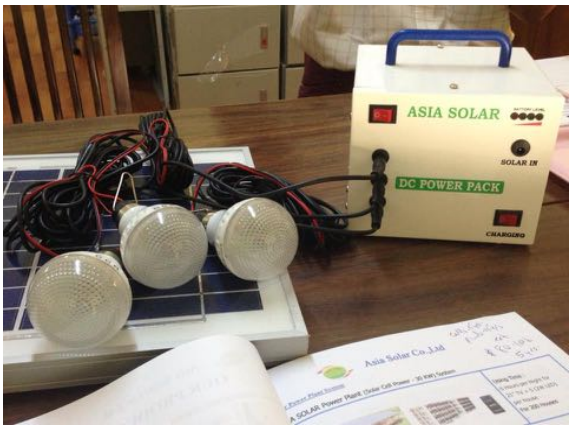
TURNING ON THE LIGHTS: INTEGRATED ENERGY AND RURAL ELECTRIFICATION DEVELOPMENT IN MYANMAR

On-the-Ground Conditions and Key Issues Relating to Rural Electrification



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May – August 2013

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On-the-Ground Conditions and Key Issues Relating to Rural Electrification in Myanmar

FINAL REPORT

SEPTEMBER 1, 2013

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

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

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

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

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Project Overview – Status

Following-up on the initial research conducted by KWR International (Asia) Pte Ltd. ("KWR") with the University of Tokyo ("UT") for the Economic Research Institution of ASEAN and East Asia ('ERIA") in 2012 and early 2013 concerning the development of an Integrated Energy Strategy in Myanmar, KWR was retained to conduct Phase I fieldwork for this initiative over a period ranging from May 1 to August 31, 2013. The following constitutes its final report for this phase of this initiative.

The scope of work for this effort includes identification of data gaps and further evaluation of the current environment for integrated energy development (IED) in Myanmar. A special emphasis was placed on evaluating prospects in different geographic areas around three themes: **1) grid extension**, **2) regional integration and international cooperation** and **3) off-grid development**. The Team has also planned and attended relevant workshops, stakeholder and other meetings and seminars; and worked with ERIA and UT to plan Phase II priorities and fieldwork as well as other activities related to IED in Myanmar and ERIA/UT's work in this area.

To date, KWR has conducted fieldwork trips to: **1) Bagan/Nyaung-Oo**, **2) Monywa**, **3) Mandalay**, **4) Pathein**, **5) Pyin Oo Lwin**, **6) Tachileik**, and **7) Kengtung**. KWR has also conducted follow-up visits to Monywa and Mandalay to obtain additional information concerning incentive programs and activities of local regional government.

An updated summary of each fieldwork trip is included within this interim report, placing emphasis on the three themes noted above.

In addition to the approximately 50+ interviews and meetings it has held as part of these fieldwork trips, KWR has also conducted numerous additional interviews and meetings (see Appendix 1) 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 the Director Generals of Ministry of Energy, Ministry of Electrical Power, and Ministry of Science and Technology; 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.

KWR has also worked to organize, plan and attend the second Integrated Energy Key Stakeholders Meeting in Naypyitaw on June 17-18, 2013 (see Appendix 2) and the ERI-UT Joint Conference on Energy Integration in Myanmar: A view from abroad on June 24, 2013 (see Appendix 3). It has also undertaken efforts to encourage formation of an Energy Experts Working Group, which will consist of senior government officials from the seven Ministries involved in Myanmar's energy and electricity sector as well as targeted representatives of the private sector.

KWR has reviewed and in now analyzing the fieldwork results, to developing a more detailed understanding of Myanmar's energy/electricity sector as well as hypotheses that can be tested through more comprehensive fieldwork to advance Myanmar's efforts to promote grid extension, regional energy/electrical integration and international cooperation and off-grid development across a range of geographic areas in Myanmar.

This report includes conclusions and recommendations to help ERIA and UT establish Phase II priorities, more comprehensive fieldwork initiatives as well as an ongoing operational structure and an expansion of efforts to build capacity and relationships with relevant experts, stakeholders and other individuals and entities—both domestic and foreign—with an existing and potential interest and involvement in the sector.

