,032,000	354,200
MEPE Earthing System	1			1,440,000	1,500
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
(50m length)	20	Total 1,000 meters		21,120,000	22,000
Supply 10KVA AVR Single Phase	*1*			1,440,000	1,500
Posts	*50*		50,000	2,500,000	2,604
per house hold cost	*56*		120,000	6,720,000	7,000
Transmission Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Cost	*2*		500,000	1,000,000	1,042
Connection Fee per household	*2*	(for one trip -25 men-day)	500,000	1,000,000	1,042
Operation and Maintenance Cost	*2*	(for one trip 10 man-day)	300,000	600,000	625
TOTAL				395,268,000	411,738

Kyar Kan Daung

Village Name		Kyar Kan Daung		
Number of Households		72	MMK TO USD rate	960
Distance to grid (miles)		11	Cost of Diesel (Kyat/ liter)	980
Non-household demand		1 Church/assembly hall; 1 Schoolhouse	5	

		Percentage	Kilowatt	Demand
% Poor		95%	0.12	8.208
% Aspirant		5%	0.5	1.8
% Emerging		0%	1	0
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				10.008
Non- household demand				5
			Total Village Demand (KW)	15.008

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
35% Poor (Poverty) - 90/100W Off-grid Solar Power System	25	Solar 100Wp + Controller+Battery+Inverter+++	340,000	8,568,000	8,925
60% Poor - 150W Off-grid Solar Power System	43	Solar 150Wp + Controller+Battery+Inverter+++	435,000	18,792,000	19,575
5% Aspirant - 500W Off-grid Solar Power System	4	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	4,338,000	4,519
% Emerging - 1000W Off-grid Solar Power System	0	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	-	0
% Established - 2000W Off-grid Solar Power System - School	1	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	4,480,000	4,667
% Affluent - 3000W Off-grid Solar Power System - Church/assembly hall	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	6,730,000	7,010
The solar street light system	6	Solar 100Wp + Controller+Battery+Pole+++	360,000	2,160,000	2,250
Transportation Costs	4	(for one trip - 2 car x 1Ton x 2 days)	600,000	2,400,000	2,500
Installation Cost	2	(for one trip -25 men-day)	500,000	1,000,000	1,042
Operation and Maintenance Cost	4	(for one trip 10 men-day)	300,000	1,200,000	1,250
TOTAL				49,668,000	51,738

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost	Village Cost
Gasifier		15 KW		(Kyat)	(USD)
Gasifier unit - downdraft, open-core throatless	1	Modular gasifier	1,000,000	1,000,000	1042
Water Pump, pipes and valves	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	1		1,000,000	1,000,000	1042
Generator - duel fuel - 15 KW	1	3,200,000	4,160,000	4,160,000	4,333
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	80	Cable + Main Board + Braker + Lighting +++	120,000	9,600,000	10,000
Transportation Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*2*		500,000	1,000,000	1,042
Connection Fee per household Cost	*3*	(for one trip -25 men-day)	500,000	1,500,000	1,563
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	500,000	1,000,000	1,042
TOTAL				33,225,840	34,610

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost	Village Cost
Generator				(Kyat)	(USD)
Generator (kW)		15 KW			
Generator Power by 15 KW	1	Silent Type, 3 Phase (Starter)	3,200,000	3,200,000	3,333
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	80	Cable + Main Board + Braker + Lighting +++	120,000	9,600,000	10,000
Transportation Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*2*		500,000	1,000,000	1,042
Connection Fee per household Cost	*3*	(for one trip -25 men-day)	500,000	1,500,000	1,563
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	500,000	1,000,000	1,042
Total				29,265,840	30,485

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 50KVA transformer	1	11-6.6/0.4KV, 50KVA transformer		8,160,000	8,500
Switch Gear / Distribution Panel	1			3,840,000	4,000
Supply and install (overhead) Cable with pole 120mm2 A.C.S.R (50m length)	354	Total 17,710 meters		373,824,000	389,400
MEPE Earthing System	1			1,440,000	1,500
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
Supply and install (overhead) Cable with pole 95mm2 A.C.S.R (50m length)	20	Total 1,000 meters		21,120,000	22,000
Supply 10KVA AVR Single Phase	*3*			1,440,000	1,500
Posts	*75*		50,000	3,750,000	3,906
per house hold cost	*80*		120,000	9,600,000	10,000
Transmission Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Cost	*2*		500,000	1,000,000	1,042
Connection Fee per household	*3*	(for one trip -25 men-day)	500,000	1,500,000	1,563
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	300,000	600,000	625
TOTAL				433,690,000	451,760

Aung Mingalar

Village Name		Aung Mingalar	**MMK TO USD rate**	960
Number of Households		110	**Cost of Diesel (Kyat/ liter)**	980
Distance to grid (miles)		42		
Non-household demand		1 Monastery; 1 school	5	
		Percentage	**Kilowatt**	**Demand**
% Poor		85%	0.12	11.22
% Aspirant		15%	0.5	8.25
% Emerging		0%	1	0
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				19.47
Non- household demand				5
			Total Village Demand (KW)	24.47

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD0
Solar Home System					
30% Poor (Poverty) - 100W Off-grid Solar Power System	33	Solar 100Wp + Controller+Battery+Inverter+++	340,000	11,220,000	11,688
55% Poor - 150W Off-grid Solar Power System	61	Solar 150Wp + Controller+Battery+Inverter+++	435,000	26,317,500	27,414
15% Aspirant - 500W Off-grid Solar Power System	17	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	19,882,500	20,711
% Emerging - 1000W Off-grid Solar Power System	0	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	-	0
% Established - 2000W Off-grid Solar Power System - School	1	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	4,480,000	4,667
% Affluent - 3000W Off-grid Solar Power System - Monastery	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	6,730,000	7,010
The solar street light system	6	Solar 100Wp + Controller+Battery+Pole+++	360,000	2,160,000	2,250
Transportation Costs	5	(for one trip - 2 car x 1Ton x 2 days)	600,000	3,000,000	3,125
Installation Cost	3	(for one trip -25 men-day)	500,000	1,500,000	1,563
Operation and Maintenance Cost	4	(for one trip 10 men-day)	300,000	1,200,000	1,250
TOTAL				**76,490,000**	**79,677**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Gasifier		40 KW			
Gasifier unit - downdraft, open-core throatless	1	Modular gasifier	5,000,000	5,000,000	5,208
Water Pump, pipes and valves	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	1		1,000,000	1,000,000	1,042
Generator - gas engine - 40 KW	1	7,500,000	9,750,000	9,750,000	10,156
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	120	Cable + Main Board + Braker + Lighting +++	120,000	14,400,000	15,000
Transportation Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*3*		500,000	1,500,000	1,563
Connection Fee per household Cost	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	*(for one trip 10 men-day)*	500,000	1,000,000	1,042
TOTAL				**48,615,840**	**50,642**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (kyat) (Kyat)	USD (USD)
Generator					
Generator (kW)		40 KW			
Generator Power by 40 KW	1	Silent Type, 3 Phase (Starter)	7,500,000	7,500,000	7,813
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	120	Cable + Main Board + Braker + Lighting +++	120,000	14,400,000	15,000
Transportation Costs (for one trip - 2 car x 1Ton x 2 days)	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*3*		500,000	1,500,000	1,563
Connection Fee per household Cost	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	*(for one trip 10 men-day)*	500,000	1,000,000	1,042
Total				**39,365,840**	**41,006**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 50KVA transformer	1	11-6.6/0.4KV, 50KVA transformer		8,160,000	8,500
Switch Gear / Distribution Panel	1			3,840,000	4,000
(50m length)	1352	Total 67,600 meters		1,427,712,000	1,487,200
MEPE Earthing System	1			1,440,000	1,500
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
(50m length)	20	Total 1,000 meters		21,120,000	22,000
Supply 10KVA AVR Single Phase	*3*			1,440,000	1,500
Posts	*113*		50,000	5,650,000	5,885
per house hold cost	*120*		120,000	14,400,000	15,000
Transmission Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Cost	*3*		500,000	1,500,000	1,563
Connection Fee per household	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	300,000	600,000	625
TOTAL				1,495,278,000	1,557,581

U To

Village Name		U To	**MMK TO USD rate**	960
Number of Households		120	**Cost of Diesel (Kyat/ liter)**	980
Distance to grid (miles)		37		
Non-household demand		1 Monastery; 1 school; 1 clinic (plans to build)	6	
		Percentage	**Kilowatt**	**Demand**
% Poor		80%	0.12	11.52
% Aspirant		15%	0.5	9
% Emerging		5%	1	6
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				26.52
Non- household demand				5.5
			Total Village Demand (KW)	32.02

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
30% Poor (Poverty) - 100W Off-grid Solar Power System	36	Solar 100Wp + Controller+Battery+Inverter+++	340,000	12,240,000	12,750
50% Poor - 150W Off-grid Solar Power System	60	Solar 150Wp + Controller+Battery+Inverter+++	435,000	26,100,000	27,188
15% Aspirant - 500W Off-grid Solar Power System	19	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	22,895,000	23,849
5% Emerging - 1000W Off-grid Solar Power System	6	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	13,800,000	14,375
% Established - 2000W Off-grid Solar Power System - School	1	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	4,480,000	4,667
% Affluent - 3000W Off-grid Solar Power System - Monastery	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	6,730,000	7,010
The solar street light system	6	Solar 100Wp + Controller+Battery+Pole+++	360,000	2,160,000	2,250
Transportation Costs	5	(for one trip - 2 car x 1Ton x 2 days)	600,000	3,000,000	3,125
Installation Cost	3	(for one trip -25 men-day)	500,000	1,500,000	1,563
Operation and Maintenance Cost	4	(for one trip 10 men-day)	300,000	1,200,000	1,250
TOTAL				**94,105,000**	**98,026**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Gasifier		40 KW			
Gasifier unit - downdraft, open-core throatless	1	Modular gasifier	5,000,000	5,000,000	5,208
Water Pump	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	*1*		1,000,000	1,000,000	1,042
Generator - duel fuel engine - 40 KW	1	7,500,000	9,750,000	9,750,000	10,156
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	126	Cable + Main Board + Braker + Lighting +++	120,000	15,120,000	15,750
Transportation Costs	3	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	3		500,000	1,500,000	1,563
Connection Fee per household Cost	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	500,000	1,000,000	1,042
TOTAL				49,335,840	51,392

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Generator					
Generator (kW)		40 KW			
Generator Power by 40 KW	1	Silent Type, 3 Phase (Starter)	7,500,000	7,500,000	7,813
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	126	Cable + Main Board + Braker + Lighting +++	120,000	15,120,000	15,750
Transportation Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*3*		500,000	1,500,000	1,563
Connection Fee per household Cost	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	500,000	1,000,000	1,042
Total				40,085,840	41,756

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 50KVA transformer	1	11-6.6/0.4KV, 50KVA transformer		8,160,000	8,500
Switch Gear / Distribution Panel	1			3,840,000	4,000
(50m length)	1191	Total 59,550 meters		1,257,696,000	1,310,100
MEPE Earthing System	1			1,440,000	1,500
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
(50m length)	20	Total 1,000 meters		21,120,000	22,000
Supply 10KVA AVR Single Phase	*3*			1,440,000	1,500
Posts	*123*		50,000	6,150,000	6,406
per house hold cost	*126*		120,000	15,120,000	15,750
Transmission Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Cost	*3*		500,000	1,500,000	1,563
Connection Fee per household	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	300,000	600,000	625
TOTAL				1,326,482,000	1,381,752

Mezali

Village Name		Mezali	**MMK TO USD rate**	960
Number of Households		94	**Cost of Diesel (Kyat/ liter)**	980
Distance to grid (miles)		7		
Non-household demand		1 Monastery; 1 school	5	
		Percentage	**Kilowatt**	**Demand**
% Poor		11%	0.12	1.2408
% Aspirant		42%	0.5	19.74
% Emerging		47%	1	44.18
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				65.1608
Non- household demand				5
			Total Village Demand (KW)	70.1608

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
3% Poor (Poverty) - 100W Off-grid Solar Power System	3	Solar 100Wp + Controller+Battery+Inverter+++	340,000	958,800	999
8% Poor - 150W Off-grid Solar Power System	8	Solar 150Wp + Controller+Battery+Inverter+++	435,000	3,271,200	3,408
42% Aspirant - 500W Off-grid Solar Power System	39	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	47,573,400	49,556
47% Emerging - 1000W Off-grid Solar Power System	44	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	101,200,000	105,417
% Established - 2000W Off-grid Solar Power System - School	1	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	4,480,000	4,667
% Affluent - 3000W Off-grid Solar Power System - Monastery	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	6,730,000	7,010
The solar street light system	15	Solar 100Wp + Controller+Battery+Pole+++	360,000	5,400,000	5,625
Transportation Costs	5	(for one trip - 2 car x 1Ton x 2 days)	600,000	3,000,000	3,125
Installation Cost	3	(for one trip -25 men-day)	500,000	1,500,000	1,563
Operation and Maintenance Cost	4	(for one trip 10 men-day)	300,000	1,200,000	1,250
TOTAL				**175,313,400**	**182,618**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Gasifier		80 KW			
Gasifier unit - downdraft, open-core throatless	1	Modular Gasifier	7,100,000	7,100,000	7,396
Water Pump, pipes and valves	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	*1*		1,000,000	1,000,000	1,042
Generator - duel fuel engine -80 KW	*1*	28,000,000	36,400,000	36,400,000	37,917
Primary Cost for Generator house and main distribution cost	*1*	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	98	Cable + Main Board + Braker + Lighting +++	120,000	11,760,000	12,250
Transportation Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	*3*		500,000	1,500,000	1,563
Connection Fee per household Cost	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	500,000	1,000,000	1,042
TOTAL				74,725,840	77,839

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Generator					
Generator (kW)		80 KW			
Generator Power by 80 KW	1	Silent Type, 3 Phase (Starter)	28,000,000	28,000,000	29,167
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	98	Cable + Main Board + Braker + Lighting +++	120,000	11,760,000	12,250
Transportation Costs	3	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Costs	3		500,000	1,500,000	1,563
Connection Fee per household Cost	4	(for one trip -25 men-day)	500,000	2,000,000	2,083
Fuel Cost per day (24 hour operating for test run)	*24*	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	2	(for one trip 10 men-day)	500,000	1,000,000	1,042
Total				56,225,840	58,569

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 50KVA transformer	1	11-6.6/0.4KV, 50KVA transformer		8,160,000	8,500
Switch Gear / Distribution Panel	1			3,840,000	4,000
(50m length)	228	Total 11,270 meters		238,656,000	248,600
MEPE Earthing System	1			1,440,000	1,500
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
(50m length)	20	Total 1,000 meters		21,120,000	22,000
Supply 10KVA AVR Single Phase	*2*			960,000	1,000
Posts	96		50,000	4,800,000	5,000
per house hold cost	98		120,000	11,760,000	12,250
Transmission Costs	*3*	(for one trip - 2 car x 1Ton x 2 days)	600,000	1,800,000	1,875
Installation Cost	*3*		500,000	1,500,000	1,563
Connection Fee per household	*4*	(for one trip -25 men-day)	500,000	2,000,000	2,083
Operation and Maintenance Cost	*2*	(for one trip 10 men-day)	300,000	600,000	625
TOTAL				302,252,000	314,846

Za Di Ya

Village Name		Za Di Ya	MMK TO USD rate	960
Number of Households		520	Cost of Diesel (Kyat/ liter)	980
Distance to grid (miles)		2		
Non-household demand		1 Monastery; 1 school;	5	

		Percentage	Kilowatt	Demand
% Poor		23%	0.12	14.352
% Aspirant		58%	0.5	150.8
% Emerging		19%	1	98.8
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				263.952
Non- household demand				5
			Total Village Demand (KW)	268.952

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
7% Poor (Poverty) - 100W Off-grid Solar Power System	36	Solar 100Wp + Controller+Battery+Inverter+++	340,000	12,376,000	12,892
16% Poor - 150W Off-grid Solar Power System	83	Solar 150Wp + Controller+Battery+Inverter+++	435,000	36,192,000	37,700
58% Aspirant - 500W Off-grid Solar Power System	302	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	363,428,000	378,571
19% Emerging - 1000W Off-grid Solar Power System	99	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	227,240,000	236,708
% Established - 2000W Off-grid Solar Power System - School	1	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	4,480,000	4,667
% Affluent - 3000W Off-grid Solar Power System - Monsatery	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	6,730,000	7,010
The solar street light system	20	Solar 100Wp + Controller+Battery+Pole+++	360,000	7,200,000	7,500
Transportation Costs	20	(for one trip - 2 car x 1Ton x 2 days)	600,000	12,000,000	12,500
Installation Cost	12	(for one trip -25 men-day)	500,000	6,000,000	6,250
Operation and Maintenance Cost	16	(for one trip 10 men-day)	300,000	4,800,000	5,000
TOTAL				680,446,000	708,798

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Gasifier		250 KW			
Gasifier unit - downdraft, open-core throatless	1	Modular Gasifier	17,800,000	17,800,000	18,542
Water Pump	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	*1*		1,000,000	1,000,000	1,042
Generator - gas engine -250 KW	1	70,000,000	91,000,000	91,000,000	94,792
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	525	Cable + Main Board + Braker + Lighting +++	120,000	63,000,000	65,625
Transportation Costs	*12*	(for one trip - 2 car x 1Ton x 2 days)	600,000	7,200,000	7,500
Installation Costs	*12*		500,000	6,000,000	6,250
Connection Fee per household Cost	*16*	(for one trip -25 men-day)	500,000	8,000,000	8,333
Fuel Cost per day (24 hour operating for test run)	*60*	less than 1 hour per gallon	4,410	264,600	276
Operation and Maintenance Cost	*10*	(for one trip 10 men-day)	500,000	5,000,000	5,208
TOTAL				**211,324,600**	**220,130**
Technology	**No of Unit**	**Size (indicate watt/length/number/amount)**	**Unit Cost (kyat)**	**Village Cost (Kyat)**	**Village Cost (USD)**
Generator					
Generator (kW)		250 KW			
Generator Power by 250 KW	1	Silent Type, 3 Phase (Starter)	70,000,000	70,000,000	72,917
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	525	Cable + Main Board + Braker + Lighting +++	120,000	63,000,000	65,625
Transportation Costs	*12*	(for one trip - 2 car x 1Ton x 2 days)	600,000	7,200,000	7,500
Installation Costs	*12*		500,000	6,000,000	6,250
Connection Fee per household Cost	*16*	(for one trip -25 men-day)	500,000	8,000,000	8,333
Fuel Cost per day (24 hour operating for test run)	*60*	less than 1 hour per gallon	1,210	72,617	76
Operation and Maintenance Cost	*10*	(for one trip 10 men-day)	500,000	5,000,000	5,208
Total				**170,332,617**	**177,430**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 150KVA transformer	1	11-6.6/0.4KV, 150KVA transformer		28,800,000	30,000
Switch Gear / Distribution Panel	1			9,600,000	10,000
(50m length)	65	Total 3,220 meters		68,640,000	71,500
MEPE Earthing System	1			1,440,000	1,500
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
(50m length)	60	Total 3,000 meters		21,120,000	22,000
Supply 10KVA AVR Single Phase	*2*			1,440,000	1,500
Posts	*525*		50,000	26,250,000	27,344
per house hold cost	*522*		120,000	62,640,000	65,250
Transmission Costs	*12*	(for one trip - 2 car x 1Ton x 2 days)	600,000	7,200,000	7,500
Installation Cost	*12*		500,000	6,000,000	6,250
Connection Fee per household	*16*	(for one trip -25 men-day)	500,000	8,000,000	8,333
Operation and Maintenance Cost	*10*	(for one trip 10 men-day)	300,000	3,000,000	3,125
TOTAL				249,746,000	260,152

Grid Extension Cost - at present	
Households without grid connection	260
Estimated cost per connection (MMK)	200,000
Total (MMK)	**52,000,000**
Total (USD)	**54,167**

War Taung

Village Name		War Taung	MMK TO USD rate	960
Number of Households		161	Cost of Diesel (Kyat/ liter)	980
Distance to grid (miles)		13		
Non-household demand		1 Monastery; 1 school	5	
		Percentage	Kilowatt	Demand
% Poor		80%	0.12	15.456
% Aspirant		15%	0.5	12.075
% Emerging		5%	1	8.05
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				35.581
Non- household demand				5
			Total Village Demand (KW)	40.581

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
30% Poor (Poverty) - 100W Off-grid Solar Power System	48	Solar 100Wp + Controller+Battery+Inverter+++	340,000	16,422,000	17,106
50% Poor - 150W Off-grid Solar Power System	81	Solar 150Wp + Controller+Battery+Inverter+++	435,000	35,017,500	36,477
15% Aspirant - 500W Off-grid Solar Power System	24	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	29,100,750	30,313
5% Emerging - 1000W Off-grid Solar Power System	8	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	18,400,000	19,167
% Established - 2000W Off-grid Solar Power System - School	1	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	4,480,000	4,667
% Affluent - 3000W Off-grid Solar Power System - Monastery	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	-	0
The solar street light system	10	Solar 100Wp + Controller+Battery+Pole+++	360,000	3,600,000	3,750
Transportation Costs	8	(for one trip - 2 car x 1Ton x 2 days)	600,000	4,800,000	5,000
Installation Cost	5	(for one trip -25 men-day)	500,000	2,500,000	2,604
Operation and Maintenance Cost	7	(for one trip 10 men-day)	300,000	2,100,000	2,188
TOTAL				116,420,250	121,271

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Gasifier		40 KW			
Gasifier unit - downdraft, open-core throatless	1	Modular gasifier	5,000,000	5,000,000	5,208
Water Pump	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	1		1,000,000	1,000,000	1,042
Generator - gas engine -40 KW	1	7,500,000	9,750,000	9,750,000	10,156
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	165	Cable + Main Board + Braker + Lighting +++	120,000	19,800,000	20,625
Transportation Costs	6	(for one trip - 2 car x 1Ton x 2 days)	600,000	3,600,000	3,750
Installation Costs	6		500,000	3,000,000	3,125
Connection Fee per household Cost	8	(for one trip -25 man-day)	500,000	4,000,000	4,167
Fuel Cost per day (24 hour operating for test run)	24	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost (for one trip 10 man-day)	5	10 man-day	500,000	2,500,000	2,604
TOTAL				60,815,840	63,350

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Generator					
Generator (kW)	1	40 KW			
Generator Power by 40 KW	1	Silent Type, 3 Phase (Starter)	7,500,000	7,500,000	7,813
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	165	Cable + Main Board + Braker + Lighting +++	120,000	19,800,000	20,625
Transportation Costs	6	(for one trip - 2 car x 1Ton x 2 days)	600,000	3,600,000	3,750
Installation Costs	6		500,000	3,000,000	3,125
Connection Fee per household Cost	8	(for one trip -25 man-day)	500,000	4,000,000	4,167
Fuel Cost per day (24 hour operating for test run)	24	less than 1 hour per gallon	4,410	105,840	110
Operation and Maintenance Cost	5	(for one trip 10 man-day)	500,000	2,500,000	2,604
Total				51,565,840	53,714

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 50KVA transformer	1	11-6.6/0.4KV, 50KVA transformer		8,160,000	8,500
Switch Gear / Distribution Panel	1			3,840,000	4,000
(50m length)	420	Total 21,000 meters		443,520,000	462,000
MEPE Earthing System	1			1,440,000	1,500
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
(50m length)	30	Total 1,500 meters		31,680,000	33,000
Supply 10KVA AVR Single Phase	*2*			960,000	1,000
Posts	*161*		50,000	8,050,000	8,385
per house hold cost	*165*		120,000	19,800,000	20,625
Transmission Costs	*6*	(for one trip - 2 car x 150m x 2 days)	600,000	3,600,000	3,750
Installation Cost	*6*		500,000	3,000,000	3,125
Connection Fee per household	*8*	(for one trip -25 men-day)	500,000	4,000,000	4,167
Operation and Maintenance Cost	*4*	(for one trip 10 men-day)	300,000	1,200,000	1,250
TOTAL				534,866,000	557,152

Myoma

Village Name		Myoma	**MMK TO USD rate**	960
Number of Households		600	**Cost of Diesel (Kyat/ liter)**	980
Distance to grid (miles)		246		
Non-household demand		5 Monastaries; 2 schools; 1 clinic;	19.5	

		Percentage	Kilowatt	Demand
% Poor		7%	0.12	5.04
% Aspirant		60%	0.5	180
% Emerging		31%	1	186
% Established		2%	2.5	30
% Affluent		0%	5	0
Total Household Demand				401.04
Non- household demand				19.5
			Total Village Demand (KW)	420.54

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
0% Poor (Poverty) - 100W Off-grid Solar Power System	0	Solar 100Wp + Controller+Battery+Inverter+++	340,000	-	0
7% Poor - 150W Off-grid Solar Power System	42	Solar 150Wp + Controller+Battery+Inverter+++	435,000	18,270,000	19,031
60% Aspirant - 500W Off-grid Solar Power System	361	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	435,005,000	453,130
31% Emerging - 1000W Off-grid Solar Power System	186	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	427,800,000	445,625
2% Established - 2000W Off-grid Solar Power System + 2 schools	14	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	62,720,000	65,333
% Affluent - 3000W Off-grid Solar Power System - 5 Monasteries	5	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	33,650,000	35,052
The solar street light system	20	Solar 100Wp + Controller+Battery+Pole+++	360,000	7,200,000	7,500
Transportation Costs	20	(for one trip - 2 car x 1Ton x 2 days)	600,000	12,000,000	12,500
Installation Cost	12	(for one trip -25 men-day)	500,000	6,000,000	6,250
Operation and Maintenance Cost	16	for four trip 10 men-day	300,000	4,800,000	5,000
TOTAL				**1,002,645,000**	**1,044,422**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost	Village Cost
Mini-Hydro				(Kyat)	(USD)
Turbine	1	100 KVA	40,000,000	40,000,000	41,667
Powerhouse	1		10,000,000	10,000,000	10,417
Generator	1		6,000,000	6,000,000	6,250
Penstock	1		20,000,000	20,000,000	20,833
Intake/head race	1		24,000,000	24,000,000	25,000
Tail race	1		10,000,000	10,000,000	10,417
Conductor Lines and Posts	1		40,000,000	40,000,000	41,667
Pipes, Accessories and general items	1		4,000,000	4,000,000	4,167
Household connections (per household)	620		7,500	4,650,000	4,844
Installation Cost	*1*		5,000,000	5,000,000	5,208
Operation and Maintenance Cost	*1*		2,000,000	2,000,000	2,083
TOTAL				165,650,000	172,552

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost	Village Cost
Gasifier		500 KW		(Kyat)	(USD)
Gasifier unit - downdraft, open-core throatless	1	Modular Gasifier	35,600,000	35,600,000	37,083
Water Pump, pipes and valves	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	*1*		1,000,000	1,000,000	1,042
Generator - gas engine -500 KW	1	119,800,000	155,740,000	155,740,000	162,229
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	620	Cable + Main Board + Braker + Lighting +++	120,000	74,400,000	77,500
Transportation Costs	*12*	(for one trip - 2 car x 1Ton x 2 days)	600,000	7,200,000	7,500
Installation Costs	*12*		500,000	6,000,000	6,250
Connection Fee per household Cost	*16*	(for one trip -25 man-day)	500,000	8,000,000	8,333
Fuel Cost per day (24 hour operating for test run)	*60*	less than 1 hour per gallon	4,410	264,600	276
Operation and Maintenance Cost	*10*	(for one trip 10 man-day)	500,000	5,000,000	5,208
TOTAL				300,264,600	312,776

Village Name		Mu Du	**MMK TO USD rate**	960
Number of Households		700	Cost of Diesel (Kyat/ liter)	980
Distance to grid (miles)		234		
Non-household demand		1 monastery; 1 school	5	
		Percentage	**Kilowatt**	**Demand**
% Poor		17%	0.12	14.28
% Aspirant		71%	0.5	248.5
% Emerging		12%	1	84
% Established		0%	2.5	0
% Affluent		0%	5	0
Total Household Demand				346.78
Non- household demand				5
			Total Village Demand (KW)	351.78

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Solar Home System					
0% Poor (Poverty) - 100W Off-grid Solar Power System	0	Solar 100Wp + Controller+Battery+Inverter+++	340,000	-	0
17% Poor - 150W Off-grid Solar Power System	119	Solar 150Wp + Controller+Battery+Inverter+++	435,000	51,765,000	53,922
71% Aspirant - 500W Off-grid Solar Power System	497	Solar 500Wp + Controller+Battery+Inverter+++	1,205,000	598,885,000	623,839
12% Emerging - 1000W Off-grid Solar Power System	84	Solar 1000Wp + Controller+Battery+Inverter+++	2,300,000	193,200,000	201,250
% Established - 2000W Off-grid Solar Power System- school	1	Solar 2000Wp + Controller+Battery+Inverter+++	4,480,000	4,480,000	4,667
% Affluent - 3000W Off-grid Solar Power System- Monastery	1	Solar 3000Wp + Controller+Battery+Inverter+++	6,730,000	6,730,000	7,010
The solar street light system	20	Solar 100Wp + Controller+Battery+Pole+++	360,000	7,200,000	7,500
Transportation Costs	20	(for one trip - 2 car x 1Ton x 2 days)	600,000	12,000,000	12,500
Installation Cost	12	(for one trip -25 men-day)	500,000	6,000,000	6,250
Operation and Maintenance Cost	16	(for one trip 10 men-day)	300,000	4,800,000	5,000
TOTAL				**885,060,000**	**921,938**

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Gasifier		350 KW			
Gasifier unit - downdraft, open-core throatless	1	Modular Gasifier	18,700,000	18,700,000	19,479
Water Pump	1		200,000	200,000	208
Ground Tank (set)	1		300,000	300,000	313
Water treatment system	1		500,000	500,000	521
Gasifier Installation cost	*1*		1,000,000	1,000,000	1,042
Generator Power by 350 K.W	1	75,000,000	97,500,000	97,500,000	101,563
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	705	Cable + Main Board + Braker + Lighting +++	120,000	84,600,000	88,125
Transportation Costs	*12*	(for one trip - 2 car x 1Ton x 2 days)	600,000	7,200,000	7,500
Installation Costs	*12*		500,000	6,000,000	6,250
Connection Fee per household Cost	*16*	(for one trip -25 men-day)	500,000	8,000,000	8,333
Fuel Cost per day (24 hour operating for test run)	*60*	less than 1 hour per gallon	4,410	264,600	276
Operation and Maintenance Cost	*10*	(for one trip 10 men-day)	500,000	5,000,000	5,208
TOTAL				240,324,600	250,338

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Generator					
Generator (kW)		350 KW			
Generator Power by 350 K.W	1	Silent Type, 3 Phase (Starter)	75,000,000	75,000,000	78,125
Primary Cost for Generator house and main distribution cost	1	Gen House + Earthing + Panel + Pole	11,060,000	11,060,000	11,521
Secondary Cost (per house hold cost)	705	Cable + Main Board + Braker + Lighting +++	120,000	84,600,000	88,125
Transportation Costs	*12*	(for one trip - 2 car x 1Ton x 2 days)	600,000	7,200,000	7,500
Installation Costs	*12*		500,000	6,000,000	6,250
Connection Fee per household Cost	*16*	(for one trip -25 men-day)	500,000	8,000,000	8,333
Fuel Cost per day (24 hour operating for test run)	*60*	less than 1 hour per gallon	4,410	264,600	276
Operation and Maintenance Cost	*10*	(for one trip 10 men-day)	500,000	5,000,000	5,208
Total				197,324,600	205,338

Technology	No of Unit	Size (indicate watt/length/number/amount)	Unit Cost (kyat)	Village Cost (Kyat)	Village Cost (USD)
Grid Extension					
Hightension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			4,992,000	5,200
Supply and install 11-6.6/0.4KV, 50KVA transformer	1	11-6.6/0.4KV, 50KVA transformer		8,160,000	8,500
Switch Gear / Distribution Panel	1			3,840,000	4,000
(50m length)	7540	Total 376,800 meters		7,962,240,000	8,294,000
MEPE Earthing System	10			14,400,000	15,000
Low Tension Line 3 Phase +N +Earth Cost					
Survey and application cost	1			624,000	650
(50m length)	60	Total 3,000 meters		63,360,000	66,000
Supply 10KVA AVR Single Phase	*2*			960,000	1,000
Posts	*702*		50,000	35,100,000	36,563
per house hold cost	*705*		120,000	84,600,000	88,125
Transmission Costs	*12*	(for one trip - 2 car x 1Ton x 2 days)	600,000	7,200,000	7,500
Installation Cost	*12*		500,000	6,000,000	6,250
Connection Fee per household	*16*	(for one trip -25 man-day)	500,000	8,000,000	8,333
Operation and Maintenance Cost	*10*	(for one trip 10 men-day)	300,000	3,000,000	3,125
TOTAL				8,202,476,000	8,544,246

Equipment

Sr	System Equipment	Qty	Unit Price	Myr Kyat	Cost USD $	Load	Remarks
	Solar Power System			1 USD $ = 960 Myr Kyat			
1		Set		**340,000**	**354**		
	Solar panel - 90/ 100Wp	1	95,000	95,000		Lighting	Can provide electricity for 6-8hours/day
	Mounting structure - Roof, pole and ground mounted	1	20,000	20,000		17 inch LCD TV + DVD player	Output voltage is customized, DC12/24V, AC 230V
	Controller - 10A	1	25,000	25,000		Radio + Fan	Battery Charger Protection, Battery Low Voltage Protection
	Battery - 12V/100AH (Maintenance free)	1	150,000	150,000			Overload Short Circuit Protection, Thermal Protection
	Inverter 300 W	1	25,000	25,000			
	Panel Box + wiring + others	1	25,000	25,000			
2	***150W Off-grid Solar Power System***	Set		**435,000**	**453**		
	Solar panel - 150Wp	1	140,000	140,000		Lighting	Can provide electricity for 6-8hours/day
	Mounting structure - Roof, pole and ground mounted	1	20,000	20,000		19 inch LCD TV + DVD player	Output voltage is customized, DC12/24V, AC 230V
	Controller - 15A	1	25,000	25,000		Radio + Fan	Battery Charger Protection, Battery Low Voltage Protection
	Battery - 12V/150AH (Maintenance free)	1	200,000	200,000			Overload Short Circuit Protection, Thermal Protection
	Inverter 300 W	1	25,000	25,000			
	Panel Box + wiring + others	1	25,000	25,000			
3	***500W Off-grid Solar Power System***	Set		**1,205,000**	**1,255**		
	Solar panel - 245Wp	2	280000	560,000		Lighting	Can provide electricity for 6-8hours/day
	Mounting structure - Roof, pole and ground mounted	1	30000	30,000		19 inch LCD TV + DVD player	Output voltage is customized, DC12/24V, AC 230V
	Controller - 20A	1	50000	50,000		Radio + Fan	Battery Charger Protection, Battery Low Voltage Protection
	Battery - 24V/150AH (Maintenance free)	2	220000	440,000		Laptop Computer	Overload Short Circuit Protection, Thermal Protection
	Inverter 1000 W	1	100000	100,000			
	Panel Box + wiring + others	1	25000	25,000			
4	***1000W Off-grid Solar Power System***			**2,300,000**	**2,396**		
	Solar panel - 245Wp	4	280000	1,120,000		Lighting	For Community Center
	Mounting structure - Roof, pole and ground mounted	1	70000	70,000		32 inch LCD TV + DVD player	School, monastery, healthcare center, assembly hall
	Controller - 20A	2	50000	100,000		Audio system	
	Battery - 24V/150AH (Maintenance free)	4	220000	880,000		Laptop Computer	
	Inverter 1000 W	1	100000	100,000			
	Panel Box + wiring + others	1	30000	30,000			

5	**5000W Off-grid Solar Power System**			**4,480,000**	**4,667**		
	Solar panel - 245Wp	8	280000	2,240,000		Lighting	For Community Center
	Mounting structure - Roof, pole and ground mounted	1	140000	140,000		32 inch LCD TV + DVD player	School, monastery, healthcare center, assembly hall
	Controller - 30A	2	80000	160,000		Audio system	
	Battery - 24V/150AH (Maintenance free)	8	220000	1,760,000		Laptop Computer	
	Inverter 5000 W	1	140000	140,000			
	Panel Box + wiring + others	1	40000	40,000			
6	**10000W Off-grid Solar Power System**			**6,730,000**	**7,010**		
	Solar panel - 245Wp	12	280000	3,360,000			
	Mounting structure - Roof, pole and ground mounted	1	200000	200,000			
	Controller - 30A	4	80000	320,000			
	Battery - 24V/150AH (Maintenance free)	12	220000	2,640,000			
	Inverter 5000 W	1	150000	150,000			
	Panel Box + wiring + others	1	60000	60,000			
7	**Solar street light system**			**360,000**	**375**		
	Solar panel - 80/ 100Wp	1	95000	95,000			
	Battery - 12V/100AH (Maintenance free)	1	120000	120,000			
	10A/24V charge controller/inverter	1	35000	35,000			
	30W LED lamp with fixture	1	50000	50,000			
	5m galvanized steel pole + base frame	1	60000	60,000			

System Equipment	Qty	Unit Price	Myr Kyat	Cost USD $	Load	Remarks
Generator Power by 15 KW	1	3,200,000	3,200,000	3,333		
Generator Power by 40 KW	1	7,500,000	7,500,000	7,813		
Generator Power by 80 KW	1	28,000,000	28,000,000	29,167		
Generator Power by 250 KW	1	70,000,000	70,000,000	72,917		
Generator Power by 350 KW	1	75,000,000	75,000,000	78,125		
Generator Power by 500 KW	1	119,800,000	119,800,000	124,792		
Primary Cost			11,060,000	11,521		
Generator House (5m x 4m x 3m) 1RC Bldg	1	5,500,000	5,500,000			
Earthing System	1	500,000	500,000			
Power Distribution Panel (100 A 3 Ph+N, 2x60A 3 Ph+N)	1	300,000	300,000			
Pole and street light	6	60,000	360,000			
Panel (60A 3ph+N, 6x30A Ph+N)	6	300,000	1,800,000			
Supply and install (underground) 3 phases + N, 30KW, cable 35mm2, XLPE/PVC 100 meter	100	26,000	2,600,000			
Secondary Cost (per house hold cost)			120,000	125		
20A single phase CBK	1	15,000	15,000			
Main Board (3 Switch + 1 Socket + 2 ft lamp)	1	20,000	20,000			
Wire (7/036 (50m) + 3/036 (25m)	1	80,000	80,000			
Tape, Clip, Lugs and others	1	5,000	5,000			

System Equipment	Qty	Unit Price	Myr Kyat	Cost USD $	Remarks
Gasifier					
Modular gasifier unit - Downdraft, open core, throatless - 15 KW	1	1,000,000	1,000,000	1,042	
Generator - Dual Fuel engine - 15 KW	1	4,160,000	4,160,000	4,333	Assuming dual fuel engine is 30% higher in price than diesel generator
Modular gasifier unit - Downdraft, open core, throatless - 40 KW	1	5,000,000	5,000,000	5,208	
Generator - Dual Fuel engine - 40 KW	1	9,750,000	9,750,000	10,156	Assuming dual fuel engine is 30% higher in price than diesel generator
Modular gasifier unit - Downdraft, open core, throatless - 80 KW	1	7,100,000	7,100,000	7,396	
Generator - Dual Fuel engine - 80 KW	1	36,400,000	36,400,000	37,917	Assuming dual fuel engine is 30% higher in price than diesel generator
Modular gasifier unit - Downdraft, open core, throatless - 250 KW	1	17,800,000	17,800,000	18,542	
Generator - Dual Fuel engine -250 KW	1	91,000,000	91,000,000	94,792	Assuming dual fuel engine is 30% higher in price than diesel generator
Modular gasifier unit - Downdraft, open core, throatless - 350 KW	1	18,700,000	18,700,000	19,479	
Generator - Dual Fuel engine -350 KW	1	97,500,000	97,500,000	101,563	Assuming dual fuel engine is 30% higher in price than diesel generator
Modular gasifier unit - Downdraft, open core, throatless - 500 KW	1	35,600,000	35,600,000	37,083	
Generator - Dual Fuel engine - 500 KW	1	155,740,000	155,740,000	162,229	Assuming dual fuel engine is 30% higher in price than diesel generator
Water pump, pipes and valves	1	200,000	200,000	208	
Ground tank	1	300,000	300,000	313	
Water treatment system	1	500,000	500,000	521	
Gasifier installation cost	1	1,000,000	1,000,000	1,042	
Primary Cost			11,060,000	11,521	
Generator House (5m x 4m x 3m) 1RC Bldg	1	5,500,000	5,500,000		
Earthing System	1	500,000	500,000		
Power Distribution Panel (100 A 3 Ph+N, 2x60A 3 Ph+N)	1	300,000	300,000		
Pole and street light	6	60,000	360,000		
Panel (60A 3ph+N, 6x30A Ph+N)	6	300,000	1,800,000		
Supply and install (underground) 3 phases + N, 30KW, cable 35mm2, XLPE/PVC 100 meter	100	26,000	2,600,000		
Secondary Cost (per house hold cost)			120,000	125	
20A single phase CBK	1	15,000	15,000		
Main Board (3 Switch + 1 Socket + 2 ft lamp)	1	20,000	20,000		
Wire (7/036 (50m) + 3/036 (25m)	1	80,000	80,000		
Tape, Clip, Lugs and others	1	5,000	5,000		

Sr	System Equipment	Qty	Unit Price	Myr Kyat	Cost USD $	Load	Remarks
	Grid Extension						
1	**Hightension Line 3 Phase +N +Earth Cost**						
	Survey and application cost				5200		Applied to Ministry of Electric Power
	Supply and install 11-6.6/0.4KV, 50KVA transformer	1			8500		Operation by MEP persons and their responsible
	Switch Gear / Distribution Panel	1			4000		
	Supply and install (overhead) Cable with pole 120mm2 A.C.S.R (50m length)	1			1,100		
	MEPE Earthing System	1			1,500		
2	**Low Tension Line 3 Phase +N +Earth Cost**						Permission by Ministry of Electric Power
	Survey and application cost				650		Operation by Local Electrician Group
	Supply and install (overhead) Cable with pole 95mm2 A.C.S.R (50m length)	1			1100		
	Supply 10KVA AVR Single Phase	1			500		

System Equipment	Qty	Unit Price	Myr Kyat	Cost USD $	Cost ($/KW)	Remarks
Mini Hydro - 2.5KW				USD		
Capital cost	1			4,500,000		Assumes $1.8 per KW
Mini-grid Medium Tension Line	1			3,000,000		Assumes 11kV, 3 Phase+N+Earth for 5km plus transformer and Switch gear
Household hook-up	1					Assumes $125 per household
Total (without household hook-up)				**7,500,000**	3,000	
O&M cost pa				130,000		Assumes $0.01 per kwh @ 60% availability for labour, maintenance & overhead
Mini Hydro - 500KW						
Capital cost	1			850,000		Assumes $1.7 per W due to lower civils cost compared to 2.5KW
Mini-grid Medium Tension Line	1			800,000		Assumes 11kV, 3 Phase+N+Earth for 2km plus transformer and Switch gear
Household hook-up	1					Assumes $125 per household
Total (without household hook-up)				**1,650,000**	3,300	
O&M cost pa				26,000		Assumes $0.01 per kwh @ 60% availability for labour, maintenance & overhead
Mini Hydro - 350KW						
Capital cost	1			595,000		Assumes $1.7 per KW due to lower civils cost compared to 2.5MW
Mini-grid Medium Tension Line	1			800,000		Assumes 11kV, 3 Phase+N+Earth for 2km plus transformer and Switch gear
Household hook-up	1					Assumes $125 per household
Total (without household hook-up)				**1,395,000**	3,986	
O&M cost pa				26,000		Assumes same labour, maintenance & overhead cost as 500KVA and 60% availability

Mini Hydro - 250KW						
Capital cost	1			425,000		Assumes $1.7 per KW due to lower civils cost compared to 2.5MW
Mini-grid Medium Tension Line	1			800,000		Assumes 11kV, 3 Phase+N+Earth for 2km plus transformer and Switch gear
Household hook-up	1					Assumes $125 per household
Total (without household hook-up)				**1,225,000**	4,900	Due to high distribution cost per KW
O&M cost pa				26,000		Assumes same labour, maintenance & overhead cost as 500KVA and 60% availability
Mini Hydro - 100KW						
Capital cost	1			170,000		Assumes $1.7 per KW due to lower civils cost compared to 2.5MW
Mini-grid Medium Tension Line	1			800,000		Assumes 11kV, 3 Phase+N+Earth for 2km plus transformer and Switch gear
Household hook-up	1					Assumes $125 per household
Total (without household hook-up)				**970,000**	9,700	Due to high distribution cost per KW
O&M cost pa				26,000		Assumes same labour, maintenance & overhead cost as 500KW and 60% availability

APPENDIX II

Figure 1 - Third Stakeholder's Meeting at UMFCCI

Myanmar Integrated Energy Policy Project
Third Stakeholder Meeting to
Improve Rural Electricity Access in Myanmar
Yangon, April 2014
Activity Review and Analysis

On 1 April 2014, the University of Tokyo ("UT") and KWR International (Asia) Pte Ltd. ("KWR") joined with the Union of Myanmar Federation of Chambers of Commerce and Industry ("UMFCCI") to organize a Third Stakeholder Meeting to Improve Electricity Access in Myanmar. This event was organized in cooperation with the Myanmar Engineering Society ("MES"), Myanmar Industries Association ("MIA") and the Investment and Industrial Development Committee, Pyithu Hluttaw. This follows two earlier stakeholder meetings organized by UT/KWR held in March and June of last year.

The prior meetings discussed initial research and fieldwork conducted by UT and KWR for inclusion as the energy component in Myanmar's Comprehensive Development Vision ("MCDV"), a policy proposal sponsored by the Economic Research Institute of ASEAN and East Asia ("ERIA"). In researching integrated energy development in Myanmar, UT and KWR emphasized evaluating prospects in different geographic areas around three themes: 1) grid extension, 2) regional integration and international cooperation, and 3) off-grid development. Through the two prior meetings and its other fieldwork and research activities, UT and KWR were able to successfully establish contact and relationships with many pubic and private sector entities involved with Myanmar's energy policy and sector.