UT/KWR Fieldwork Team Meeting with Deputy Ministry of Energy and Director General of Ministry of Agriculture and Irrigation in Naypyitaw

Bagan/Nyaung-Oo: Accommodating Tourism Growth and Agricultural Viability

The situation in Bagan, a burgeoning tourist destination in Upper Myanmar, and neighboring Nyaung-Oo, populated mostly by farmers, underscores the challenges Myanmar will face as it opens to the outside world and is required to balance the needs of an emerging tourism industry with those of the agricultural sector, the country's largest industry and employer. It also demonstrates the importance of strong village-level leadership in organizing and financing electricity access, as national ministries prioritize township-level grid connection over village-level connection and are struggling to coordinate policies on electricity supply and distribution.

Overview

Bagan is home to roughly 3,000 temples, monasteries and pagodas, many of which date to the 11th and 13th centuries, during the height of the then-ruling Kingdom of Bagan. Today the town is a rapidly developing tourist destination on the Ayeyarwady River, dominated by hotels and resorts. As Myanmar continues to open politically and economically, the tourism industry in this region is predicted to grow substantially as better conditions allow for rising numbers of visitors and greater hotel development.

Nearby Nyaung-Oo, on the eastern bank of the Ayeyarwady, is small agricultural zone populated by farmers and individuals who raise livestock. It is considered a gateway to Bagan, about four kilometers away, because of key air, rail and bus links. Some

villagers work in Bagan and bring their relatively high earnings back to Nyaung-Oo. Consequently the economic power of the villages is said to be quite strong.

Meeting with villagers and officials at Lakanandar pumping station

The Lakanandar pumping station, used by local farmers to irrigate land, receives a significant amount of the region's electricity, followed by the 110 hotels and resorts in the area. Electricity is also used to light villages, schools and households, for entertainment, and in a small number of cases for agricultural purposes such as to weigh beans or grind nuts to make oil.

While the need to balance between tourism and other “new” industries with traditional sectors such as agriculture is important throughout Myanmar, this challenge is particularly important in Bagan/Nyaung-Oo. Its vast potential as a major tourism destination is tempered by a lack of infrastructure and electrical capacity and the need to remain attentive to basic industries such as agriculture which continue to represent major sources of potential growth and have served as the primary employer and principal source of economic activity in the region for several centuries. As a result it serves as a key area from which to examine and evaluate potential policy options that will help to resolve these divergent needs and to allow Myanmar an expanded as well as a sustainable and equitable development path.

Electricity Use and Reach

Fifteen of the 17 wards within the territory covered by the Bagan/Nyaung-Oo office of the Ministry of Electric Power (MOEP) are said to receive electricity from the grid. The area receives electricity from a substation in Chauk, located roughly 28 miles away across the Ayeyarwady River, with an overall capacity of 36MW.

Although the maximum capacity of the electricity allocated to the official's area is 12MW, only 7.5MW is reportedly being used. One third of that (or 2.3MW) is used for the pumping station. Of the remaining two thirds (5MW), three-quarters is used for hotels and businesses, and one quarter for consumers. The substation supplies 7.5MW of electricity to the area, covering roughly 25 villages—22 out of 219 villages in the Nyaung-Oo district and 3 in Nat Kyo Aing.

As is common in much of Myanmar, the grid system in Bagan/Nyaung-Oo has extra supply available during the rainy season, when hydropower is more accessible and the farmers have less demand for irrigation through the pumping station. Therefore, during the dry season, when demand for irrigation is higher and tourist season is in effect, electrical capacity is limited.

The situation is complicated by a combination of factors, including a lack of sufficient energy supply to and from the grid, a need for upgrades to the Chauk substation, transmission losses and possibly illegal connections. It was noted there are several small 5kW transformers installed whose purpose is unclear.

As a result, the grid cannot meet the region's current needs – let alone the added demand presented by growing demand for new tourism and hotel facilities plus growing demand from villages that are seeking connections to the grid.