At this present phase of research, UT and KWR are developing a more comprehensive understanding, and further definition, of potential rural electrification strategies. Accordingly, the Third Stakeholder Meeting sought to strengthen existing relationships within the public sector and to broaden the range of contacts and relationships to the private sector.

As a result, UT and KWR hosted the Third Stakeholder Meeting at UMFCCI's headquarter office in Yangon. The meeting involved nearly 50 key stakeholders from government, non-government organizations and the private sector with an interest in rural electrification in Myanmar.

The main objectives of the meeting were: 1) to facilitate a productive and open dialogue among key stakeholders concerning issues related to rural electrification in Myanmar; 2) to explain the extent, scope and goals of UT/KWR's research on rural electrification and development of an integrated energy policy in Myanmar; 3) to share and discuss UT/KWR's recent and ongoing fieldwork, including initial analyses; 4) to deepen key public and private sector stakeholder relationships to facilitate future opportunities for cooperation in policy development and potential electrification projects; and 5) to further strengthen UT/KWR's relationships with local stakeholders and expand UT/KWR's network of contacts within relevant energy-related Ministries and organizations as well as representatives of the private sector.

Third Stakeholders' Meeting

The third stakeholders' meeting brought together almost 50 participants of varied experiences in government, non-government organizations, private sector and academic institutions. Representatives from Parliament, Ministry of Livestock, Fisheries and Development, Ministry of Electric Power, Myanmar Industries Association, Myanmar Engineering Society, and UMFCCI to attended the third stakeholder meeting. (Please see Appendix for a full participant list.)

Mr. Keith Rabin of KWR opened the meeting introducing Professor Yoshikawa of the UT who commenced the proceedings with a brief introduction of UT's role in developing an integrated energy policy for Myanmar and the scope of the research conducted by UT and KWR. He emphasized that at this phase UT is interested in developing a view of energy demand from industry and other end users and welcomed the view and understanding of participants with regard to rural electrification and the future of energy use.

Dr. Maung Maung Lay, the Vice President of UMFCCI, followed with welcoming remarks. The doctor was gracious and supportive of UT's efforts and the objectives of the stakeholder meeting. He called attention to the significant changes undergone by Myanmar and the challenges of moving from authoritarianism and isolation to a more open society. Dr. Maung Maung Lay highlighted the major challenge of infrastructure in Myanmar and asserted that rural electrification is of great importance to Myanmar's development. He ended his remarks by wishing the participants a fruitful and meaningful discussion.

Following Dr. Maung Maung Lay, U Kyi Tha, member of the Pyithu Hluttaw and Secretary of the Investment and Industrial Development Committee. U Kyi Tha, summarized his view on rural electrification by addressing three key issues: legal, financial and technical support. Pointing to the experiences of the United States, India and China, U Kyi Tha illustrated the successful means by which the aforementioned governments promoted rural electrification in their respective countries. *See U Kyi Tha's presentation*

Figure 2 - U Kyi Tha speaking

In terms of legal support, and especially as a Member of Parliament, U Kyi Tha stressed the importance of legislation in advancing rural electrification. Such legislation should define a goal, as in India, and outline a means by which the government could assist rural electrification in a fair and equitable manner. This includes financial support such that villagers do not have to bear the full and burdensome cost of accessing the grid by themselves.

In the U.S., the 1936 Rural Electrification Act included a government backed loan program by which citizens could access electricity through low-cost financing. In China, there is a "one-third" policy by which the central, provincial and local governments each cover a third of the costs of electrification. U Kyi Tha provided these examples to demonstrate the means by which the Myanmar government can provide critical financial support in rural electrification efforts. U Kyi Tha also drew on the Chinese experience of government-provided technical support. In China, the central government distributes technical handbooks to every township. The handbooks include technical specifications and drawings on how to install and maintain mini-hydro turbines. U Kyi Tha requested that outside agencies such as those from the U.S. and Japan assist in issues of technical support.

Additionally, U Kyi Tha pointed out that government had to address issues of fairness. In many areas without grid access, villages and towns run on diesel generators. High fuel costs lead to exorbitant per unit costs of electricity. In U Kyi Tha's district of Gwa, in Rakhine state, electricity costs more than 600 kyat per unit. As compared to the subsidized rate of 35 kyat per unit paid by household consumers in Yangon and other markets connected to the grid, who also have the privilege of twenty-four hour electricity access, this is highly unfair.

In concluding his comments, U Kyi Tha pointed to an insightful conclusion from a 2003 study on the "Introduction of Renewable Energies in Rural Areas" by JICA. The conclusion stated that Myanmar lacked both a champion for rural electrification and a comprehensive renewable energy policy as well as coordination among its many ministries. U Kyi Tha enumerated on the many ministries involved in different aspects of renewable energy: biomass energy by the Ministry of Science and Technology, wind and hydro power by the Ministry of Electric Power, and so on. Finally, he ended with a request that UT's study go beyond a report and be of "practical help to Myanmar."

To this, Professor Yoshikawa followed with his assurance that UT had no desire to only produce a report. Professor Yoshikawa emphasized that UT's research aims to begin a process by which relevant stakeholders can achieve and advance the goal of rural electrification. This process would be difficult because energy is not a single issue, as it involves many other issues such as the economy, national security, diplomacy and education.

Professor Yoshikawa classified the major, visible challenges of Myanmar's electricity access into two categories: short term and medium to long term. In the short term, Myanmar needs to attend to the supply issues on the grid and develop an appropriate electricity tariff structure. In the medium and long term, Myanmar has to more fully address the challenges of rural electrification, investment to improve rural access, policy integration and finally technical support through human resource development. *See Professor Yoshikawa's presentation*

Understanding there are many agencies assisting and working on energy issues, and to provide a meaningful contribution, Professor Yoshikawa explained that UT is focused on off-grid issues. To do this, UT has prioritized on-the-ground research through fieldwork. To involve all relevant stakeholders, this fieldwork allows for a view from villagers – a key stakeholder – and is critical to developing a holistic policy and goals that incorporate a realistic view of energy demand.

Indeed Keith Rabin's subsequent presentation of the team's fieldwork research and impressions thus far, were well received and prompted a fruitful discussion. The presentation gave an overview of each of the six villages visited in the Ayeyarwady Delta region, including classification of estimated levels of energy demand, estimated energy demand and recommended electrification strategies. The presentation also highlighted key themes the team has encountered including the prevalence of amateur installations, the importance of leadership and entrepreneurship in villages, as well as the need to provide villagers with technical support, training and maintenance. *See Keith Rabin's presentation*

Mr. Rabin's presentation of fieldwork also included a case study of the NEDO project in Chaungthar. In 2003, NEDO installed a hybrid power system that included wind and solar PV technologies. The systems and equipment were top of the line. However, the project ceased operations in 2011. The team's study of why the hybrid power system was discontinued revealed that challenges included a relocation of the wind turbine from an intended site with better wind outputs, mismatch between technology and capacity, systems failure and population growth. The NEDO project highlighted the immense importance of understanding local capacity and input. Local officials in Chaungthar were unable to handle the advanced systems. Mr. Rabin noted that an important lesson to be learned from the NEDO project was that use of modern, advanced technology in Myanmar requires associated training in operations, maintenance and repair.

Next, in a brief presentation, Hajime Sasaki of UT, discussed how proper planning of distribution networks could be an opportunity for Myanmar to get things right from the start. Mr. Sasaki explained that transmission and distribution systems are often done without strategic planning and that the ad-hoc manner of planning causes difficulties with operating costs as well as structural disadvantages and vulnerabilities.

In many developed countries, it is too late to make radical changes to these ad hoc networks without huge disruptions and costs. However, in Myanmar, there is the opportunity to avoid these structural disadvantages. By planning for an optimal distribution network system, Mr Sasaki believes Myanmar can "save an enormous amount of money" and expand a reliable electricity grid.

Before the coffee break, there was a brief Q&A session and discussion. During the discussion, U Soe Myint, former Director General of the Minister of Energy, gave his input on rural electrification matters. U Soe Myint pointedly commented that out of a population of about 60 million people, only 30% have access to electric power. While most of the remaining 70%, which lacks access to electrical power coming from rural areas, there is currently no legislation to facilitate rural access in Myanmar. He went on toe suggest that first there should be a legal structure that allows the private sector to move ahead. He firmly supported U Kyi Tha's assessment of the three main needs of legal, financial and technical support.

Additionally, U Soe Myint noted that it is unfair that the majority of power goes to Yangon, Mandalay and Naypyidaw. In his view MOEP focuses too much of its attention on grid consumers without giving adequate thought to the unmet demand in the rural areas.
Next to comment was Ken Tun, CEO of Parami Energy. Impressed with the presentations, Mr. Tun wanted to call attention to the importance of legislation. He expressed his disappointment in the delays of the electrification law and expressed a desire for the draft law to be fast tracked to approval. In his view, there is a clear business case for the private sector to contribute to rural electrification. Moreover, he believes the private sector has a role to play in easing the government's burden of heavy subsidization of electricity and power, except "the law is the bottleneck."

After the coffee break, U Win Khaing, President of the Myanmar Engineering Society, resumed the meeting with a presentation on private sector participation in off-grid renewable energy solutions for rural electrification. U Win Khaing's thorough presentation began with a brief overview of the government's energy sector policy and objectives. To form a more coherent a national energy policy, last year the President ordered the formation of the National Energy Management Committee (NEMC), of which he is a member. *See U Win Khaing's presentation*

In presenting the government's policies, U Win Khaing provided a look at the government's future plans for power generation. These included a potential scenario for private sector to participate in power generation and distribution as independent power producers or in a joint venture with the MOEP.

Finally, in looking at rural electrification, U Win Khaing provided recent statistics on the number of electrified villages in Myanmar and the breakdown of those numbers across regions. He described Myanmar's experiences of off-grid electrification with renewables and detailed the renewables potential in biogas, solar, wind, and biomass.

U Win Khaing concluded by presenting his view on the main issues of rural electrification and the specific challenges of renewable energy based off-grid electrification. He also recognized the many ministries involved in electrification and pointed to a potential lack of clarity in roles and project execution. Further he raised the issue that with uncertainty in legal frameworks, the private sector would be reluctant to invest in off-grid projects without having a clear view of long-term returns. In highlighting the specific challenges of off –grid electrification using renewable technologies, he repeated the technical, legal and financial difficulties pointed out earlier in the meeting.

Following U Win Khaing was U Myint Zaw, the Vice President of the Myanmar Industries Association. Like the speakers before him, U Myint Zaw also pointed out the importance of leadership and legal frameworks. But he also pointed out that in tackling rural electrification, it was important to be mindful of corruption. U Myint Zaw illustrated the point by describing challenges he had in installing real time metering. He stressed that without addressing corruption, Myanmar would not be able to achieve its objectives. *See U Myint Zaw's presentation*

Figure 3 - U Myint Zaw

Further, U Myint Zaw advocated that rural electrification policy should be inclusive of all relevant and appropriate stakeholders, especially local villagers to gauge local village input and needs. Ultimately, U Myint Zaw believes that private sector involvement is crucial, not just for investment, but also important in policymaking. He ended his presentation by urging that government should work hand in hand with the private sector to achieve the goal of rural electrification.

The last speaker of the meeting was Daw Khine Khine Nwe, Joint Secretary General of UMFCCI. In her view, with all the discussion of challenges and issues, the true difficulty was in the prioritization. She noted there were social and economic benefits to rural development through electrification. However, she posed the question asking which of these benefits stakeholders would emphasize. If for economic benefit, policymakers would also need to consider developing economic activities through value-added production and along with it, training. Daw Khine Khine Nwe believes rural electrification is important for national development but ultimately achieving the objectives of development would depend on prioritization.

Figure 4 - Daw Khine Khine Nwe

Before concluding the meeting, there was another session of Q&A and discussion. Keith Rabin followed up on Daw Khine Khine Nwe's comments by pointing out that in Myanmar there is an abundance of opportunity. Yet with the enormous tasks at hand it could become a bit overwhelming. Daw Khine Khine Nwe responded by saying pragmatism was the way forward.

To Mr. Tun's earlier comments on the electrification law, U Kyi Tha elaborated on the difficulties of the legislation process. He pointed out that first of all, Myanmar's existing electricity law is 30 years old and was the product of a socialist system. Therefore, constructing a new modern law was difficult. He also explained that there was political infighting and a problem of coordination. According to U Kyi Tha, MOEP is not the only representative. In his words, "there are many players on the playground."

Further, U Kyi Tha noted the difficulties of public opinion. In late March of this year, a petition was submitted to Parliament and the President. Citing environmental concerns, the petition called to end all plans for coal-powered plants. Though plans for coal-power are going ahead, U Kyi Tha commented that public opposition and concerns were being acknowledged in an environmental bill, which is a relatively new phenomenon in Myanmar.

Next, U Zaw Wynn, former Director General of the Ministry of Electric Power, followed with some remarks and advice. He reiterated the importance of distribution and echoed similar chances of opportunity. U Zaw Wynn emphasized the importance of developing and committing to international standards early on to avoid future complications. Further, he remarked that adopting standards should not be limited to safety of equipment and installation but to quality as well.

Retired Colonel U Thoung Win, Chairman of the Energy and Renewable Energy Committee of the Myanmar Engineering Society, provided the concluding comments. He shared in the optimism of Myanmar's many opportunities and noted that stakeholders must listen to each other in order to have a medium to work together. He recognized the importance of the stakeholder meeting as a means of exchanging and hearing the different ideas, views and approaches to achieving Myanmar's electrification needs.

For his part, Colonel U Thoung Win recognized that there were many approaches and possibilities for solutions and that it was important to conduct a proper and thorough analysis before moving ahead. The Colonel also shared the contents of a policy paper that his committee is developing. The paper touches on energy efficiency and regulation and calls for a national electrification program. The paper will is awaiting approval from the President's office.

Finally, the Colonel concluded by saying that Myanmar's people have been impatient and that going forward they must be positive and optimistic.

Conclusions

The meeting revealed that expectations are high among stakeholders, who are eager to participate an involve themselves in the effort to promote rural electrification in Myanmar. Everyone recognized the immense challenges and though there was optimism, there was also concern. U Myint Zaw, Vice President of the Myanmar Industries Association, cautioned that corruption and inefficiencies must be addressed and Ken Tun, expressed doubt that Parliament could get an electricity law through anytime soon.

The prevailing theme of the stakeholder meeting was that rural electrification is a multi-faceted challenge. Accomplishing the goal of universal access to electricity will take a lot of hard work and cooperation. Given the myriad of concerns brought up by speakers and participants, the meeting also made clear that among the difficulties is prioritization, as emphasized by speaker Daw Khine Khine Nwe.

Several key points that participants sought to address, and which bear further discussion, include:
1. Enhance public –private dialogue to promote cooperation
2. Improve communication among government counterparts as well to the public
3. Establish clear legislative frameworks that include means of financial support for rural electrification efforts
4. Provide of technical support and training
5. Facilitate opportunities for the private sector
6. Clearly delineate authority within government ministries
7. Incorporate environmental and equality concerns

It is clear that the stakeholders in this meeting were well informed and knowledgeable. In fact, many of the participants in the meeting are trained engineers with extensive experience dealing with the electricity and energy sector in Myanmar. Moreover, the issues raised during the meeting demonstrate that they care deeply about equity, standards, environmental concerns and sustainability and ultimately hope to contribute to Myanmar's development. The success of future electrification efforts will depend on their ability to communicate and cooperate together.

Finally, it should be noted that discussion during the stakeholder meeting focused largely on what government should be doing and suggested that only government could move the process forward. As important as the role of government is in providing rural electrification, the private sector does not necessarily have to wait on Parliament to pass legislation. As was highlighted in the proceedings, there are opportunities for the private sector to participate in and contribute to rural electrification on the regional level. Projects under 10 MW are within the purview of regional governments and they are eager for public-private partnerships. Interested parties in the private sector should not hesitate to move forward on regional projects.

Next Steps

UT and KWR will continue with fieldwork, discussions, meetings with relevant stakeholders and it development of analysis over coming months.

There was a lot of discussion of the lack of cooperation and coordination in matters of energy policy. The exchange of ideas and views during the stakeholder meeting will have hopefully increased the likelihood of collaboration among stakeholders. Stakeholder meeting provide an important forum for such dialogue between public and private actors. As such, UT and KWR hope to organize additional stakeholder meetings in the near future.

Program Agenda

University of Tokyo • UMFCCI • KWR International

Third Stakeholder Meeting to Improve Rural Electricity Access in Myanmar
Yangon • April 1, 2014

Organized in cooperation with Economic Research Institute for ASEAN and East Asia Myanmar Engineering Society Myanmar Industries Association
Investment & Industrial Development Committee, Pyithu Hluttaw

8:30 - 9:00 Registration
9:00 - 9:05 Introduction - University of Tokyo
Professor Hisashi Yoshikawa
9:05 - 9:10 Welcoming Remarks – UMFCCI
Dr. Maung Maung Lay, Vice President, UMFCCI
9:10 - 9:20 Opening Comments: Prospects and Challenges of Rural Electrification in Myanmar
U Kyi Tha, Secy., Investment & Industrial Development Committee, Pyithu Hluttaw
9:20 - 9:40 Introduction: Integrated Energy Development/Rural Electrification in Myanmar
Professor Hisashi Yoshikawa, University of Tokyo
9:40 -10:00 Fieldwork, Off-Grid Generation and the Challenge of Rural Electrification in Myanmar
Keith Rabin, President, KWR International (Asia) PTE LTD.
10:00 -10:10 Connectivity Development among Future Mini-grids
Hajime Sasaki, University of Tokyo
10:10 -10:30 Q&A - Discussion
10:30 -10:45 Coffee Break
10:45 -11:00 Views from Myanmar's Private Sector - Myanmar Engineering Society
U Win Khaing, President
11:00 -11:15 Views from Myanmar's Private Sector - Myanmar Industries Association
U Myint Zaw, Vice President
11:15 -11:30 Views from Myanmar's Private Sector - UMFCCI
Daw Khine Khine Nwe, Joint Secretary General
11:30 -12:00 Q&A - Discussion
12:00 -12:15 Wrap-Up/Conclusion
12:15 -14:00 Lunch / Networking

Third Stakeholder Meeting to Improve Rural Electricity Access in Myanmar

Confirmed Participants

1	Hisashi Yoshikawa	Professor	University of Tokyo
2	Kensuke Yamaguchi		University of Tokyo
3	Hajime Sasaki		University of Tokyo
4	Nobuo Hashimoto		University of Tokyo
5	Masayuki Seino		University of Tokyo
6	Keith Rabin	President	KWR International (Asia) Pte Ltd.
7	Annie Su	Sr. Consultant	KWR International (Asia) Pte Ltd.
8	Kyaw Min Han	Sr. Consultant	KWR International (Asia) Pte Ltd.
9	Lynn Hteik Oo	Consultant	KWR International (Asia) Pte Ltd.
10	U Win Khaing	President	Myanmar Engineering Society
11	Dr Sein Myint	Past President	Myanmar Engineering Society
12	Col. Thoung Win	Chairman of Energy & RE Cmte	Myanmar Engineering Society
13	U Khin Maung Win	Joint General Secretary	Myanmar Engineering Society
14	Daw Khin Sandar Tun	Joint General Secretary	Myanmar Engineering Society
15	U Aung Thet Paing	Member, E & RE Cmte	Myanmar Engineering Society
16	U Myint Zaw	Vice President	Myanmar Industries Association
17	U Tin Latt	CEO	Seezar Soesan
18	U Kyi Tha	Secretary	Inv. & Infrastructure Dev. Com
19	U Kyaw Kyaw Naing	Infrastructure Consultant	Yoma Power Public Company
20	U Zaw Wynn	Former DG, MOEP	
21	U Soe Myint	Former DG, MOE	
22	U Tin Maung Ohn	Vice Chairman	Triumph Myanmar Co., Ltd
23	U Maung Maung Kyaw	Electrification Consultant	
24	Ken Tun	CEO	Parami Energy
25	U Zaw Maung	Project Mgr Power Dept.	Parami Energy
26	Daw Mya Mya Htay	National Grid Code Consultant	ADB
27	U Myo Myint	Advisor - Solar	Earth Group of Companies
28	U Phyo Min Llian	Managing Director	Llian Brothers Co.ltd
29	U Thant Zaw	Managing Director	Asia Solar Company
30	Daw Naw Ni Ni Aung	Managing Director	Sha Mu Htaung Co.,Ltd
31	Mr. Thet Tun Oo	Managing Director	Triumph Myanmar Co., Ltd
32	Mr. Simon	Technical Director	Triumph Myanmar Co., Ltd
33	U Aung Thant Oo	Business Development Director	Seezar Soesan
34	U Htin Lin Tha	Director	Yoma Power Public Company
35	Nang Shwe Yi	Business Insight	MMRD Co.
36	U Win Aung	President	UMFCCI
37	Dr. Maing Maing Lay	Vice President	UMFCCI
38	Daw Khine Khine Nwe	Joint Secy General	UMFCCI
39	U Aung Soe Tha	CEC Member	UMFCCI
40	Daw Khine Zaw	CEC Member	UMFCCI
41	U Win Myint +1	Ret. DG, MOC	UMFCCI
42	U Win Myint	Ret. DG, MOC	UMFCCI
43	Dr. Aung Thein	Vice Chair	Myanmar Industries Association
44	U Tun Naing Aung	Joint Secretary	Myanmar Industries Association
45	U Myint Than	CEC Member	Myanmar Industries Association
46	Daw Khine Zaw	CEC Member	Myanmar Industries Association
47-48		Representative 1 & 2	Ministry of Livestock, Fisheries & Rural Development

東京大学政策ビジョン研究センター
UTokyo Policy Alternatives Research Institute

KWR
INTERNATIONAL

**"မြန်မာနိုင်ငံရှိ ကျေးလက်ဒေသမီးလင်းရေးအတွက်ကဏ္ဍပေါင်းစုံမှ
ပူးပေါင်းပါဝင်ဆောင်ရွက်နိုင်ရေးဆိုင်ရာတတိယအကြိမ်ဆွေးနွေးပွဲ"**

"THIRD STAKEHOLDER MEETING TO IMPROVE RURAL ELECTRICITY ACCESS IN MYANMAR"

Organized in cooperation with

Economic Research Institute for ASEAN and East Asia
Myanmar Engineering Society
Myanmar Industries Association
Investment & Industrial Development Committee, Pyithu Hluttaw

1.4.2014
(Tuesday)

Conference Hall
UMFCCI Office Tower

APPENDIX III

ERI-PARI Joint Workshop:

ASEAN Connectivity:
Power Integration between Thailand and Myanmar

April 4, 2014, The Sukosol Hotel, Bangkok

Co-hosted by
Energy Research Institute (ERI), Chulalongkorn University And
U Tokyo Policy Alternative Research Institute (PARI), the University of Tokyo
Supported by
Economic Research Institute for ASEAN and East Asia (ERIA)

1. Objective:

Regarding electric power developments in Myanmar, this conference aims:

- to understand current situations and barriers of on-going Thai investment projects in Myanmar;
- to compare each barriers in terms of political/institutional, physical/technical, and environmental/social aspects ; and
- to draw policy implications to overcome those barriers for an expected power integration between Thailand and Myanmar

2. Outline:

After the opening of the country, Myanmar economy has remarkably progressed. Its energy development, however, has been lag behind the economic boom. The country's further progress is promising with the energy development. For the development, PARI has held stakeholder's meetings in collaboration with ERIA.

As a matter of fact, the country cannot achieve energy development without sound global/regional linkages. Focusing on the energy relationship with Thailand, this workshop tries to discuss the barriers of the Thai's electric power developments in Myanmar.

What are barriers for the Thai/Myanmar power integration? What kind of win-win relationship could be imagined through power integrations? What kind of energy policies / regulations is needed to craft win-win situation? By discussing those questions, we will draw implications for our further research.

3. Program:

Friday, April 4, 2014	
9:30-10:00 am	**Registration**
10:00-10:10 am	**Welcome Remarks** Prof. Tharapon VITIDSANT (Chula)
10:10-10:20 am	**Opening Speech: ERIA Project** Prof. Ichiro SAKATA (UTokyo)
10:20-10:30 am	**Scope of the Workshop**

	Mr. Kensuke YAMAGUCHI (Chula)
10:30-10:40 am	**Keynote: SEA Energy outlook and Perspectives on Bilateral Cooperation** Dr. Venkatachalam ANBUMOZHI (ERIA)
10:40-11:00 am	**IPP's Perspective** Mr. Danuja SIMASATHIEN (EGCO)
11:00-11:20 am	**Lessons from Neighboring Countries** Mr. Masayuki SEINO (UTokyo)
11:20-12:00 pm	**Panel I: Implications for Myanmar** Moderator: Prof. Hisashi YOSHIKAWA (UTokyo)
12:00-1:00 pm	*****Lunch*****
1:00-1:10 pm	**Opening Speech** Mr. Simpei YAMAMOTO (ERIA)
1:10-1:20 pm	**Keynote: Investment in Myanmar** TBA (JETRO)
1:20-1:40 pm	**Case Introduction: Dawei/Tasan/Hutghi** Dr. Suthee TRAIVIVATANE (Chula)
1:40-2:00 pm	**Fieldwork in Dawei** Mr. Keith W. RABIN (KWR International, Inc.)
2:00-2:20 pm	**TBA** Dr. Ukrist PATHAMANAND (Chula)
2:20-2:50 pm	**Small Group Discussion for Dawei / Tasan / Hutgi**
2:50-3:20 pm	*****Coffee Break*****
3:20-3:40 pm	**Barrier Removal: Role of JICA** Mr. Tomoyuki KAWABATA (JICA)
3:40-3:50 pm	**Q&A**
3:50-4:20 pm	**Panel II: Removal of Barriers** Moderator: Prof. Hisashi YOSHIKAWA (UTokyo)
4:20-4:40 pm	**Q&A**
4:40-4:55 pm	**Wrap Up** Prof. Hisashi YOSHIKAWA (UTokyo)
4:55-5:00 pm	**Closing Remarks** Prof. Surichai WUNGAEO (Chula)

***Outreach:**

The workshop will be summarized and outreached on a website within this year.

APPENDIX IV

140 West End Avenue, New York, NY 10023
Tel. +1-212-532-3005 • Yangon 09-421135567 • E-mail: myanmar@kwrintl.com
http://www.kwrintl.com • http://www.myanmarbusinessdevelopment.com

April 9, 2014

H.E. U Tin Ngwe
Deputy Minister, Rural Development
Ministry of Livestock, Fisheries and Rural Development
Building (36), Naypyitaw
Republic of the Union of Myanmar

Subject: Components of a Comprehensive Rural Electrification Policy

Dear Esteemed Sir,

Thank you very much for your kind support and for taking time to meet with the visiting delegation from the University of Tokyo and the KWR team during our recent visit to Naypyitaw.

We really appreciated the opportunity to engage in this detailed discussion with you concerning your Ministry's efforts to enact a comprehensive rural electrification initiative as well as potential parameters of legislation that address Myanmar's specific needs and requirements.

Following our meeting, Prof. Hisashi Yoshikawa and I discussed this matter in detail. I then asked our analytical team to prepare the following draft memo, which I am forwarding for your review. Please understand this memo is intended only as a preliminary review of this important issue, given our desire to provide it to you before Thingyan and to allow for feedback before further refinement.

Do not hesitate to forward on any questions or comments and on my return to Myanmar at the end of April I would be pleased to meet with you to discuss this in greater detail.

Finally, best wishes for you and your family as well as those of your colleagues at the Ministry of Livestock, Fisheries and Rural Development for a most enjoyable holiday and happy, healthy and prosperous New Year.

Best Regards,

KWR INTERNATIONAL, INC.

Keith W. Rabin
Keith W. Rabin
President

CC: Professor Hisashi Yoshikawa, University of Tokyo
U Soe Ko Ko, Director General, Rural Development

Turning on Myanmar's Lights:
Components of a Comprehensive Rural Electrification Policy

In 1935, the United States established a Rural Electrification Administration through an executive order. The Rural Electrification Act had the dual purpose of extending loans and other assistance for electrification to rural cooperatives and increasing employment and reviving the US economy as part of then-President Franklin Delano Roosevelt's New Deal initiative following the Great Depression.

The legislation was such a success that within two years 1.5 million farms in 45 states were electrified and the cost of distribution lines dropped from $2,000 per mile to $600 per mile. By the 1950s, virtually all US farms were electrified and the act had been extended to apply to telephone companies and other utilities looking to provide services in rural areas.

Following the success of the US Rural Electrification Act, a number of emerging economies, including India, China, South Africa and Vietnam, also enacted rural electrification legislation and policies tailored to their needs. Some of these provisions fall within broader legislation governing nation-wide electrification, long-term development plans or campaigns to promote rural electrification.

Given Myanmar's desire to advance its national economic development goals and to raise living standards and employment in rural areas - most of which currently lacks even basic electrical connectivity and capacity - adoption of its own Rural Electrification Policy with supporting legislation, policies, regulations and standards is indeed essential. To facilitate discussion concerning the parameters that should to be included in an initiative of this kind, KWR International has conducted a preliminary review of available literature and prepared the following memorandum. It highlights a number of key points that any comprehensive policy on rural electrification should consider, including:

1. Definition of rural electrification and standards for when a village is considered electrified. In the case of the United States, the term "rural area" was defined as an area with a population of 1,500 or less. Indian legislation twice changed its definition of what constituted an electrified village. Earlier versions of Indian legislation did not accurately account for all rural areas where electrification assistance was necessary, as a village only required one household or storefront to have electricity to be considered electrified. The definition was finally changed so that at least 10% of village households had to have electricity for a village to be considered electrified.

2. Targets for the percentage of the rural population and number of villages or districts to be electrified by a certain date. The broad goals set out in India's Rural Electrification Policy, for instance, seek to achieve 100% household electrification by 2012. A report by the International Energy Agency (IEA)[§§§§§§§§§§§§§§§§§§§§§] states that sound statistical data on rural populations and the electrification situation is a prerequisite to successful rural electrification policy and essential to avoiding the risk of overlooking certain remote populations in need of electrification assistance.

3. Strategy and goals for rural electrification. Electrification brings a number of improvements to the communities that receive assistance, including to quality of life, education and income-generation opportunities. Priority goals can be included in the rural electrification strategies. For instance, India aligned rural electrification strategy first with food security goals to meet the needs of agriculture and farming populations, then targeted assistance toward the development of economic activities and productive end uses. South Africa's Integrated National Electrification Programme's primary focus is on grid connectivity, as opposed to off-grid electricity solutions, while the country places special emphasis on connecting schools and clinics to priority education and healthcare.

4. Administration and governance of rural electrification. Rural electrification legislation should establish a body with the authority to make and handle loans, determine and manage electrification strategies and enforce rural electrification agendas. In the case of the United States, the Rural Electrification Administration was established to handle loans and assistance. Myanmar may consider a role for village leaders, given that University of Tokyo/KWR fieldwork suggests these leaders are highly influential and a significant indicator of a village's organization, ability to meet loan obligations and overall readiness for electrification initiatives. Likewise, the IEA report states that involvement of rural communities in electrification initiatives and decision-making processes establishes ownership, support and understanding of electrification efforts. Local and regional government is also likely to be important. Given Myanmar’s goal of electrifying 20,000 villages over the next two years - which would essentially double the number of villages with electrical capacity - consideration should also be given to development of a national entity that can help manage, coordinate and facilitate this ambitious effort.

5. Long-term budget. Rural electrification legislation must include a budget that accounts for overall loan assistance, as well as maximum loan amount, in addition to salaries, training and maintenance. The IEA points to long-term funding and sustained government support as two factors that can guarantee more effective implementation of electrification initiatives and funds.

6. Provisions on theft of electricity. Unauthorized power use is a significant concern in many developing nations, including Myanmar, and is a leading cause of transmission losses and safety issues. In India, where transmission losses rose 7% in the five years leading up to 2003-2004, the country's Electricity Act of 1910 was amended in 2003 to render theft of electricity a heavily penalized criminal offense.

[§§§§§§§§§§§§§§§§§§§§§] Comparative Study on Rural Electrification Policies in Emerging Economies, International Energy Agency, March 2010
https://www.iea.org/publications/freepublications/publication/rural_elect.pdf

7. Financing and loan assistance. Legislation should clarify the providers of loans, eligible recipients, the terms of the loan and any loan or subsidy conditions. These conditions can align with a country's development goals and electrification strategy, or be used to unify nationwide electrification initiatives. In China, for instance, loans and financial assistance are only provided for renewable sources. The level of government funding varies by province and is determined by the connections for consumers below the poverty line. In South Africa, loan recipients must meet certain level of social and economic development. In the case of India, the government grants free electricity
technical standards, which can be used to control costs, transmission losses, quality and safety of the electrification projects.

8. Involvement and management of the private sector. Rural electrification legislation must set out the appropriate roles and regulation for the private sector. This includes establishing a competitive bid process and business incentives and investor protection, as well as determining feed-in tariffs, power purchase agreements, any conditions on foreign investment and oversight of private sector involvement. In China, foreign investment is prohibited for the use of coal-fired power plants and strongly encouraged in renewable energy.

9. Maintenance and Warranty. Rural electrification legislation should consider the costs of maintaining, upgrading and replacing electrification. Otherwise electrification projects risk losing effectiveness and money over the long-term as malfunctioning or outdated equipment is abandoned. Local communities must be trained in maintenance of the systems or how to contact assistance. In India, an "after sales approach" is integrated into the design of electrification projects, whereby any project seeking financial support must incorporate plans for regular maintenance and upgrading and should demonstrate that measures will be taken to minimize technical and commercial losses.

10. Tariffs. Legislation must grant authority to a body to determine tariffs and set out a plan for the tariff amount and by what amount and procedures tariffs will be amended. Legislation should also determine if certain segments of the population will receive subsidies or free electricity and if the rates will be adjusted on a sliding scale basis.

11. Monitoring and Quality Check. Legislation should include provisions for quality monitoring, including the development of monitoring methodology and responsibility for inspections. In Brazil, Eletrobrás, a federally-owned holding company for electricity assets which, through its subsidiaries, controls a large part of the country's electric power generation and transmission systems, is in charge of quality monitoring. In India, states are asked to form state-level coordination committees required to meet regularly to resolve any issues that could slow project development. States are also required to form District Committees with representatives from various stakeholders, including elected members and local communities. A web-based monitoring system has also been introduced at village level for implementing agencies to provide all data related to activities carried out.

12. Supporting legislation, policies and campaigns. Supplemental legislation, including campaigns dedicated to rural electrification goals and long-term development plans that include relevant measures such as access to credit or energy efficiency policies, can support the implementation of rural electrification initiatives. Brazil, for instance, launched a series of campaigns—Energy Development Programme of States and Municipalities, Light in the Countryside and Light for All—which helped the country achieve an overall electrification rate of 97.8 percent (and 88 percent in rural areas) by 2009. India's 11th Five-Year Plan is credited with accelerating electrification in the country by cultivating strong political will and funding.

APPENDIX V

Twenty-Four MOEP Conditions Allowing Grid Connection

In the presence of responsible personnel of Department of Power Transmission and Distribution, Electrical Power Transmission and Distribution, Ministry for Electrical Power No (2), Nay-pyi-daw, the three members of Village Electricity Supply Committee of Pauk-Kon Village, Pauk-Kon Village Tract, Pathein, Ayeyarwady Region, signed the agreement on the following 24 items to be followed in the implementation of the tasks for the access to the electricity in their village.
24 items to be pledged and performed by the Electricity Supply Committee

1) The committee shall have public agreement.
2) It shall be well established.
3) Sufficient amount of money shall be saved to do that task. (This money shall be able to shown in term of a bank account.)
4) The posts supporting the electric wires/power cables shall be the concrete ones having the following specifications.
   a) Standard 12 M concrete posts for 33 KV line
   b) Standard 10 M concrete posts for 11 KV line
   c) Standard 9 M concrete posts for 400 line
5) The power cables shall be the ones having the following specifications.
   a) ACSR 120 mm^2 (or) 150 mm^2 cables shall be used to take electricity from 33 KV line owned by Ministry for Electrical Power No (2).
   b) ACSR 95 mm^2 cables shall be used to take electricity from 11 KV line owned by Ministry for Electrical Power No (2).
   c) The construction of 400 V line in the village shall have the following specifications
      - HDBC Wire No 4 shall be used for 5 lines of triple-strand wire in 400 V line.
      - HDBC Wire No 6 shall be used for 3 lines of double-strand wire in 400 V line.
      - HDBC Wire No 6 shall be used for 2 lines of single-strand wire in 230 V line.
      - HDBC Wire No 8 shall be used for roadside bulbs.
6) Specific cross-arm shall be fixed in posts.
7) Standard pin-insulator horn shall be used.
8) Standard transformers produced domestically, which are permitted to use by Ministry for Electrical Power No (2), shall be used. Red, yellow and blue colours shall be used in electric wires, switches and nodes. Other colours shall not be used. The substation for transformers shall be built in specific model. A fence having 16 feet each side shall be built around the substation and it shall be obstructed with wire mesh. The floor of the substation shall be the cement one.

9) Roadside lights shall be included.
10) The committee shall bear expenses for losses.
11) Electricity utilization shall be according to the specific days agreed.
12) The posts shall be supported with the concrete footings (2 x 2 x 2 ½ ft high) according to the specific standards and these footings shall be built 6 inches over the ground and 2 feet in the ground.
13) Trees and bushes shall be cleared up completely within the specific distance from electrical power lines and posts.
    a) Trees and bushes shall be cleaned up completely within the area of 20 feet – 10 feet to the left and 10 feet to the right from the centre of 11 KV line. There shall be no trees 10 feet high or higher within 5 feet on both sides of the cleaned-up area. (illustration attached)
    b) Trees and bushes shall be cleaned up completely within the area of 10 feet – 5 feet to the left and 5 feet to the right from the centre of 400 V line. There shall be no trees 10 feet high or higher within 5 feet on both sides of the cleaned-up area. (illustration attached)
14) Since the project is not considered completed as soon as the electric power lines, posts and transformers have been constructed, the electricity supply committee shall save "maintenance fund" because the strength of transformers, posts and electric power lines shall always be examined and they shall always be repaired and maintained.
15) If the transformers used in the private electric power line are destroyed due to natural disasters, the maintenance fund saved by the electricity supply committee shall be spent for repairing works.
16) The committee members shall sign the agreement that Ministry for Electrical Power No (2) shall not be asked for help or donation to get the materials free of charge which are needed in implementing for electricity supply and that Ministry for Electrical Power shall not be asked for help to get the materials free of charge with the help of other people.
17) The committee shall sign the agreement that the steps in implementing for the access to electricity supply shall be carried out by making plans within the period of at least four years.

a) First Year	- Making posts
b) Second Year	- Fixing cross-arm and pin-insulator horn to the posts and connecting cables
c) Third Year	- Building substations
d) Fourth Year	- Finish connecting cables and accessing electricity supply

18) If the construction of electric power lines and substations are to be carried out by external technicians, they shall hold certificate of electrical inspection Grade (1) recommended by Ministry for Industry No (1). Lists of items to be used in construction works and maps of the electric power lines and substations shall be

presented to the chief engineer of Department of Electrical Power Distribution and his permission shall be taken.

19) Concerned with the access to the electricity in the village, the permission is only for the village having the savings relied on themselves. If the project cannot be implemented as the village's programme, and if the help from others are asked for or the donation is asked for, the project for the access to the electricity in the village shall not be permitted. And even if it has been permitted but it is found out that there is asking for donation here and there, the permission shall be terminated.

20) The permission for the installation and implementation of the access to the electricity in the village relying on the village itself is not the permission for the 24 hours electricity utilization. The permission is just the preparation for the future electricity supply programme, aiming to be ready to be able to utilize the electricity when there will be enough electricity supply in future. An agreement shall be signed to show the proof of knowing that the distribution of the electrical power is based on the electrical power gained.

21) To implement the access to the electricity, the village electricity supply committee shall contact directly to Ministry of Electric Power No (2) with the state and/or divisional electrical engineers and shall make a formal promise not to contact with brokers and agencies.

22) While getting the electric power for the access to the electricity in the village, there shall be a formal promise made not to take the electric power connecting with the electric power lines which are not of Ministry of Electric Power No (2) such as the electric power lines of other ministries, those of the army, those of industrial zones and so on. The electric power shall only be taken from the lines allowed by Ministry of Electric Power No (2). For example, the electric power shall not be allowed to take from the lines such as those for pumping up the river water, those by industries and workshops, those by airway, those by navigation, those by the hospital, those by Myanmar Economic Bank, those by battalions and military units, private electric power lines.

23) The committee shall agree on knowing that unless the above 22 items for implementing access to the electricity supply are followed, the permission for implementing access to the electricity supply be cancelled.

24) The committee members shall agree on understanding that they shall be sued by Department of Electrical Power Transmission and Distribution, on behalf of villagers and the ministry, together with the representative of the villagers as the plaintiff if they misuse, do wrong and unfairly spend the money collected from villagers without spending it for any tasks related to implementing access to the electricity in the village.

Agreed on the above 24 items to be followed in implementing access to the electricity supply

APPENDIX VI

WORLD BANK:
The Third Workshop on the Development of Myanmar National Electrification Plan
Grand Ballroom, Thingaha Hotel, Nay Pyi Taw

Thursday, March 20, 2014

Draft Agenda

Hour	Session	Presenter
08:00 – 08:30	Registration of participants	
08:30 – 09:00	Opening remarks	U Khin Maung Soe, Union Minister, MOEP Mr. Ohn Myint, Union Minister, MLFRD Ms. Julia Fraser, Sector Manager, The World Bank Group
09:00 – 09:30	Coffee/Tea break	
	Session #1: Interim Results of the NEP Study	
09:30 – 09:45	**NEP Study: Implementation Progress** Presenter: Dr. Xiaoping Wang, Senior Energy Specialist, The World Bank	Chairs: U Zaw Oo, Economic Advisor to the President Ms. Julia Fraser, Sector Manager, The World Bank Group
09:45 – 11:15	**Myanmar Geospatial Least-Cost Electrification Plan** Presenter: Dr. Vijay Modi, Professor, Columbia University Q&A Topics: Methodologies and key assumptions for geospatial, least-cost planning analysis Interim results of electrification rollout plans for Kayin and Chin States	
11:15 – 12:30	**3. Institutional Framework for NEP Implementation** Presenter: Mr. Alex Sundakov, Executive Director, Castalia Strategic Advisors Topics: Institutional challenges and barriers to electrification faced in Myanmar Institutional requirements for a programmatic, sector wide approach Institutional options for implementing NEP	Chairs: U Tin Maung Than, Policy Advisor to the President Dr. Dejan Ostojic, Energy Sector Leader, The World Bank
12:30 – 14:00	Lunch	
	Session #1: Interim Results of the NEP Study	

	(Continued)	
14:00 – 15:15	**Universal Access Roadmap and Investment Prospectus** Presenter: Mr. Peter Hoogland, Director, Castalia Strategic Advisors Topics: Methodologies and key assumptions for developing investment prospectus Interim results for Kayin and Chin States	Chairs: U Tin Htut Oo, Social Economic Advisor to the President Mr. Chong Chi Nai, Director, Southeast Asia, Energy Division, ADB
15:15 – 15:45	Coffee/Tea break	
	Session #2: Development Partners' Initiatives Supporting National Electrification	
15:45 – 16:00	**5. Off-grid Electrification: Field Findings** Presenter: Mr. Chong Chi Nai, Director, Southeast Asia, Energy Division, ADB	Chairs: Ms. Julia Fraser, Sector Manager, The World Bank Group Kyosuke Inada, Senior Representative, JICA Myanmar Office
16:00 – 16:15	**6. Electricity (Power Sector) Master Plan: Update and Implications for Electrification** Presenters: Mr. Satoshi Yamaoka, Newjec Mr. Seiji Ueoka, Kansai Electric	
16:15 – 16:30	**7. UNIDO's Support in Energy Access in Myanmar** Presenter: Mr. Chin-Pen Chua, UNIDO Representative and Director of Regional Office in Thailand	
16:30 – 16:45	**8. Technology solutions for grid and off-grid electrification** Presenter: tbd, GE	
16:45 – 17:00	**Q&A**	
	Wrap-up Session: Conclusions and Next Steps	
17:00 – 17:15	Summary of Workshop Discussions and Next Steps Presenters: Dr. Dejan Ostojic, Energy Sector Leader, The World Bank Dr. Xiaoping Wang, Senior Energy Specialist, The World Bank	Ms. Julia Fraser, Sector Manager, The World Bank Group

ADB Investor Forum | Off-grid Renewable Energy Opportunities

21 – 22 March 2014   Hotel Thingaha   Nay Pyi Taw, Myanmar

DAY 1   21 March 2014

08:00 – 09:00   Registration

09:00 – 09:30   Introduction
Keynote address
H.E. U Maung Myint – Union Minister, Ministry of Industry
Opening remarks by ADB
Mr. Chong Chi Nai – Director, Southeast Energy Division, Asian Development Bank
Government of Norway's efforts to scale up energy access in developing countries.
Ann Ollestad, Ambassador, Embassy of Norway in Myanmar

09:30 –10:00   SESSION 1: ADB Off-grid renewable energy program in Myanmar

ADB will present the findings of its on-going renewable energy program in Myanmar. The presentation will discuss:
1) Off-Grid renewable energy applications in Mandalay and Chin state.
Mr. Pradeep Tharakan, Senior Climate Change Specialist, Asian Development Bank
2) Geo-spatial mapping for least cost electrification planning for Mandalay region
Mr. Edwin Adkins, Earth Institute, Columbia University, USA

10:00 – 10:30   COFFEE BREAK

10:30 - 12:00   SESSION 2:   Technology Applications for lighting and productive uses.
This session will identify suitable clean energy technologies for lighting and livelihood generation and appropriate business models.
Chair: Dr Vijay Modi, Earth Institute, Columbia University, USA
1) Solar water pumping for irrigation
Mr. Misbah Moin, MD, Rahim Afrooz, Bangladesh
2) Lighting a million life –triple down approach – light, water and mobile charging
Ms. Fiza Farhan, CEO Buksh Energy, Pakistan
3) Solar home solutions
Philips, XXXXX
4) Scaling up of Solar Home Solutions in Bangladesh
Didar Islam, MD Soalric, Bangladesh
Panel discussion – 30 mins

12:00 – 13:00   LUNCH BREAK

13:00 –14:30   SESSION 3:   Best practices for scaling up mini-grid systems
Present the various technologies and modalities to develop sustainable mini-grid systems. Best practices from various countries will be shared and discussed within the context of Myanmar.
Chair: TBC
1) Designing a minigrid for rural communities
Brian Shaad, Mera Gao Power

2) Opportunities for off-grid Solar -Tapping into Myanmar's Anchor Client Base
Andy Schroeter, CEO, Sunlabob Renewable Energy, Laos
3) Micro grids experience in Africa
Dr Vijay Modi, Earth Institute, Columbia university, USA
4) PV Systems Considerations for minigrids– Southeast Asia Case Study,
Sutthi Somnuk, REC, Singapore
Panel discussion – 30 mins

14:30 – 15:00 COFFEE BREAK

15:00– 16:30 SESSION 4: Programmatic Approach to energy access – Lessons learnt

Discuss various programs, approaches and lessons learnt from successful initiatives in the context of Myanmar.
Chair: Mr. Chong Chi Nai – Director, Southeast Energy Division, ADB

1) Small Hydro Power-World Development and Chinese Practices- Solution to Off-Grid Rural Electrification
Dr. LIU Heng, Director-General, International Center on Small Hydropower, under UNIDO and China's Ministry of Water Resources and Ministry of Commerce
2) Lightning a Billion Lives – lessons learnt
TERI , India
3) Lightning Africa and Asia - Lessons learnt
Hemant Mandal, IFC
4) Energy for All - Empowering the poor through increasing access to energy
ADB, Jiwan Acharya, Senior Climate Change Specialist (Clean Energy)

16:30 – 17:30 Session 5: Policy frame work and regulatory mechanism – Way forward

This session will have a presentation from government on the current government initiatives, programs and regulatory mechanism. Other bilateral financing institutions will discuss about their programs and discuss way forward to support government in creating an enabling environment for scaling up energy access in Myanmar followed by a panel discussion.
Chair: DG MOEP (TBC)
1) Ministry of Industries –MOI initiatives and government regulatory mechanism on off-grid rural electrification
2) Department of Rural Development, Mr. U Khant Zaw, Government current initiatives, policies on rural electrification

Panelist, ADB, World Bank, JICA

Investor Forum | Off-grid Renewable Energy Opportunities

21 – 22 March 2014 **Nay Pyi Taw, Myanmar**

DAY 2 22 March 2014

08:00 – 09:00 Registration

09:00 – 09:30 Opening

Welcoming remarks
Chief Minister of Mandalay Region /Minister of EP&I Mandalay Region(TBC)
ADB Energy for All Program
Mr. Jiwan Acharya, Asian Development Bank

09:30 –10:45 SESSION 6: Private sector barriers to universal energy access.

Achieving universal energy access by 2030 poses a tremendous challenge to the Government Myanmar. As demonstrated by Vietnam, an accelerated pace of electrification is possible through a well-conceived policy and regulatory framework. Session 6 focuses on specfic barriers companies in Myanmar face in expanding their impact to the energy poor. More importantly, this session discusses corresponding solutions to these challenges by drawing experience from international policy programs.

Moderator
U Thoung Win, National Energy Development Committee
Barriers to renewable energy development in Myanmar
U Kyaw Min, Earth Energy Systems
U Phyo Minllian, Llian Brothers Co. Ltd.
U Kyaw Thiha Soe, Comet
Panelists
U Khant Zaw, Ministry of Livestock, Fisheries and Rural Development (MLFRD)
Katharina, IFC

10:45 – 11:00 COFFEE BREAK

11:00 –12:00 SESSION 7: Transition from donor-driven to commercial sustainability.

Majority of the rural electrification programs in Myanmar are donor-funded. This is necessary to build awareness about the benefits of electricity in rural areas and create a critical mass of demand. In the same way, these programs also provide a venue for technology providers to develop their expertise and strengthen the supply chain for equipment and parts for decentralized energy systems. However, continued subsidy by the Government is unsustainable, and ultimately harmful. Session 7 analyzes how the community organizations, infrastructure and equipment installed by the Government's programs can transition to commercial units.

Professionalizing community organizations for sustainability
Ms. Laurie Navarro, AMORE
Human resource development to strengthen the distribution network
Mr. Erel Narida, One Renewable Energy

12:00 – 13:00 LUNCH BREAK

13:00 –14:00 SESSION 8: Funding sources for energy access companies

Securing early stage funding is a 2-step process. First, the company has to invest in development costs such as developing a viable business model and validating the core assumptions of this business model through feasibility studies. Second, the company has to identify investors that are willing to invest in greenfield companies and qualify to their selection criteria. Session 8 presents Energy for All's partners in both the project development and early stage investment phase.

A platform for impact investment
Mr. Robert Kraybill, Impact Investment Exchange (IIX)
Impact funds
Mr. Bradley Kopsick, Insitor Management
Ms. Joan Yao, LGT Venture Philantropy
Ms. Suzanne Chew, Nexus Carbon for Development
Mr. XXXXX, Htoo Foundation

14:00 –15:00 SESSION 9 : Programs that support SME's and energy access

Commercial banks in Myanmar are partnering with international development organizations to develop programs that support small and medium enterprises (SMEs) and energy access. Session 9 creates a platform where these commercial banks can market their programs to the stakeholders in the energy access space.

Moderator:
Mr. XXXXX, Chairman of the Bank Association of Myanmar / Representative from the Central Bank
Potential collaboration with multilateral agencies
Saw Harry Hla, Myanmar Citizens Bank Limited
Financing for SMEs
Tin Maung Htay, Small & Medium Industrial Development Bank (SMIDB)
Working capital loans for SMEs
Mr. Winston Cheng, Director/Senior General Manager, Myanmar Oriental Bank Ltd.
Expanding outreach to the rural poor through mobile banking
PE Myint, Managing Director, CB Bank (pemyint@cbbankmm.com)

15:00 – 15:30 COFFEE BREAK

15:30 –17:00 SESSION 10: Business plan presentation

In nascent industries like the renewable energy and energy access sectors, there is exists a lack of information that limits the accessibility of capital for the private sector. This phenomenon has come to be known as the "missing middle." In order to bridge the "missing middle," Session 10 brings together both entpreneurs and finanicial institutions to meet directly and explore opportunities for collaboration.

NGWE Wathon Group of Companies
Dato Leong Kin Mun
Poly Ice Co. Ltd.
Thein Han, Managing Director
SolaRiseSys
Kyaw Min Tun, Managing Director
Myanmar Solar Power Trading Co., Ltd.
Win Zaw, Director (myanmarsolarpower@gmail.com)
Myanmar Sustainable Energy System

U Soe Thein Tun, Assistant General Manager (sttun9@gmail.com)
Salay Engineering & Construction Ltd.
U Thein Maw, Managing Director (nayminn.solar@gmail.com, solar.nayminn@gmail.com)
Myanmar Eco Solutions (Orb Energy)
Min Chan Win, Managing Director (myanmarecosolutions@gmail.com)
Panelists:
Michele Boario, UNIDO
Aung Myo Khaing, Ministry of Industry, Central Department of SME Development
XXXXX, Directorate of Industrial Planning, Renewable Energy Division

17:00 – 18:00 Closing remarks and inauguration of the networking room

Participating energy access enterprises will be designated a small booth in the networking room where they can meet with interested participants.

APPENDIX VII: Myanmar Comprehensive Development Vision

The energy and electrification components of ERIA's Myanmar Comprehensive Development Vision (MCDV) were prepared in **July 2012** by KWR International (Asia) Pte Ltd in cooperation with the University of Tokyo and incorporated into the Infrastructure and Energy chapter of the MCDV included below.

Infrastructure and Energy

1. Infrastructure

1.1. Current Situation and Challenges

Myanmar's aspiration to high and balanced growth could not be achieved without having proper development of public infrastructure. Indeed, infrastructure is a driving force to the economic growth since there is a positive and statistically significant correlation between investment in infrastructure and economic performance (Aschauer 1990). Although there is no empirical analysis, the observers noted that absence of reliable infrastructure such as poor transportation, energy shortage and low-grade communication is great bottleneck not only to harness its growth potentials but also to fulfill obligation to ASEAN Economic Community in the near future. As well, the IMF's 2012 report argued for industrial development citing that Myanmar has an advantage of lower wages but the manufacturing sector remains stifle by poor infrastructure amongst the others. Therefore, immediate implementation of infrastructure development becomes very crucial in recent days of economic liberalization and reception to global investments.

In order to determine major obstruction in infrastructure sector and to find the way to overcome, it is important to see the present status. Table 6-1 tabulates connectivity related indicators in ASEAN compiled by UNESCAP. Myanmar has all the data in the list. However, this table explains the seriousness of the current situation of infrastructure and infrastructure usage in Myanmar. Myanmar is far behind other ASEAN countries in road density per 100 km^2. It had more than half of below class III level road sections of the Asian highway network in ASEAN. Paved road in Myanmar was 11.9 percent[*], which was better than Cambodia and the Philippines but still very low[†] . The number of passenger cars per 1,000 persons was only 5. Port container freight was comparable with Brunei despite the huge difference in population. Only railway density, 5.1 km per 1,000 km^2, was relatively higher in ASEAN countries. The number was lower than Singapore[‡] , Thailand and Vietnam but better than other countries. Of course, it does not necessarily mean that Myanmar has better railway system when we think of the quality of the services and technology.

Table 6-1: Connectivity Related Indicators in ASEAN[§]

[*] By now, it increases to 21.7 percent

[†] According to the ministry of construction, paved roads reached 21.7% for whole country in March 2012.

[‡] Data was not available for Singapore.

[§] According to Myanmar official data, Railway density is 8.6 (Myanmar Railways), Road density is 203.3 (Public Works), Paved road is 20.89% (Public Works), Passenger car is 5 (Dept. of Road

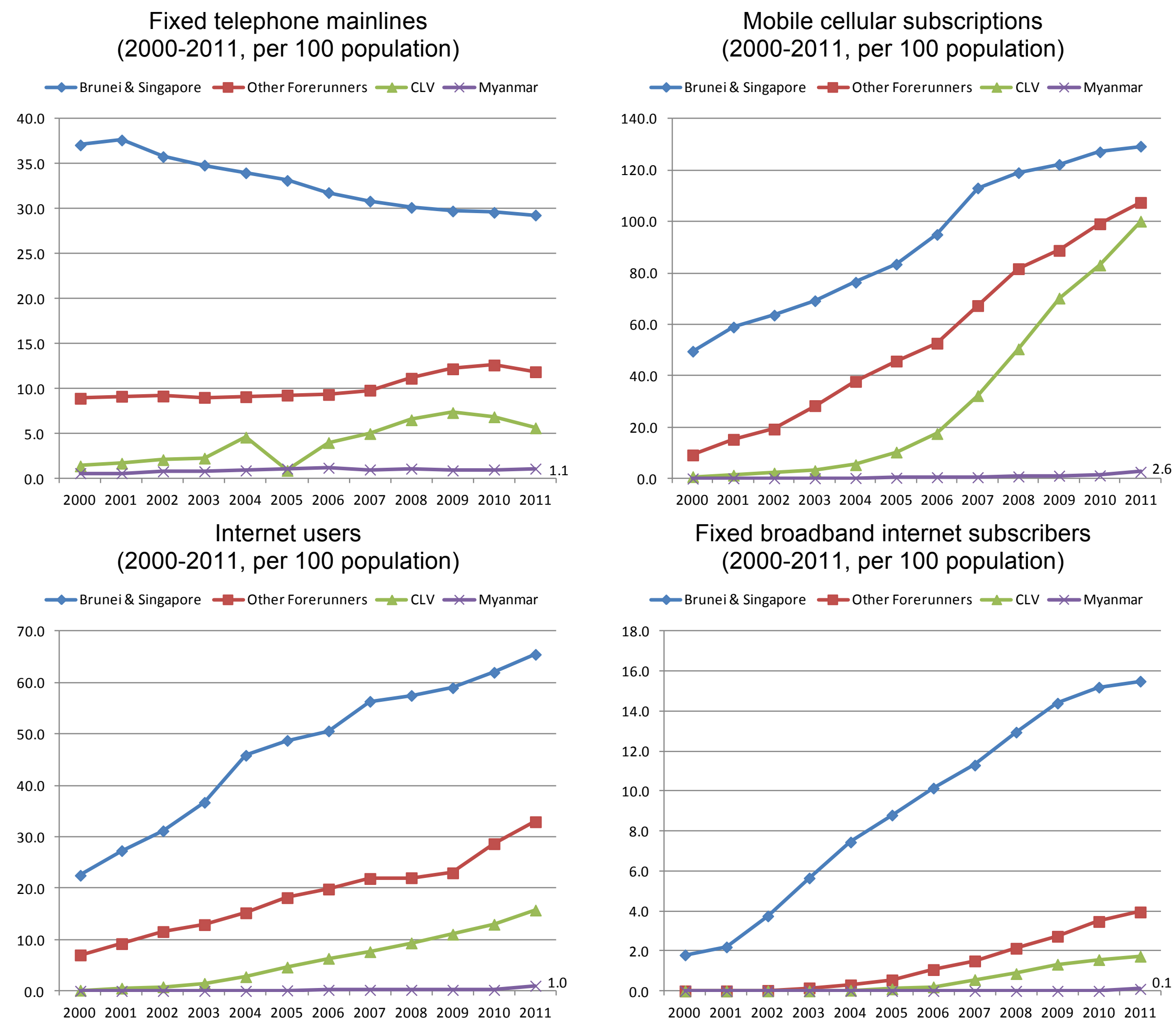
	Railway density	Road density	Paved road	Passenger cars	Air passengers carried	Port container freight	Asian Highway Total	Asian Highway Below class III
	(2010)	(2010)	(2010)	(2010)	(2010)	(2010)	(2010)	(2010)
Brunei	-	564	77.2	485	1,263	0.09	-	-
Cambodia	3.7	216.7	6.3	18	455	0.22	1,347	0
Indonesia	1.9	262.9	59.1	45	52,283	8.37	4,091	0
Lao PDR	n.a.	171.4	13.5	2	555	-	2,857	306
Malaysia	5.1	300.5	82.8	313	30,997	18.25	1,673	0
Myanmar	**5.1**	**41.3**	**11.9**	**5**	**396**	**0.17**	**3,009**	**1,064**
Philippines	1.6	470.9	9.9	8	21,024	4.95	3,367	451
Singapore	n.a.	4794.3	100	121	26,709	29.18	19	0
Thailand	8.7	352.4	98.5	57	27,162	6.65	5,111	2
Viet Nam	7.6	516.3	47.6	13	14,407	5.98	2,597	264
Unit	per 1000 km2	per 1000 km2	%	per 1,000 population	1,000	million TEU	km	km

Source: UNESCAP (2012) and database on the UNESCAP website

The data on telecommunications shows much serious backwardness. Figure 6-1 depicts the ICT related indicators in ASEAN countries. Given the different development stages, we divided ASEAN countries in to 4 groups, that is, (1) Brunei and Singapore (small and advanced countries), (2) Other forerunner countries, (3) Cambodia, Lao PDR and Vietnam (CLV), and (4) Myanmar. Myanmar has a long way to go to catch up with even CLV countries. In the other ASEAN countries, we saw rapid increase of mobile cellular subscriptions and declining trend in fixed telephone mainlines. In fact, the indicators on mobile cellular subscriptions per 100 population of the 3 groups exceeded 100, which meant that people have more than 1 mobile phone on average. On the other hand, mobile cellular subscriptions per 100 population in Myanmar were only 2.6 and fixed telephone mainlines were 1.1 in 2011. Myanmar has not experienced the downward trend in fixed or even upward trend. The figures for internet users and fixed broadband internet subscribers showed the same backwardness. For the internet users in 100 population, Brunei and Singapore reached 65.5, other forerunners got 32.9, and CLV countries also had 15.7 while Myanmar had only 1.0 in 2011.

Transport Administration), Air passengers carried is 2074 (Dept. of Civil Aviation) and Port container freight is 0.3034 (Myanmar Port Authority)

Figure 6-1: ICT related Indicators in ASEAN (2000-2011)



Source: ITU website.

We could say that Myanmar had 10 years of delay in getting internet users to the average of Cambodia, Laos and Vietnam. Fixed broadband internet subscribers in 100 population showed relatively lower figures in other countries, while Myanmar's figures are evidently lower than the others. Telecommunication service costs were extremely high due to monopoly of Myanmar Post and Telecommunication (MPT), a state-owned enterprise, which has monopolized license for 2G and 3G and this created a great challenge for telecommunication sector to grow in Myanmar. The situation is now changing after the reform. The government has started inviting private sector to invest in the country.

Table 6-2 and Table 6-3 indicate access to improved water sources and sanitation in ASEAN countries. Access to improved water resource in Myanmar is the 2nd lowest in both of rural area and urban area in 2008. The percentage in the urban area had dropped from 87 percent to 1990 to 75 percent in 2008. It seems to imply that development of water supply infrastructure could not catch up with the speed of urban development.

Table 6-2: Access to Improved Water Sources (% of population)

Unit: %

	Rural				Urban				Total			
	1990	2000	2005	2008	1990	2000	2005	2008	1990	2000	2005	2008
Myanmar	47	60	69	69	87	80	75	75	57	66	71	71
Vietnam	51	74	85	92	88	94	97	99	58	79	88	94
Cambodia	33	42	51	56	52	64	75	81	35	46	56	61
Lao PDR	-	40	47	51	-	77	74	72	-	48	54	57
Thailand	89	95	97	98	97	98	99	99	91	96	98	98
Malaysia	82	93	99	99	94	99	100	100	88	97	100	100

Source: Statistical Yearbook for Asia and the Pacific 2011

Table 6-3: Access to Sanitation (% of population)

Unit: %

	Rural				Urban				Total			
	1990	2000	2005	2008	1990	2000	2005	2008	1990	2000	2005	2008
Myanmar	15	59	79	79	47	81	86	86	23	65	81	81
Vietnam	29	50	61	67	61	79	88	94	35	57	68	75
Cambodia	5	10	15	18	38	50	60	67	9	17	24	29
Lao PDR	-	16	30	38	-	62	77	86	-	26	43	53
Thailand	74	92	96	96	93	94	95	95	80	93	96	96
Malaysia	81	90	95	95	88	94	96	96	84	92	96	96

Source: Statistical Yearbook for Asia and the Pacific 2011

Access to sanitation is better than water supply as indicated in the Table 6-3. The percentage has improved significantly during 1990 and 2000, and the result of the total (81%) ranked Myanmar at top in the CLMV countries.

1.2. Key strategies

(1) Need for prioritization

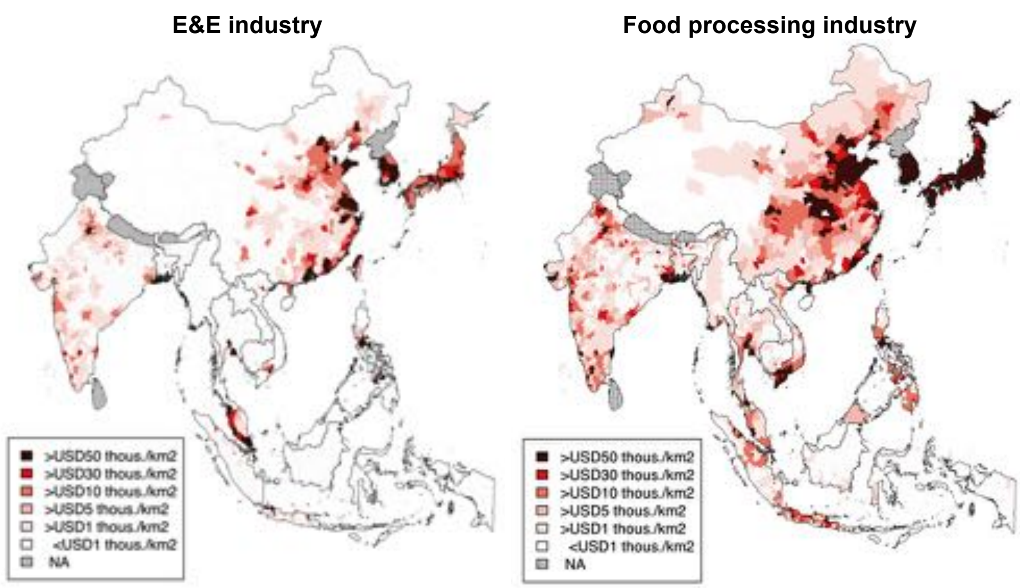
Given the circumstances, Myanmar needs all-round reforms. We need new roads, and existing roads need to be paved and upgraded. Passenger and commercial cars will increase and it will require new roads. There is a need to reduce road traffic deaths. Ports and airports need to be upgraded. Railway needs rehabilitation. Myanmar needs to catch up with increasing ICT demand of people and industries. We must tackle various MDG issues. At the same time, Myanmar needs to provide internationally comparable data and improve data quality.

Obviously these cannot be achieved at once, even though Myanmar is now addressing them all in parallel. Finance and human resources are limited and infrastructure projects take time. Therefore, *we must have clear objective and strategy to prioritize the infrastructure projects*.

One practical way to prioritize the projects is taking the same way as the other ASEAN countries have taken. ASEAN forerunners and Vietnam have long pursued the trade and FDI driven industrialization. Fragmentation theory and the concept of '2^{nd} unbundling' clearly explain what we have seen in those countries. ASEAN forerunners and Vietnam have successfully attracted some production processes and tasks in the production networks developed by multinational enterprises (MNEs). The East Asian countries including ASEAN forerunners and MNEs were main drivers to promote international division of labor in terms of production processes and tasks and created the most sophisticated production networks in the world. Moreover, ASEAN forerunners have expanded the variety of the processes and tasks as they raised their capacity.

Those countries initiated trade and FDI driven industrialization from their primary cities. In ASEAN, most production processes in automotive industry and electronics and electric appliances (E&E) industry are located in limited areas near the big cities. Figure 6-2 illustrates the agglomeration of E&E and food processing industries based on the industrial value added divided by area. There is more uneven distribution of E&E industry, when compared with food processing industry. E&E industry is located near the big cities and only a few other regions can attract the industry. Malaysia succeeded in dispersing the electronics industry to the states along the Strait of Malacca, but for Thailand, Indonesia, the Philippines and Vietnam, agglomerations in production can be seen in limited areas. It implies that even though ASEAN forerunners and Vietnam could attract FDI and some production processes, it is still a long way for them to disperse the industry to other regions in the countries.

Figure 6-2: Agglomeration of E&E and food processing industries (2005, USD per km^2)



Source: IDE-GSM team. NA for some countries and regions due to data availability.

The Comprehensive Asia Development Plan (CADP, ERIA 2010) emphasized the interactions among the regions in different development stages. The report classified the regions to three tiers, that is, existing industrial agglomerations such as Singapore, Bangkok and Chennai (Tier 1), potential growth nodes to be linked with production networks (Tier 2) and other regions (Tier 3). In the report, Yangon, Mandalay and Dawei are mentioned as possible Tier 2 regions to be involved with the production networks. Realistically, Yangon, Mandalay and Dawei have great opportunity to be connected with production networks.

(2) Development of Yangon with international standardized infrastructure

Myanmar's primary city is Yangon and its primary port is Yangon port. As there is going to be a gradual shift of the primary port from Yangon port to Thilawa port, so both the ports are discussed in this section. There is a need to think of upgrading infrastructure, providing new infrastructure, and providing international standard infrastructure. Especially, as international infrastructure requires higher costs and technical assistance from other countries, there is a need to identify which infrastructure projects should be of international standard.

Table 6-4: Strategy for Yangon (target years for partial operation)

	Urban	Industrial
Up to 2015	**Thilawa Port** **Yangon to Thilawa access road** Rehabilitation and upgrading the roads	**Thilawa SEZ** Upgrading current Industrial Zones
2016-2020	**Ring road** (Yangon) **Urban railway** (Rehabilitation) **Hanthawaddy International Airport**	Thilawa and suburban Yangon
2021-2025	**Urban Railway** (New in Yangon) **Airport Link to Hanthawaddy**	
2026-2030	**Urban Expressway**	

Note: Bold text items require international standard and/or technical assistance
Source: ERIA.

As far as infrastructure is concerned, international standard infrastructure is needed for industrial estates/SEZ, primary ports, and access roads between them in the Greater Yangon area. Thilawa SEZ and Thilawa port upgrading will be a model case of international standard infrastructure in Yangon and Myanmar. International standard SEZ should be with stable electricity, internet and water supply, wastewater treatment facility, international standard customs office, international standard freight forwarders, transparent labor/SEZ laws and regulations, and various incentives to the investors. One stop center of trade and investment can be established in SEZ as in Cambodia so that firms can get all information and all import, export and investment related documents, and consult with the staff of the center on any kind of difficulties in trade and investment.

Living condition should also be improved to attract foreign investors. High-standard hotels, residents, service apartments, hospitals, supermarkets, international schools, and even golf courses or other entertainment facilities are necessary for the visitors, managers and their families. Although those amenities are provided by private companies, Myanmar government can give incentives and facilitation measures to attract these companies and enhance living condition for the investors.

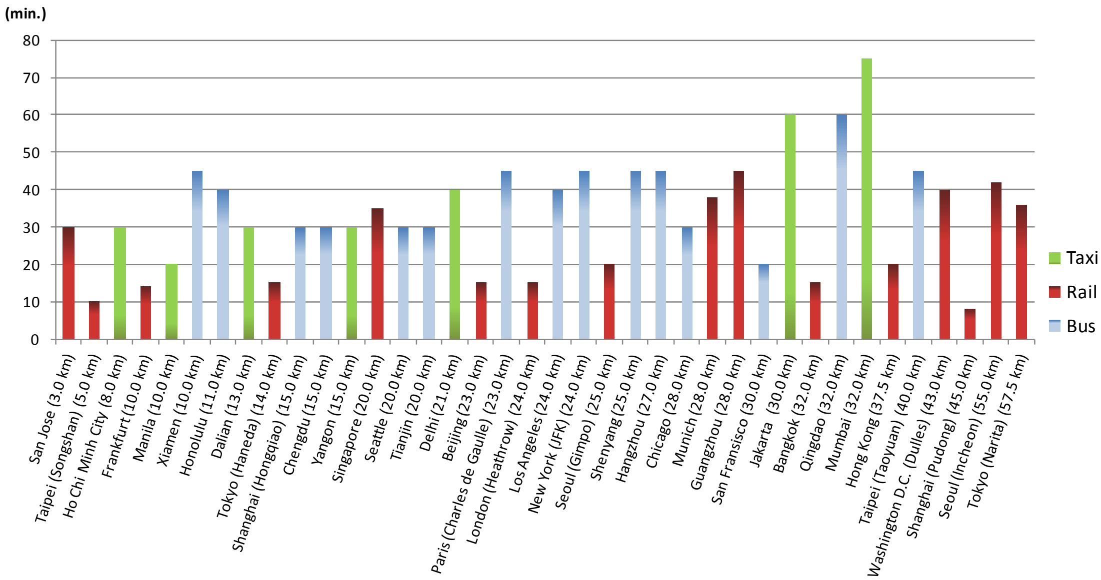
Mitigating the traffic jams in Yangon must be a long-term effort as in all other countries. Because economic development must induce the inflow of households and firms into the primary city, we can say the population of Yangon, including suburban areas, can exceed 10 million[**********************]. There should be continued upgrading of current roads and urban railways, build new bridges, plan for new urban railways such as subways, and develop a ring road. And the territory of Yangon City should be expanded so that urban functions work smoothly.

Myanmar needs to upgrade the current industrial estates. New industrial estates in suburban areas of Yangon, especially north-eastern area of Yangon along national roads should be planned. Better access from these areas to the Thilawa port will be critical.

Yangon will have new Hanthawaddy International Airport and start its construction very soon. Current handling capacity of the Yangon International Airport is 2.7 million passengers. The Yangon Airport already exceeded 3 million passengers in 2012 and forecast tells that traffic will be 5.4 million in 2015, so the development of the new port is an urgent matter. *Better access to the Hanthawaddy International Airport will also be a key in the global competition, especially in electronics sector and services industry*. As shown in Figure 6-3, many airports have access times less than 45 minutes. Especially, airports in distant place have railway access from/to the city, e.g., Bangkok, Hong Kong, Shanghai (Pudong), Seoul (Incheon) and Tokyo (Narita). Given the 80 km road distance between Hanthawaddy International Airport and Yangon city center, better rail link between the two is essential.

[**********************] Both JICA study on Master Plan for the Greater Yangon and IDE/ERIA-GSM analysis estimated that the Greater Yangon will have more than 10 million populations.

Figure 6-3: Shortest Time between The Cities and The Airports



Note: Need to choose a better mode between “Rail” and “Bus”.
Source: ANA (Japanese airline)’s magazine.

(3) Mandalay and Yangon-Mandalay link

Mandalay is the second largest city in Myanmar and is a logistics hub connecting northern cities. Yangon-Mandalay link is the most important link within Myanmar. Infrastructure development in Mandalay is crucial because it should be the first step to industrial dispersion in Myanmar. If some industries are successfully in dispersed to Mandalay, the geographical coverage to other cities, regions and states could also be expanded. Otherwise, inclusive growth and high economic growth cannot be achieved simultaneously.

Table 6-5: Strategy for Mandalay and Yangon-Mandalay link (target years for partial operation)

	Urban	Industrial	Intercity
Up to 2015	Rehabilitation and upgrading Incentive in Mandalay airport	Upgrading current Industrial Zones	Rehabilitation and utilization of existing infrastructure, incl. Yangon-Mandalay Expressway
2016-2020		**Mandalay area**	Further upgrading of **Yangon-Mandalay link, incl. rehabilitation of railway** **Upgrading inland waterways**
2021-2025	Ring road (Mandalay)		
2026-2030	Urban Expressway		

Note: Bold text items require international standard and/or technical assistance
Source: ERIA.

The issues in Yangon-Mandalay link can be divided by two stages. First is *enhancing the capacity of current expressway running between Yangon and Mandalay via Nay Pyi Taw to allow freight transport*. Currently, there is an expressway with 4 lanes between Yangon and Mandalay, which has enough space to be upgraded to 8 lanes. However, trucks are not allowed to run on this road till the full pavement width of expressway is finished. Most freights are shipped through narrow National Road No.1. For better accessibility between Yangon and Mandalay, upgrading the current expressway to allow freight transport is important. Second is *planning and forecasting better modal mix among National road No.1, expressway, railway and inland waterway*. Rehabilitation of railway and inland waterway can be assisted by other countries or international organizations. *Collection of quality data, especially in terms of usage of those modes, is essential to discuss the current and future modal mix*. Also, we should consider the gradual modal shift of passenger and cargo transport from inland waterway to road as industries and people become more time-sensitive.

Mandalay can be a growth pole as well as an international hub in terms of air-cargo. Based on other countries' experience, Myanmar needs to have an international logistics company in Myanmar. Also, landing fee should be lowered. Malaysia and Thailand have lower landing fees for Kuala Lumpur International Airport and Suvarnabhumi Airport, respectively. Myanmar can consider better incentive schemes to the air carriers as well as to the logistics companies.

(4) Dawei and Kyaukphyu as development node

Dawei and Kyaukphyu, which have SEZ plans, can be a milestone to disperse the international production networks to other cities in Myanmar. First of all, Dawei and Kyaukphyu have different characteristics in that they will be the gateways for Thailand and China, respectively. To develop these cities, connectivity enhancement to Thailand and China is required. For China, Kyaukphyu will be a strategic project to get a gateway to Indian Ocean as well as disperse the industries from coastal areas of China to western areas (Isono, Kumagai and Kimura, 2012). For Myanmar, Kyaukphyu project must be accompanied with domestic road/railway improvement. For Thailand and other Mekong countries, Dawei will create large economic impacts, as we discuss in the next section. If we provide good gateways for China or Thailand, SEZ and other industrial development near the SEZ sites can be considered. Upgrading Dawei airport into an international airport will provide a better access from Bangkok or other cities.

(5) Fulfilling the basic needs

Yangon development is essential for the economic development of Myanmar, though it does not ensure inclusive growth. Yangon development will attract people and firms which will lead to increased traffic congestion. *Upgrading of current infrastructure outside Yangon should be undertaken simultaneously either with ODA or through Myanmar's own budget*.

However, two facts must be borne on mind. First, Yangon development together with institutional development benefits real per capita GRDP growth in northern regions, despite the outflow of households and firms from those areas. People in northern regions and states can increase their sales and purchase to/from Yangon and increase exports and their imports to/from other countries, through efficient port or airport of Yangon. For example, agricultural sector can benefit from better access in Yangon area, because deregulation and better access from Yangon port to other countries will induce relocation of the distribution center function of agricultural goods to areas closer to Yangon city (Kudo, Gokan and Kuroiwa). It also applies to ICT. Better internet connectivity is a primary requirement, and ensuring better internet access in Yangon city should be pursued continuously despite the rapid increase in demand. Second, just because Yangon's congestion is too severe, building of other industrial estates and SEZs outside Yangon should not be considered. Industries, especially FDI driven development cannot be dispersed without better infrastructure in the primary city. Building other industrial estates and SEZs in other regions without tackling the congestion in Yangon cannot attract foreign firms to another industrial estate. It will also lessen the economic impact and long-term economic growth will slow down.

Better decentralization mechanism is a key to provide basic infrastructures in rural areas. Local governments should have better knowledge about their regions and elected local governments must think of voter's preferences. We can learn from Indonesia, which has experienced drastic change toward decentralization and has a lot of literature in both qualitative and quantitative analyses. Some key findings are as follows:

- A statistical analysis revealed that decentralization has increased infrastructure provision in rural areas (Chowdhury, 2009). Moreover, villages with lower average income acquired infrastructure provision more than pre-decentralization era and the decentralization has narrowed the infrastructure gaps between higher income villages and lower income villages.

- Another statistical analysis showed that corruption increased the local government expenditure significantly (Murwito, *et al*., 2012). The study suggested that we need an eprocurement system as well as a monitoring mechanism by third-party outside the local government.

- The law No. 22/1999 in 1999 eliminated the decision hierarchy between provincial and district governments for the decentralization. Since districts had started to have similar projects of new port construction or new bus station development without any direction or coordination, the law No. 32/2004 in 2004 restored the decision hierarchy and required approvals from provincial governors for districts' spatial planning (Okamoto, 2010).

1.3.Domestic Corridors Utilizing International Initiatives

The principle infrastructure to facilitate smooth transportation along economic corridors should be upgraded. Transport infrastructure in all modes of transport related facilities and services should be improved for domestic transport, overseas trade and border trade. Potential investment projects in road and logistic facilitation subsectors are needed.

Table 6-6: Strategies for Investment on Infrastructure Development

Area of focus	Short-term strategy	Medium-term strategy	Long-term strategy
Road Infrastructure	• Construction of major trade routes • Upgrading existing roads	• Improve all Union Highway road status to meet at least ASEAN Highway Standard Class III	• Improve all Union Highway road status to meet at least ASEAN Highway Standard Class II
Road transportation services	• State-owned transportation services should be further privatized • Efficient public transport	• Expand Intra and Intercity transport • Extend network in the international and regional cooperation programmes • Construction of roads and bridges	• Implementation of the Intelligent Transport System in Nay Pyi Taw and Yangon • Implementation of international road Safety standard
Railway transportation services	• Encourage investment to improve Yangon – Mandalay railroad to meet the travel time of 12 hours. • Cooperation with private sectors to improve the effectiveness of Yangon circular railway system • Improve cargo trains for cargo transport	• Construction of Muse- Kyauk Phyu rail line and Dawei-Kanchanaburi rail line which connects neighbouring countries by BOT system • Change railroad in line with ASEAN gauge in main railroads	• Change railroad in line with ASEAN gauge to all railroads
Air transport services	• Construction of new Hanthawaddy	• Operation of four International	• Upgrading the existing domestic

	International Airport • Allow private sectors to operate the airports • Upgrading airline services	Airports in full swing • Upgrading the existing domestic airports • Expansion of domestic and international airlines and air routes	airports to international airports such as Bagan, Dawei and Kyauk Phyu
Port Infrastructure	• Upgrading existing port facilities especially in Yangon •	• Implementation of deep seaports projects in Dawei and Kyauk Phyu • Implementation of other seaports projects in Sittwe , Pathein, Myeik and Kaw Thaung • Construction of 6 ports: Bhamaw port, Mandalay port, Pakokku port, Magway port, Monywa port, Kalaywa port	• Myanmar ports to be on the international sea routes •
Inland water and maritime transport	• Upgrading existing ports facilities along the Yangon river • Improve inland water transportation especially Yangon-Mandalay-Bhamaw route • Formulation of the national integrated transport master plan	• Improve shipping lines • Extend cargo ships for inland water transport • Introduce routes to connect international maritime routes • Implementation of the national integrated transport master plan	• Upgrade all shipyards of the inland water transport • Implementation of the national integrated transport master plan • Construction of new international port terminal in mouth of Yangon River to approach Regular mother vessels routes

Source: ERIA.

Among them, many sections have been designated as international economic corridors by ADB GMS, ESCAP, ASEAN or other organizations and initiatives. Yangon-Mandalay, Myawaddy-Paan-Yangon and Mandalay-Monywa-Tamu sections are part of Asian Highway No.1 as well as ASEAN Highway No.1. A part of the expressway between Yangon and Mandalay is a part of India-Myanmar-Thailand Trilateral Highway. Muse-Mandalay section is Asian Highway No.14. Myanmar can ask for assistance for these infrastructure developments, starting from repairing current pavement and reduce missing links. Myanmar can gradually extend the sections at international standard with clear prioritization.

As domestic corridors are part of international corridors, trade and transport facilitation at the borders are indispensable. As an ASEAN member state, Myanmar has a responsibility to take part in the ASEAN Framework Agreement on the Facilitation of Goods in Transit (AFAFGIT) signed in 1998[†††††††††††††††††††††††], the ASEAN Framework Agreement on Multimodal Transport (AFAMT) signed in 2005, and the ASEAN Framework Agreement on Facilitation of Interstate Transport (AFAFIST) signed in 2009. Myanmar has acceded to the GMS cross border transport agreement (CBTA) in 2003[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] so that it can fully utilize the agreement should it want to.

2. Integrated Energy Development

2.1. Energy situation and policy of Myanmar

(1) General condition

While the development of a comprehensive integrated energy strategy requires attention to both the sourcing of primary power inputs as well as distribution, perhaps no challenge is as important as Myanmar's ability to electrify its domestic economy. This is due to the massive scale and scope of the initiative needed, and capital required, to maintain, repair, expand and supplement existing infrastructure. In addition there are many technical, social, political, financial and other issues that need to be addressed. Furthermore, without adequate power, Myanmar cannot industrialize as it will not be able to create competitive manufacturing facilities. Nor will it be able to upgrade its telecommunications, technology and overall capacity to deliver necessary services to businesses and consumers.

Until these issues can be resolved, the nation is experiencing increased blackouts, even during the rainy season when hydropower plants operate at high capacity. Rapid growth in electricity consumption—averaging 14.7 percent per year between 2008 and 2011[§§§§§§§§§§§§§§§§§§§§§§§]—is placing further strains on capacity and increasing generator failure[***********************].

Efforts to improve electrification have also come under literal and figurative attacks. After insurgents bombed transmission lines linking Shweli hydropower station to the national grid, generator capacity was reduced by 200 MW. People in Myanmar have also organized protests and accused the government of diverting electricity to neighboring countries. Projects funded by

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[†††††††††††††††††††††††] There are 9 Protocols. Five were ratified. Protocol 2 & 7 are to be signed and 1 & 6 are to be ratified.

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] There are 20 Annexes and Protocols. All except Annex 5, 13 (a), 13 (b) & Protocol 3 have been sent to other GMS members and ADB.

[§§§§§§§§§§§§§§§§§§§§§§§] According to the Dept. of Electric Power, household electrification rates (% of households) are 21, 23, 24, 25 and 27 for the years 2008/09 to 2011/12 respectively.

[***********************] David Dapice, Electricity in Myanmar: The Missing Prerequisite to Development, Harvard University, May 31, 2012

Chinese and Thai companies have been suspended or cancelled and last year a government official declared all future natural gas finds reserved for domestic purposes[††††††††††††††††††††††††] .

Myanmar's size, as well as its lack of development and large rural population, necessitates an integrated and comprehensive approach to energy, including electricity. It is not a question of addressing selective deficiencies within largely functional infrastructure but rather building on a rudimentary and largely antiquated system almost from scratch. Further, it requires an in-depth understanding of political, social and economic issues.

(2) Supply and Demand of Energy

Supply and Demand of Energy

Myanmar possesses substantial energy resources. The country's natural gas reserves are the 10th largest in the world; its vast water supply provides the country with rich hydropower capacity; and forests and abundant arable land contribute to a sizeable potential for renewable energy including geothermal. It is no coincidence that Myanmar's energy industry has been the country's leading recipient of foreign investment.

Given Myanmar's underdeveloped state, its Ministry of Energy introduced a diversification strategy emphasizing exploration and production to generate export revenues and meet domestic demand. The country's total energy mix is comprised of 61 percent biomass, 11 percent natural gas, 11.5 percent oil, 14.5 percent hydropower, and 2 percent coal.[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡]

Of total electricity generation in 2009, production from hydroelectricity climbed to 72 percent, from 62 percent in 2008 and 57 percent in 2007.[§§§§§§§§§§§§§§§§§§§§§§§§] Production from oil, gas and coal declined to 29 percent, from 39 percent in 2008 and 43 percent in 2007.[************************] Natural gas produced 1,146 million kWh in 2009, or 20 percent, down from 29 percent in 2008 and 30 percent in 2007.[†††††††††††††††††††††††††] Production from crude oil and petroleum decreased to 523 million kWh in 2009, or 9 percent, down from 10 percent the year prior and 14 percent in 2007. Renewable sources, including solar, wind and biofuel, are being explored to meet rural household needs.

[††††††††††††††††††††††††] Patrick Winn, Myanmar's Real Power Struggle? Keeping on the Lights, *Global Post,* June 23, 2012

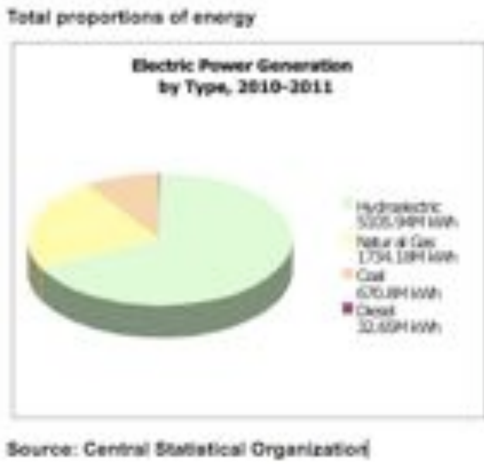
[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Wah Wah Thaung, Oil and Gas Sector in Myanmar: The energy related issues and challenges from the perspective of Ministry of Energy, Myanma Oil and Gas Enterprise, Ministry of Energy, Republic of the Union of Myanmar. Presented at "Energy challenges in ASEAN: Implications for Myanmar" workshop, February 2013

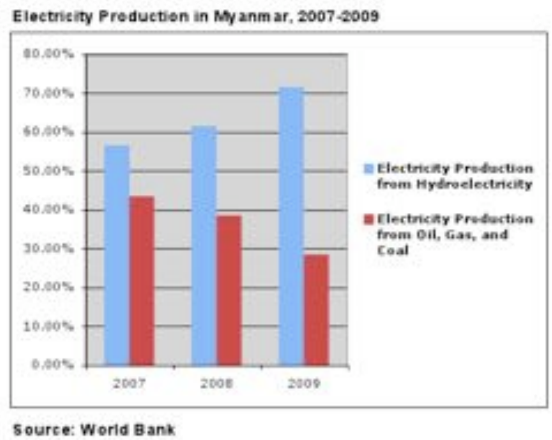
[§§§§§§§§§§§§§§§§§§§§§§§§] Electricity Production from Hydroelectric Sources (% of total), The World Bank Group, accessed: June 29, 2012

[************************] Electricity Production from Oil, Gas and Coal Sources (% of total), The World Bank Group, accessed: June 29, 2012

[†††††††††††††††††††††††††] Electricity Production from Oil Sources (% of total), The World Bank Group, accessed: June 29, 2012

Figure 6-4: Power generation in recent years





Oil and Gas: Myanmar has about 150 million barrels of future recoverable oil reserves and 11.197 Trillion cubic feet of natural gas reserves as of April 2012. It produces over 17,000 barrels of Crude Oil and nearly 1300 MMCF of Natural Gas per day .[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Of natural gas produced, more than 80 percent is exported to Thailand.[§§§§§§§§§§§§§§§§§§§§§§§§§§] Given public demand to utilize this resource domestically, a contract with Thailand has been renegotiated to allocate more natural gas for domestic use in Myanmar.[***************************]

Myanmar's electricity production from natural gas sources reached a peak of 70.6 percent of total electricity production in 1998 and declined to 19.6 percent of total production in 2009, according to the International Energy Agency.

More than 90 percent of Myanmar's natural gas production comes from the Yadana and Yetagun offshore fields in the Andaman Sea. These primarily supply Thailand though some gas from Yadana is used for domestic supply. Gas from Nyaungdon, Myanmar's largest onshore gas field, located roughly 55 km off the coast of Yangon, supplies state and privately owned factories as well as Yangon. Thai company PTTEP has made discoveries in M-9 and M-7 blocks which include Zawtika, Gawthika, Shweypyihtay, Kakona and Zatila. Shwe, an offshore field near Sittway was discovered in 2004, and will deliver gas to China. Production in Shwe and Zawtika, both scheduled to begin in 2013, is anticipated to bring Myanmar's total gas output to roughly 2.2 billion cubic feet a day by 2015[†††††††††††††††††††††††††††] . The country's gas exports are expected to reach a record USD4 billion for 2012-2013[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] . A new discovery, block M-3, will be entirely used for domestic supply[§§§§§§§§§§§§§§§§§§§§§§§§§§§].

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Nicky Black, "The Myanmar Oil and Gas Industry," in Blood Money: A Grounded Theory of Corporate Citizenship: Myanmar (Burma) as a Case in Point (University of Waikato, 2009)

[§§§§§§§§§§§§§§§§§§§§§§§§§§] Myanmar's Power Struggle Endangers Economic Boom, *op.cit.*

[***************************] Thailand to Supply More Gas to Meet High Demand in Myanmar, Arakon Oil Watch, June 21, 2012

[†††††††††††††††††††††††††††] Jacob Gronholt-Pedersen, Myanmar to Launch Offshore Oil, Gas Bidding Round in April, Dow Jones, Mar. 4, 2013

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Myanmar Gas Export May Touch $4bn, Natural Gas Asia, March 27, 2013.

[§§§§§§§§§§§§§§§§§§§§§§§§§§§] Wah Wah Thaung, *op.cit.*

To meet the challenge of increasing domestic demand, Myanmar will step up exploration for natural gas by 25 percent in FY2013-14, according to the National Planning Bill approved by parliament in March 2013. Myanmar has also relaxed its policy on the import of crude oil and petroleum products and welcomed joint venture operations with foreign companies for domestic oil exploration and production.

As of June 2013, 11 foreign companies were exploring for oil at 20 offshore sites, and 13 foreign companies, in addition to 18 joint ventures with Myanmar firms, were exploring in 18 onshore fields.[**************************] Myanmar is reported to have more than one hundred exploration blocks, 60 of which are open for investment. Of those, 29 are onshore, 12 in shallow and 19 in deep water.[††††††††††††††††††††††††††]

Companies operating in Myanmar's oil and gas sector include Hong Kong's EPI Holdings, India's Jubilant Energy, Switzerland's Geopetro International Holding, Malaysia's Petronas, Thailand's PTT Exploration and Production, South Korea's Daewoo, Indonesia's Istech Energy, and U.S.-based Chevron, which is operating in Myanmar under a grandfather clause. Australia's Woodside Petroleum and France's Total SA are also operating through partnerships.

The country held its first international bidding round for 18 onshore blocks in August 2011, and 8 blocks were awarded to 6 companies. A second international bidding round for another 18 onshore blocks was announced in January 2013, but it is unlikely decisions will be finalized before November 2013. Some onshore blocks will be kept as reserves by state-owned Myanma Oil and Gas Enterprise (MOGE).

Offshore oil and gas blocks tend to be seen as having more potential and therefore generate more interest from foreign firms. Myanmar announced first international bidding round on 30 offshore blocks on April 10, 2013 and in a new development has allowed foreign companies to bid for full control without mandating the companies take a local partner as in the past[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡]. Bidding firms are, however, required to enter a production-sharing agreement with MOGE[§§§§§§§§§§§§§§§§§§§§§§§§§§§].

It is also noted that the pipelines for natural gas and oil connecting the coast of the Western Myanmar with China will be completed in 2013.

Coal: Myanmar produced an average 416 thousand tons of coal per year between 1988 and January 2009[***************************]. The country has 36 major coal deposits with total estimated reserves of over 519.21 million tons, mostly in the north. Higher quality coal deposits,

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[**************************] Foreign oil companies ink exploration deals, Agence France Presse, June 21, 2012

[††††††††††††††††††††††††††] Daniel Ten Kate, Myanmar Oil Veteran Rebuffs Suu Kyi a Shell, Chevron Weigh Bids, Bloomberg, Sept. 18, 2012

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Myanmar open to foreign energy bids, Bangkok Post, March 6, 2013

[§§§§§§§§§§§§§§§§§§§§§§§§§§§] Myanmar opens keenly awaited oil and gas auction, Agence France Presse, April 10, 2013

[***************************] Myanmar Energy Sector Assessment, Asian Development Bank, October 2012.

consisting of lignite to sub-bituminous coal, are primarily found in Sagaing Division, Magwe Division, and Tanintharyi Division, while lower quality coal is found in Shan State. Coal accounts for roughly 8 percent of electricity production. It is mainly used for power generation, cement production, steel production and industrial zones or for export to Thailand and, to a lesser extent, China. There is growing concern, however, over coal's environmental and societal impact, as evidenced by the recent cancellation of the Dawei coal-fired plant.

Nevertheless, Myanmar's Ministry of Mines is emphasizing exploration—with coal production scheduled to increase by 6 percent annually up to FY2031—to allow expanded use for both power generation and non-power-related uses. There are currently ten mining companies involved in coal production in Myanmar: Htun Thwin Mining, Geo Asia Industry and Mining, Myanmar Economic Corporation, Yangon City Development Committee, AAA Cement Int'l Co., Ltd., U.E Export & Import Co., Ltd., Mine Htet Co., Ltd., Ngwe Yee Pale Mining Co., Ltd., and the Max Myanmar Group. Myanmar's membership in the ASEAN Forum on Coal (AFOC) has opened additional opportunities for coal investment, including as a means to promote rural electrification. Myanmar is also introducing clean coal technology.

Hydropower: Myanmar has a high potential for renewables that provide a low-cost alternative to diesel. The largest source is hydropower, which grew in importance after the World Bank conducted a 1995 study that predicted Myanmar had a potential production capacity of 108,000 MW[††††††††††††††††††††††††††††] .

In 2006, Myanmar announced plans to wean the country off gas to make hydropower the sole electricity source by 2030. Twenty-four hydropower plants would be developed, varying in output from 48 MW to 7,100 MW, with a projected 23,300 MW of electricity by 2030.[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Certain hydropower resources are earmarked for export, while gas would be directed to fertilizer production and other projects.

Several power plants are currently under construction in Mandalay, Magway, and Bago divisions as well as Rakhine state and the Chindwin River Valley. Additional projects are located in Upper Paunglaung, Nacho, Shwegyin, Htamanthi, Pyuchaung, Kunchaung and Thahtaychaung. Feasibility studies are also underway in Thanlwin and Tarhsan.

Although hydropower is a sound long-term option, it requires long lead-time, a significant amount of investment and environmental consideration. This must come from foreign companies, and Myanmar would prefer not to rely on external entities for basic power needs. Hydropower also suffers shortages during dry season, requiring back-up. Therefore, even though hydro capacity should be expanded, the nation must remain diversified so it will not be reliant on any one energy source.

Gas can plug short-term gaps and be stored during times of low demand for use in maximum demand periods. For base-load, however, hydropower, geothermal and tidal energy are

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[††††††††††††††††††††††††††††] Harnessing Energy from the Clouds, *The Myanmar Times*, August 20-26, 2007

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Government Will Prioritize Hydropower Projects Over Gas, *The Myanmar Times*, July 10, 2006 preferable. Natural gas can be used as a feedstock to increase added-value of Myanmar's consumer products and exports. Liquefied petroleum gas (LPG) and compressed natural gas can also be diverted for domestic use. This would reduce carbon emissions and help to develop the gas industry.

Other Renewables: Traditional biomass is, and will remain, the primary energy source in Myanmar for many years to come. In addition to hydropower, Myanmar is working to develop other renewable energy sources, including wind, solar, geothermal, and biomass, consisting of fuel wood, charcoal, agricultural waste, and animal residue.

Table 6-7: Biomass Resources in Myanmar

Type	Quantity
Rice Husk	4.392M ton/year
Lumber Waste	1.5M ton/year
Bagasse	2.126M ton/year
Molasses	240M ton/year
Livestock Waste	34.421M ton/year

Source: Myanmar Engineering Society.

While it is difficult to obtain accurate data given unreported logging, more than 50 percent of Myanmar's total land area is reported to be forest. This represents approximately 344,232 square kilometers. Myanmar's potential annual yield of fuel wood could be as high as 23.5 million hoppus tons. According to the data from the Ministry of Environmental Conservation and Forestry, fuel wood and charcoal represent about 70 percent in 2010 of the country's primary energy supply and will have a 58 percent share in 2020. Consumption is directly proportional to population growth and indirectly proportional to availability of other energy sources[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§].

To preserve forests, Myanmar's government has undertaken initiatives to substitute use of fuel wood with other biofuels or, in areas near oil and gas fields, LPG. Efforts are also being made to introduce more efficient stoves and appliances to rural households. These measures are expected to decrease dependence on fuel wood by 46 percent over a 30-year period.

Per year, Myanmar also has 4.392 million tons of rice husk resources, 1.5 million tons of lumber waste, 240,000 tons of molasses, 2.126 million tons of bagasse, and 34.421 million tons of livestock waste. All of these sources can be used for biomass gasification[*****************************]. As of 2008, 428 biomass gasification plants were operating in Myanmar. Cost savings makes biomass especially attractive for Myanmar's rural population. Nevertheless, as one analyst interviewed noted, "Use of in-country biomass is only attractive if it substitutes for imported oil. It will not replace hydro for base-load generation."

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§§§§§§§§§§§§§§§§§§§§§§§§§§§§§ Renewable Energy Sector, Myanmar Ministry of Energy, accessed: June 29, 2012

***************************** ASEAN Countries' Presentation on Renewable Energy Projects and Business Opportunities (Myanmar), Myanmar Engineering Society

Solar energy also holds promise. Myanmar's Ministry of Electric Power reports available solar energy is about 51,974 tTWh per year.[†††††††††††††††††††††††††††††] Solar energy is abundantly available in central Myanmar with a radiation intensity of 5 kWh per square meter per day during the dry season. At present it is only being used on an individual scale, primarily through photovoltaic cells. Solar panels have been a source of electricity for certain monasteries and schools in Myanmar and were provided to villages in Myanmar's Ayeyarwady Delta following power interruptions due to Cyclone Nargis[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] . Despite the savings over diesel fuel when viewed over a long timeframe, solar electricity has a relatively high start-up cost.

Myanmar's wind energy potential is 365 terawatt hours per year, according to government data, and the country has identified 93 geothermal locations.

The potential for tidal electricity generation may also be great due to 1,700+ miles of coastline and expansive delta areas. Two tidal-powered hydroelectric facilities were completed in 2005, in Ngapudaw Township, Ayeyarwady Division[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§].

(3) Structure of electricity industry

Myanmar's electricity system is centralized under government and state-owned enterprises with some private sector involvement in the generation, distribution, sale and service of electricity. The industry is regulated by the Electricity Act of 1948 (as amended in 1967), the Myanmar Electricity Law of 1984 and the Electricity Rules of 1985.

The Ministry of Electric Power, established in 1997, was restructured in 2006 and divided into two separate ministries: the Ministry of Electric Power 1 (MOEP-1), which was responsible for the development and maintenance of hydropower and coal-fired power plants; MOEP-1 was comprised of the Department of Hydropower Planning (DHPP), Department of Hydropower Implementation (DHPI) and Hydropower Generation Enterprise (HPGE). The Ministry of Electric Power 2 (MOEP-2) was responsible for the development, operation and maintenance of gas and combined power plants, transmission and distribution system. MOEP-2 was comprised of the Department of Electric Power (DEP), Myanmar Electric Power Enterprise (MEPE), Electricity Supply Enterprise (ESE) and Yangon City Electricity Supply Board (YESB). In September 2012, these two ministries were reorganized into a single ministry, Ministry of Electric Power (MOEP).

MEPE, established in 1997, is a state-owned, state-run utility. It operates and maintains Myanmar's gas turbine power stations and combined cycle power plants, and is charged with financing, constructing, and operating the country's transmission lines. MEPE also constructs

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[†††††††††††††††††††††††††††††] Mercedita A. Sombilla, Urooj S. Malik, A.K. Mahfuz Ahmed, and Sarah L. Cueno, Integrating Biofuel and Rural Renewable Energy Production in Agriculture for Poverty Reduction in the Greater Mekong Subregion, Asian Development Bank, 2009.

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Electricity in Myanmar, *op.cit.*

[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§] Delta Holds Great Potential for Tidal Power Generation, *Voice Weekly*, February 13, 2006 distribution lines as well as substations. It is charged with distributing electricity through the national grid to five of Myanmar's seven states and six of seven divisions.

Distribution of electricity was managed under a state monopoly until 1994, when, to meet increasing demand for power, the government invited the private sector to invest in Myanmar's electricity sector[*]. Low returns, coupled with international sanctions against the country, however, have been a challenge to commercialization.

YESB was formed and tasked with approving small businesses to generate and sell power to consumers in Yangon division. HPGE and MEPE supply power to local consumers, but only Shweli Hydropower Company (JV Company of HPGE and YUPD) exports electricity to other countries. Off-grid power is supplied by the Electricity Supply Enterprise[†].

(4) Decision-making structure of Ministry of Electric Power

Independent Power Providers (IPP) still cannot own transmission lines and large plants remain under government control. What constitutes an IPP in Myanmar is in a state of flux[‡]. In rural areas, small-scale hydro and bio-fuel projects generate and distribute electricity under local or commercial auspices. Commercial captive-power producers also supply some larger towns and suburban areas.

Industrial parks and other captive-power producers have their own transmission systems. State utilities are unlikely to allow sale of captive power to independent buyers in other locations. However, there is insufficient clarity regarding connectivity and power purchase agreements of IPPs.

On a larger scale, the Myanmar government has signed contracts with commercial interests on a Build-Operate-Transfer (BOT) basis. Electricity generated under a BOT contract is sold to MEPE, which then transmits and re-sells the electricity to consumers. The generating facilities are to be transferred to the government, generally after 20 to 40 years. Myanmar's largest power plants have been developed under BOT contracts with foreign power companies, including China's Yunnan Joint Power Development Co. and Thailand's Italian-Thai Industrial Company. The majority of electricity generated is exported.

State agencies produce electricity for their own use and industrial zones are known to establish their own electrical substations, transformers, transmission lines and stand-by generators. Captive-power transmission systems could account for the transmission of up to 66 kV, but more likely are less than 33 kV.

Figure 6-5: Electricity Generation in Myanmar

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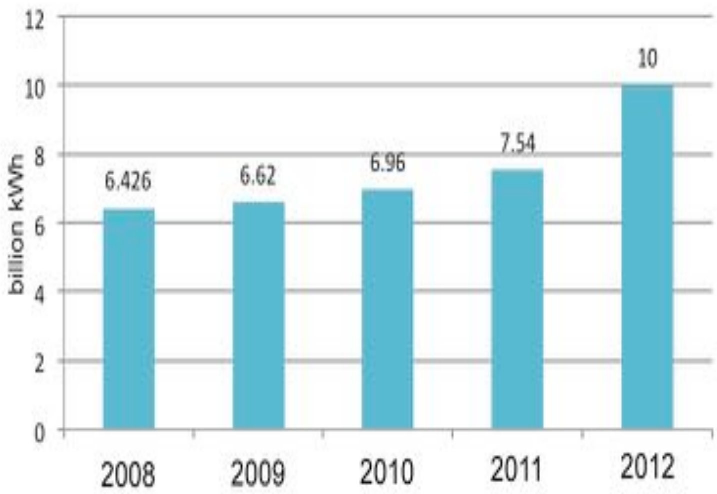
[*] Burma Eyes Private Power Producer, *Nation (Bangkok)*, February 13, 1996

[†] Myanmar: Summary of Asian Development Bank's Initial Sector Assessments, Asian Development Bank, June 2012

[‡] Electric Industry in Burma/Myanmar, Online Compendium, Burma Library, accessed: June 28, 2012



Source: CSO, 2012.

Electrical Capacity: Myanmar produced roughly 10 billion kWh of electricity, consisting of hydroelectricity, gas, coal, and diesel in 2011-2012[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§]. Myanmar's Central Statistical Organization (CSO) reports that 6.62 billion kWh of power generation in 2008-09, 6.96 billion kWh in 2009-10, and 7.54 billion kWh for 2010-11[********************************]. This follows an increase in electricity generation from 5.804 billion kWh in 2005 to 6.426 billion kWh in 2008[††††††††††††††††††††††††††††††††].

Despite an average 15 percent annual increase in electricity generation between 2008-2011, the CSO does not report any additions to installed capacity between 2009 and 2012.[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] If accurate, this suggests the already inadequate power grid is being worked more intensively, increasing potential generator failure risk and power outages. Blackouts, already a common occurrence in most parts of Myanmar, became even more frequent in Yangon and Mandalay in 2012.

It is possible the CSO has not updated its statistics on installed capacity. Asian Development Bank reports installed capacity in 2011 was 3,361 MW, compared with CSO data that states installed capacity stood at 2,947 MW in 2010, made up of 94.06 MW off the grid capacity and 2,852.94 on the grid[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§]. According to CSO, installed capacity on the grid is comprised of 2,013.5 MW of hydroelectricity, 120 MW of coal, 550 MW of gas, 165 MW of steam, and 4.5 MW of diesel. ADB states total installed capacity for 2011

[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§] David Dapice, Electricity Demand and Supply in Myanmar, Proximity Designs, December 2012

[********************************] Electric Power Generated and Sold by the Myanma Electric Power Enterprise, *op.cit.*

[††††††††††††††††††††††††††††††††] Country Analysis Brief: Myanmar (Burma), U.S. Energy Information Administration

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Electric Power Generated and Sold by the Myanma Electric Power Enterprise, *op.cit.*

[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§] The Republic of Union of Myanmar, Country Report, Myanmar Ministry of Agriculture and Irrigation, presented May 26, 2011-July 6, 2011 was comprised of 2,520 MW of hydropower capacity, 715 MW of gas-fired capacity, and 120 MW of coal-fired capacity.

Installed capacity may, however, be lower than government statistics suggest. For example, the EIA reports an installed capacity of 1,840 MW in 2008, up from 1,800 MW the year before and 692 MW in 1980.

Either way, installed capacity in the 1,800 MW to 3,500 MW range is far too low for a country of Myanmar's size. In comparison, Thailand, which has a similar population and is Myanmar's largest export partner, has an installed capacity of 28,479 MW, according to the Electricity Generating Authority of Thailand—up to 10 times that of Myanmar[*].

Myanmar currently has one of the world's lowest per capita electricity consumption rates. Myanmar consumed 104 kWh per person in 2009, compared to 131 kWh per person in Cambodia, 590 kWh per person in Indonesia and 2,045 kWh per person in Thailand[†]. Only Nepal, Haiti and a handful of sub-Saharan African countries consumed less electricity per capita than Myanmar.

Estimates place Myanmar's present electricity supply at only about half of future demand[‡]. ADB, citing the Ministry of Electric Power, estimates individual power consumption will grow from 203.9 kWh in 2012-2013 to 550.13 kWh in 2021-2022[§]. Generally speaking, electricity demand grows at the same rate as GDP, but that assumes those already connected to the grid have adequate power supply. Electricity demand in Myanmar is estimated to be growing at an annual rate of between 10-15 percent[*]. This is twice as fast as GDP growth, which the International Monetary Fund estimates at 5.5 percent in FY 2011-12 and 6.25 percent for FY 2012-13[†]. Given the state of Myanmar's power system, the growth rate of electricity demand could be 2.5 times international norms[‡].

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[*] International Energy Statistics, U.S. Energy Information Agency

[†] Electric Power Consumption (kWh per capita), The World Bank Group, accessed: June 29, 2012

[‡] Dapice, Electricity in Myanmar: The Missing Prerequisite to Development, *op.cit.*

[§] Asian Development Bank, Myanmar Energy Sector Assessment, *op.cit.*

[*] Dapice, Electricity in Myanmar: The Missing Prerequisite to Development, *op.cit.*

[†] Myanmar Set for Economic Takeoff With Right Policies, IMF Growth Survey, May 7, 2012

[‡] By contrast, according to a Harvard University study authored by David Dapice, the government's planned investments over the next five years will add only 617 MW of capacity, representing less than 5% annual growth.[‡] Dapice estimates electricity consumption for 2012 will be roughly 160 kWh per capita.[‡] According to report, annual growth averaged 3.8% over a two-decade period, and electricity consumption rose from 45 kWh per capita in 1987 to 99 kWh per capita in 2008.

Myanmar's Forest Department reports industry accounts for roughly 10 percent of final energy consumption, transportation for just over 6 percent and other users, which likely includes residential users, for 83 percent[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§]. One consulting firm states households account for 70 percent of Myanmar's electricity consumption[**********************************]. An October 2012 ADB report cites 5.4 percent annual growth in energy consumption in Myanmar's commercial sector between 2000 and 2009, 4.8 percent annual growth in the industrial sector, and negative annual growth of 1.9 percent in the transport sector. The residential sector, although it is the largest consumer of energy, experienced only 1.3 percent annual growth between 2000 and 2009[††††††††††††††††††††††††††††††††††].

As mentioned, the government is increasingly looking toward hydroelectricity to address its capacity problem. According to feasibility studies, this can add about 46,300 MW of generating capacity[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡]. A May 2012 article in *The Myanmar Times* states Myanmar's hydropower plants have maximum generation capacity of 1,270 MW, which fluctuates in a monsoon climate. During Myanmar's dry season, hydro capacity drops to 1,000 MW due to lower water levels. Citing Ministry figures, *The Myanmar Times* reported peak electricity usage during rainy season averages 1,450 MW, rising to 1,850 MW during dry season.

Hydropower can be supplemented by gas during the dry season. However, U Aung Than Oo, former Deputy Minister for MOEP-2 and current Deputy Minister for the MOEP, noted combined hydro and gas capacity was at least 500 MW below electricity demand. Speaking at a May 2012 press conference, the Deputy Minister emphasized demand was expected to grow by 15 percent in 2012.

Up to 90 percent of electricity produced by certain joint venture operations, such as the China-funded Myitsone Hydroelectric Power project, are earmarked for export. This makes citizens skeptical of foreign investments in the sector. Riots broke out in 2012, and Myanmar citizens accused the government of diverting needed electricity to China. Several Chinese- and Thai-backed investments, including the Myitsone project, were interrupted due to citizen backlash[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§][**********************************].

In response, the government agreed to dedicate future natural gas finds to domestic use. While an expedient political move, this is problematic as capacity expansion is capital intensive and substantial investment will be required. A pipeline in the Southeast that brings gas from offshore fields to Yangon is reported to have corrosion problems that substantially decrease its

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[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§] Myanmar Forest Department, presented at Stakeholders Meeting on March 25, 2012

[**********************************] Electricity in Myanmar, Thura Swiss Research, April 12, 2012

[††††††††††††††††††††††††††††††††††] Asian Development Bank, Myanmar Energy Sector Assessment, *op.cit.*

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Myanmar's Electric Power Generating Capacity Reaches 2,256 mw, *Xinhua*, January 1, 2001

[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§] Burma to Halt Myitsone Dam Project: Media Reports, *Mizzima News*, September 30, 2011

[**********************************] Myanmar Scraps Coal-fired Power Plant at Dawei, *Reuters*, January 10, 2012 capacity[†]. Other pipelines that bring gas to Yangon are already operating at capacity and would need to be upgraded. Without the hard currency revenues that can be generated through export sales, Myanmar may become overly dependent on debt and donor financing. It will also place the government under great pressure to subsidize domestic pricing. Another option is to install a modern combined cycle generator, which, according to David Dapice of Harvard University, would triple the amount of electricity produced using an equal amount of gas as the generators currently used in Myanmar.

Electricity Grid: Myanmar's national grid system connects major electric power stations—consisting of 20 hydropower plants, one coal-fired plant and ten gas-powered plants—to substations and end users using eight types of transmission and distribution lines[‡]. The country has 4,793.24 miles of transmission lines, comprised of 39 230 kV, 37 132 kV and 117 66 kV lines.[§] There are 27 23 kV, 24 132 kV, and 108 66 kV substations with a total transformation capacity of 5,875.4 megavolt amperes. Transmission losses are high in Myanmar, estimated at 27 percent as of 2011, due to relatively low voltage and antiquated equipment[**]. This is down from about 30 percent between 2003-2009.

Adding to the problem, users sometimes use transmission line voltage regulators, or step-up transformers, which can create supply imbalances and blackouts. Beyond being uncompensated, this creates safety issues. More than one third of fires that broke out in Yangon in 2011 were reportedly caused by improper use of electrical appliances. Transformers are seen as a leading cause. This makes upgrading Myanmar's distribution system imperative.

Expanding the grid system can be the least expensive means to increase connectivity, which in Myanmar is at maximum 26 percent[††]. The government plans to build 36 additional substations with 5,675 MVA and 6,444 miles of transmission lines using four 500 kV, 41 230 kV, 8 132 kV, and 20 66 kV lines. It is likely most new transmission lines will bring power from northern hydropower and southern gas-fired power plants at 230 kV and 132 kV. One analyst estimated the capital cost could be between USD 13 billion to USD 18 billion.

In terms of rural electrification, simply extending distribution lines will not provide a short- to medium-term solution due to inadequate generation capacity. A 2003 report by Japan International Cooperation Agency estimates if rural electrification were improved 2 percent

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[†] David Dapice, Electricity Demand and Supply in Myanmar, Proximity Designs, December 2012

[‡] Kan Zaw, Challenges, Prospects and Strategies for CLMV Development: The Case of Myanmar in ERIA Research Project Research 2007 No.4: Development Strategy for CLMV in the Age of Economic integration (Tokyo: IDE-JETRO, 2008)

[§] The Republic of Union of Myanmar: Country Report, *op.cit.*

[**] Asian Development Bank, Myanmar Energy Sector Assessment, *op.cit.*

[††] Addressing the Electricity Access Gap, Background Paper for the World Bank Group Energy Sector Strategy, The World Bank Group, June 2010

annually, an optimistic assumption, it would take more than 40 years for networks to reach the majority of Myanmar's towns and villages[‡].

(5) Distribution of electrification rate

According to MOEP data, electricity is distributed to 2,323,467 out of 8,905,674 families, or 26 percent. The electricity covers 220 out of 396 towns and approximately 1,600 of 6,774 villages in the current distribution network. Myanmar has a total 64,346 villages[§].

World Bank data, however, from 2009 states only 13 percent of Myanmar's population had access to electricity. Based on that rate, a 2012 presentation by the National Energy Institute at the National University of Singapore, says 19 percent of urban and 10 percent of rural populations are connected to the grid[*]. The Integrated Household Living Conditions Survey 2009-10, however, carried out jointly by UNDP and the Myanmar Ministry of National Planning and Economic Development, states overall access to electricity increased from 38 percent to 48 percent in 2005-2010. As emphasized in a strategy paper on Rural Development and Poverty Reduction in Myanmar, large differences exist between the poor, with a 28 percent access rate – up from 20 percent in 2005 – and the non-poor, with 55 percent[†]. The figures stand at 34 percent for rural and 89 percent for urban dwellers.

The discrepancy in data may result from World Bank statistics measuring access to national grid, with UNDP measuring availability from all sources, including generators and independent projects. Typically households in Myanmar derive electricity from car batteries, chargers, and inverters—commonly used to convert direct to alternating current—or purchase power from independent generators.

Small independent producers play a key but difficult to measure role in rural environments. For example, a *Reuters* article described an individual in Kya-oh, who provides energy to households using a private generator. The individual charges 3,000 kyat a month per household for 2.5 hours of electricity a night, and an extra 1,500 kyat for a television – nearly a week's income for some villagers[‡].

[‡] The Study on Introduction of Renewable Energy Sources in Myanmar, Japan International Cooperation Agency, September 2003

[§] Electricity Prices to Be Doubled, *op.cit.*

[*] S.K. Chou, Overview of ASEAN's Energy Needs and Challenges, Presented at Energy Policy Roundtable 2012, Todai Policy Alternatives Research Institute, The University of Tokyo, April 20, 2012

[†] Dr. Dolly Kyaw, Proposal for Rural Development and Poverty Reduction in Myanmar

[‡] Myanmar's Power Struggle Endangers Economic Boom, *Reuters*, April 16, 2012

Rakhine State fared among the worst in a UNDP study concerning electricity and household, water, and sanitation conditions. Access to electricity stood at 26 percent in Rakhine, 30 percent in Ayeyarwaddy, 31 percent in Magwe and 32 percent in Bago[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§]. Rakhine State is plagued by ongoing violence and was the site of an uprising that led Myanmar to declare a state of emergency in 2012. Although urban electrification is relatively easier, the government, in its attempt to build a more representative democracy, is becoming more dependent on political buy-in from traditionally marginalized and remote populations. Rural electrification, in addition to helping the country develop and industrialize, is one means of building broader support.

In pursuing rural electrification, the government must balance between connecting rural populations to the national grid and satisfying increased urban and industrial demand. Villagers, understanding the difficulties of relying on government projects, have begun implementing schemes on a self-help basis. In some cases this is done with support of NGOs, donors and SMEs, in parallel with government initiatives. Proximity Designs, for example, a Yangon-based social enterprise, introduced a solar-powered lantern that sells for about USD 11, compared to a USD 60 Chinese model.[*************************************] A Thai solar power company, SPCG, is also planning to enter Myanmar, with initial plans to establish 2 MW of solar power capacity[††††††††††††††††††††††††††††††††††††††].

Although admirable in providing a short-term solution, the sustainability of reliable decentralized power is questionable. Isolated power systems tend to use small-scale renewable sources, including hydroelectricity, as well as biofuel, solar and wind. Isolated systems are suitable options where demand density is low. They do not require large-scale investment or hard currency. While operating and maintenance costs are also low compared to projects involving the national grid, administrative and management costs by donors and other institutions seeking to develop numerous sites can be onerous. That is because individual small projects lack the scale that allows effective amortization in comparison with larger ones.

SMEs that try to deliver to rural areas also face many difficulties, including customers unable or unwilling to purchase or install electrification capacity. Marketing to the rural poor is also a challenge[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡]. Myanmar's SMEs face numerous additional problems, including a scarcity of capital, obsolete equipment and machinery, a shortage of adequate physical and human resources, an absence of current information on technical, market and legal issues, and a lack of support from the state, especially in technology transfer, credit guarantees and loans. This is an area in which donor assistance or public-private partnerships could prove vital.

[§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§§] Integrated Household Living Conditions Survey in Myanmar 2009-2010, Poverty Profile Report, UNDP Myanmar, June 2011

[*************************************] Winn, *op.cit*.

[††††††††††††††††††††††††††††††††††††††] Mridul Chadha, Off-Grid Solar Power Projects For Myanmar, Clean Technica, January 13, 2013

[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] Entrepreneurship Development in Solar Energy Sector for Rural Area in Myanmar, ARTES/SESAM Alumni Regional Level Workshop, May 2008

Electricity Cost: The need for outside financing is especially apparent when one considers the losses sustained by government through subsidies. Myanmar's electricity prices are the cheapest among 15 countries in the region, according to Deputy Minister U Aung Than Oo, but vary widely. Costs for electricity from the national grid range from 35 kyat per kWh in Myanmar's capital to 12 times that in Sittwe, the capital of Rakhine State[§].

In 2012, MOEP-2 was buying hydroelectricity from MOEP-1 at a rate of 20 kyat per kWh and spending 127 kyat per kWh to generate electricity with gas turbines[*]. The deputy minister said the ministry was spending more than 60 kyat to distribute one kWh of electricity, but charging 37.40 kyat per kWh, losing over 20 kyat for every unit sold.

The cost of distributing electricity at a loss will total 249.8 billion kyat (roughly USD285.3 million) in 2013. This creates a quandary when attempting to balance the critical upgrades required to accumulate more users and expand the infrastructure needed to promote development and industrialization, with the need to generate hard currency and raise prices to market rates. This problem is likely to be further compounded by government pledges to reserve future natural gas finds for domestic use. It will be difficult to finance new development, processing, and distribution if the output is then subsidized and sold at a loss.

Overcoming this constraint will not be easy. Since revenues gained from resource extraction were used in the past to enrich a narrow group of elites and select institutions, the public is now pushing for Myanmar's energy to be used for the public good, while market pricing and mechanisms, as well as the insidious role of subsidies—are not well understood. In particular, gradual subsidy removal to ensure sustainability of socio-political and national economic growth will be paramount.

One analyst interviewed noted he had been told industrial users and foreigners in Yangon are presently being charged for electricity in dollars, rather than kyats. Asking export-oriented consumers of electricity to make payments in foreign currency is a model that could enable both generation of foreign exchange and industrial development. It could fund industrial park development and other facilities where output is export-oriented. This would allow hard currency funding as well as partial subsidization of distribution, deemed a necessary public good.

The government increased electricity rates in 2012—from 25 to 35 kyat per unit for home use and 50 to 75 kyat per unit for industrial use—with the long-term hope of equalizing costs and revenues. This will enable the country to focus on regularizing electricity supply, maintenance and expansion of new cable lines. According to Harvard's Dapice, cited above, the cost of electricity should be closer to 90 to 100 kyat per kWh, with subsidies covering only the very poor, most of which do not currently have access to electricity[†].

[§] Myanmar's Power Struggle Endangers Economic Boom, *op.cit.*

[*] Electricity Prices to Be Doubled, *op.cit.*

[†] David Dapice, Electricity Demand and Supply in Myanmar, *op.cit.*

(6) Major energy policies

To meet its goal of tripling per capita GDP in five years and expand national electrification to satisfy growing demand, Myanmar has adopted a diversification strategy to meet both domestic needs and export requirements.

On a political and regulatory level, substantial work must be done to transform resource extraction from an industry that lacks transparency and which enriches only a small elite, to one that addresses a full range of environmental and social concerns and which has all the nation's citizens' best interests in mind.

Institutions of Policy: The Ministry of Energy and Ministry of Electric Power are the two main entities tasked with oversight. Oil and gas management falls under Ministry of Energy and MOGE; coal business under the Ministry of Mines; biofuels and micro-hydro (for irrigation use) under Ministry of Agriculture and Irrigation; fuelwood, climate change and environmental safeguards under Ministry of Environmental Conservation and Forestry; renewable energy under Ministry of Science and Technology; and energy efficiency under Ministry of Industry.

To fulfill the people’s need to systematically manage the linkage of Energy and Electrical Sectors , **National Energy Management Committee (NEMC)** and **Energy Development Committee (EDC)** was formed according to the Notification No.(12/2013) dated 9th January , 2013 issued by the President Office. For the time being 1st Draft of Energy Policy has already drawn up for short-term and long-term plans.

The Ministry of Education, responsible for vocational and technical training, and the Ministry of Co-operatives, which also has a hand in vocational skills training as well as developing mineral production and electrical goods production under the cooperative sector, also play a role in Myanmar's energy policy.

Basic Policy: The Ministry of Energy's current policy priorities are: To fulfill Domestic Energy Requirement as Priority; To Implement the Status of Sustainable Energy Development; To promote Wider Use of New and Renewable Sources of Energy; To promote Energy Efficiency and Conservation; To promote Use of Alternative Fuels in Household; To Implement Effective Utilization of Discovered Crude Oil and Natural Gas Resources in the Interest of the Entire Nation including the Regions where the Discovery was made; and to promote more Private Participation in Energy Sector. Given Myanmar's power sector is starting from such an underdeveloped state, the country has a great opportunity to create and adopt efficient and sustainable energy policies. With its current energy mix, Myanmar produces 0.04 percent of global greenhouse gas emissions, compared to 0.9 percent in Thailand and 25.55 percent in China[‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡] .

Carbon dioxide emissions for each kW of electricity produced from coal and oil are twice that from natural gas, according to British Nuclear Industries Forum. Although hydropower schemes emit very little carbon dioxide, methane emissions do rise from rotting vegetation in reservoirs. Hydropower is said to contribute only 4 percent to global

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‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡‡ Carbon Dioxide Emissions (CO2), Thousand Metric Tons of CO2, Millennium Development Goals Indicators, United Nations

warming[§]. Black carbon emissions from burning biomass in open fields are the third largest contributor to global warming[*].

In 1997, the government adopted the Myanmar Agenda 21 to integrate sustainability into everyday considerations of individuals, households, communities, corporations and government. It seeks to increase efficiency, reduce waste and promote recycling, encourage new and renewable sources of energy, utilize environmentally sound technologies for sustainable production, decrease wasteful consumption, and raise awareness of sustainability measures.

While Myanmar plans to increase its reliance on hydropower, hydropower production is centered in more remote and mountainous areas such as Kachin and Karen States. These areas have historically been troubled by ethnic tensions and are located far from population centers where demand is focused. This presents a challenge of efficiently transporting the electricity generated.

Myanmar's Ministry of Energy also has plans to address its energy pricing system, which presently operates with subsidies. The Ministry intends to introduce a pricing mechanism to not only enhance competitiveness of certain resources, such as coal, but also to increase awareness of energy use with an eye toward promoting efficiency and conservation.

The GOM, in partnership with Japan, has also launched feasibility studies for energy conservation.[†] The government enacted a conservation initiative for government entities, under which government buildings must use daylight for illumination during office hours as much as possible and government vehicles, except those on duty and emergency vehicles, were required to observe two dry days a month. Compliance was monitored by an inspection team.[‡]

The government also engages in partnerships with the private sector, foreign countries and regional agencies, as well as universities. Recent partners include Thailand's Chiang Mai University, which supported a rural electrification project in 2008, and Japan's New Energy and Industrial Technology Development Organization (NEDO), with which the Myanmar government recently signed an agreement on renewable energy and conservation technologies.[§][*]

[§] Greenhouse Gas Emissions from Dams FAQ, International Rivers, May 1, 2007

[*] For more information on the carbon footprint of electricity generation, see: http://www.parliament.uk/documents/post/postpn268.pdf

[†] Burma Infrastructure > Energy, Asia Trade Hub, accessed: June 29, 2012

[‡] ASEAN Countries' Presentation on Renewable Energy Projects and Business Opportunities (Myanmar), *op.cit.*

[§] Than Htike Oo, Villages Near Twante See the Light, *The Myanmar Times*, January 14-20, 2008

[*] NEDO and the Government of Myanmar Conclude Letter of Intent for Introduction of Renewable Energy and Energy Conservation Technologies in Myanmar, New Energy and Industrial Technology Development Organization, January 17, 2012

Additional Policy Concerns: Myanmar needs to carefully consider its options as it determines future policies and plans to plug the "electricity deficit" while balancing a mix of reliable and sustainable energy sources. It must also address the perceived inequity of many energy transactions, as well as environmental consequences beyond carbon emissions. All of this is compounded by the newfound ability of citizen's in Myanmar to exercise their democratic right of protest. Two large-scale power projects—the Myitsone dam and Dawei coal-fired plant—have been interrupted since the fall of 2011.

A survey published on *MyanmarAffairs.com* found that 90 percent of 1,059 people interviewed opposed the Myitsone dam for environmental, socioeconomic and cultural reasons.[†] Importantly, the vast majority—up to 90 percent according to some reports—of electricity generated by the project was slated for export to China. The project had initially been given the go ahead without public consultation, despite estimates that 15,000 locals would be displaced.

Hydropower on a large-scale can also threaten ecosystems and local livelihoods, including farming and fishing. Due to a lack of resources, the government has not adequately surveyed dam sites for biodiversity or formalized regulations requiring environmental impact assessments of energy projects. In the case of Myitsone dam, a USD 1.25 million environmental impact assessment that was carried was a source of controversy[‡].

As coal is the most carbon-rich fossil fuel, villagers near coal sites suffer from pollution as well as noise hazards. For example, an estimated 12,000 people living within a five-mile radius of Myanmar's largest coal mine, Tigyit, are said to be affected with health problems and breathing difficulties as a result of the mine.[§] Water contamination also threatens agriculture and ecosystems, while waste can encroach on villages, causing massive mudslides.

Though it burns cleaner than coal, natural gas production and transport carry risks of leakage and gas blowouts. Pipeline routes in Myanmar are highly protected due to so-called "pipeline security operations," with 8,500 soldiers said to be stationed along the Yetagun and Yadana pipeline route. Petroleum Operations in both Onshore and Offshore areas, after signing of Production Sharing Contract and / or Improved Petroleum Recovery , the Contractor have to conduct Environmental Impact Assessment (EIA) , Social Impact Assessment (SIA) and Environmental Management Plan (EMP) reports for MIC's approval during the Preparation Period .

Biomass and other renewable sources bring their own problems, including soil erosion, loss of biodiversity, and deforestation. When burned indoors using certain stoves, biofuels contribute to indoor air pollution and respiratory disease. Production can also divert land from agricultural use, impacting food security.

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† Opinion Poll on Ayeyawady Myitsone Hydropower Project, MyanmarAffairs.com, accessed June 28, 2012

‡ TheMyitsone Dam on the Irrawaddy River: A Briefing, International Rivers, September 28, 2011

§ Poison Clouds, *op.cit.*

There are minimal laws regulating energy projects in Myanmar and provisions of international treaties, such as the Convention on Biological Diversity, to which Myanmar is a party, have yet to be codified into domestic legislation.

The government, however, has already taken steps to join the Extractives Industries Transparency Initiative (EITI) through a group created under direction of Myanmar's president to oversee implementation in December 2012. Myanmar's government is expected to submit an application by the end of 2013.[**]

Accomplishing its new energy policy objectives will also require a repositioning of Myanmar's human resource capacity and expertise, and a clarification of the roles of ministries involved in energy policy implementation. The country is fortunate to have significant resources and several options, as outlined in Table 6-8.

Table 6-8: Energy Development Strategy for Myanmar

Short-term:	• 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 / or consumers • 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 (GT) turbines • Promote energy conservation (e.g. compact fluorescent light bulbs)
Medium-term:	• Install open-cycle GTs • 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
Long-term:	• Maximize hydropower and 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

Source: ERIA.

There are a number of drivers that will influence the way forward. These include availability of project finance, project lead-time, expectations, economic growth requirements, environmental and sociopolitical impact, reliability and supply.

[**] US official sees 'real commitment' in Myanmar's EITI efforts, *Myanmar Times,* March 4, 2013

It is important that Myanmar overcome critical short-term demands and plan for the future using medium- and long-term solutions.

2.2.Policy Implications

(1) Directions for future energy policy developments

In the course of our research and discussions, we have generally agreed on several important energy policy concerns and issues that should be tackled in the future. These include:

- Recognizing essential importance of formulating an Integrated Energy Policy. Establishment of Energy Management Committee chaired by the Vice President marks definitive progress;
- Initiating comprehensive medium/long-term energy policy planning;
- Enhancing coordination between ministries. For example, optimizing natural gas allocation and development of power generation at political and ministerial level;
- Maximizing human resource development. Capacity building and training also needed.
- Evaluating and optimizing energy prices, tariffs and use of subsidies;
- Developing a framework for public-private partnerships in the electricity sector
- Developing more comprehensive energy statistics immediately. Rectifying inconsistencies in statistical data among the ministries;
- Integrating parallel focus on off-grid areas into policy dialogue and development efforts;
- Introducing additional transparency into policymaking procedures and process;
- Improving potential for expansion and rehabilitation of transmission lines through measures that can better attract necessary investment; and
- Recognizing continuing importance of forestry in energy mix as traditional biofuels remain essential primary energy source.

(2) Three Policy Themes

Better energy access helps to provide the underlying fundamentals that lead to poverty eradication, economic development and political stability. As emphasized throughout this project to facilitate development of an Integrated Energy Strategy in Myanmar, huge additional investments of time, capital and other resources are necessary to suggest mechanisms to improve, rehabilitate and expand Myanmar's existing energy infrastructure and electricity in particular. This is necessary to provide better access to power in backbone areas including Yangon, Mandalay and Nay Pyi Taw. In addition, as emphasized throughout our first stakeholder's meeting, many other initiatives are needed to address power access in areas that extend beyond the grid, both in the short run until 2015 and longer term. Therefore, while current policy discussion is largely focused on strengthening the main grid to increase power generation, these measures alone cannot achieve broader access. Even if the grid infrastructure were totally renovated and upgraded there would still be a serious lack of transmission and distribution to major portions of the country. For this reason, the following three policy themes have been highlighted as mechanisms that can facilitate broader access to power in Myanmar.

Grid Extension

The first theme is strengthening, extending and expanding the main grid. This strategy is the most efficient on both an economic and technical basis. With economies of scale, the generation cost per unit can be reduced within a larger energy system that has an ability to draw, and integrate distribution, from a range of energy sources. At the same time, this strategy will require massive investment if it is to fulfill the requirements of the nation as a whole. Examined purely on an economic basis, investors are 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. This is, however, not likely to improve access in peripheral regions, at least, at the present time. Additionally, from the standpoint of energy security, a centralized energy system could prove problematic in Myanmar, given many energy and natural resources are located in rural areas with long histories of ethnic strife and conflict. This necessitates the introduction of safeguards against possible disruptions that could potentially hamper energy transmission, adversely impacting the entire energy system.

Regional Integration and International Cooperation

The second theme is enhanced cooperation with bordering nations as well as countries around the world that can provide essential capital, technology and other goods and services. Luckily, Myanmar has substantial energy resources including thermal, hydro, oil, gas and biofuel. This provides the potential to transform the nation into both a valued supplier as well as a consumer of energy products in the region. For example, along the Chinese border, vast potential exists for hydroelectric power, which can flow in both directions. Additionally, along its border with India, there are a number of mining sites including coal. There is also biofuel potential in Myanmar's agricultural heartland and substantial potential for offshore oil and gas development in coastal areas. If these resources are developed for generation and supply, both domestically and for export, this cross-border energy flow is beneficial for Myanmar's neighboring countries and the region. Further, electricity from Myanmar's neighbors is available in certain border towns, but strict regulations hinder its use on the Myanmar side. As noted in the strategic paper, "Border Area Development Strategy," making this electricity available legally and regularly will 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[††]. In this regard, special attention will be paid to border cities – such as Muse and Myawaddy – which have the potential to serve as major conduits to enhance regional integration and Myanmar's trade and economic relations with ASEAN and other neighbors as well as the world at large.

Rural Energy Access

The third theme is driven by the realization it will not be possible to electrify Myanmar as a whole on an economic basis. Some areas, particularly in remote regions will lag behind, and by necessity will have to rely largely on self-help approaches and stand-alone systems if they are to gain access to electricity and power over the short- and possibly intermediate-term. For these areas, we will examine the potential for alternative energy systems such as oil products like LPG,

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[††] Kitti Limskul, Toshihiro Kudo, and Hiroyuki Taguchi, Border Area Development Strategy, Myanmar Comprehensive Development Vision Strategy Paper presented March 25, 2013

traditional biomass, and mini/pico hydropower systems on an off-grid and/or mini-grid basis. 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 drawing resources away, and detracting from priority projects and initiatives. By minimizing any potential for diversion, this will also serve to provide more adequate supply and capacity to the urban and industrial areas that will drive Myanmar's economic development. It will also allow demonstrable progress in more remote areas, which can ultimately enhance long-term development in these regions.

These three core themes will be examined through fieldwork, simulation and comparative research in Myanmar and from the viewpoint of neighboring countries and the overall global energy environment. The examinations will lead to the development of actionable strategies and policy recommendations, which will then be fine-tuned through additional stakeholders meetings and an ongoing dialogue with the GOM. This will lead to the formulation of scenarios and policy recommendations and options for the GOM that will provide support for development of a comprehensive integrated energy strategy beyond 2015.

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