Officials at the Lawkanandar pumping station, which was designed for a maximum capacity of 15MW, said the station receives between 2MW in the dry season and 5MW in the rainy season. During the dry season, they report unpredictable blackouts sometimes lasting 2-3 hours. They are also prohibited from using electricity between 4pm-10pm, when demand is greater from hotels and electrical consumers in the area.

Although it is supposed to provide irrigation for 7,600 acres, the pump station is currently only able to cover a maximum of 2,300 acres. This is due not only to the gap between electricity supply and demand but also because of water losses in unlined irrigation channels and faulty infrastructure. Further, the pumping station is operating at a loss of roughly 71,000 kyat per acre.

According to a local MOEP official, the grid provides up to 80% of the region's hotels' electricity requirements. This is consistent with the account of the Bagan Umbra Hotel's General Manager who stated the grid can fully service the hotels' needs between 5pm and 5am.

The Bagan Umbra's General Manager also noted the hotel plans to expand from 56 to 100 rooms over the next few months and could expand to 240 rooms over the next two years if sufficient electricity were available. To compensate for this growth, the hotel has applied for additional capacity from the national grid and is planning to install two new generators. This will more than double the size of their current captive generator capacity.

The MOEP official also stated his department has the ability to install new transformer capacity, which could service between 400 and 500 hotels plus potential increased supply allocation to the pumping station. In addition, the Water Resources Utilization Department is trying to reduce its demand from the grid by operating the pumping stations more efficiently and developing alternative sources such as biogas and hydropower electricity generation. Success will depend on the location and the state of operating facilities.

As the region's tourism industry grows, however, reliability of electricity supply is likely to become worse due to the increasing demands in this sector as well as the pumping station, other large-scale users, villagers wishing to connect to the grid, and a general rise of living standards in the area.

Cost of Electricity

The MOEP estimates electricity from the grid is generated at a production cost of roughly 60 kyat per unit, which can vary depending on whether diesel or hydropower is used. Other individuals who have spoken with the fieldwork team, however, have estimated the real cost to be much higher, potentially up to about 130 kyat. Each unit of electricity is sold to consumers and state-owned factories at 35 kyat and to commercial users at 75 kyat. Prior to 2012, this was increased from 25 kyat and 50 kyat per unit respectively. A unit equates to 1-kilowatt hour (kWh). While there is talk of further rises or a more tiered system, which will differentiate further among different types of users, it appears unlikely this will be done quickly or in a way that will allow MOEP to adequately recover its costs.

On the other hand, the Bagan Umbra Hotel, which pays 75 kyat per kWh for electricity from the grid, said that use of its generator costs 12,500 kyat per hour for diesel costs. The hotel's average monthly electricity expenditures is about 2.5 million kyat, out of total operating expenses of 4-5 million kyat per month.

At the same time, officials with the Lawkanandar Pumping Station reported that electricity, purchased at the 35-kyat rate, accounts for approximately 80% of the pumping facilities operating expenses. The budget allocated to them by the government has proved a significant hurdle. The central government's budget is reportedly determined by agricultural output, which is constrained by the pumping station's poor infrastructure and lack of sufficient electricity supply. Further, the budget allocated to maintain existing projects is very small and only covers canal cleaning, not upgrades or the maintenance that could be used to increase efficiency and enhanced productivity. The local government reportedly does not use its budget for farmers.

Villagers repairing locally installed power lines near Bagan

Officials at the pumping station as well as within MOEP local office voiced concerns about government coordination and its impact on electricity distribution. On a national level, the Ministry of Energy (MOE) and MOEP manage energy supply and distribution. The MOE tends to favor selling gas reserves to neighboring Thailand at market rates, rather than to MOEP for subsidized domestic consumption. This is an issue that needs to be resolved.

For villages, the cost of connecting to the national grid was estimated in the US$30,000 to US$50,000 range, depending upon the village's distance from the grid. On average it costs US$250 per household; the smaller the village, the more expensive it is for each household to connect.

The 25 villages in the area that are on the grid have self-financed their connection. While no one interviewed claimed personal knowledge or familiarity, several people interviewed believed financial assistance could be made available to facilitate these connection. For example, one individual noted the local government can get a loan from the central government, at an interest rate of 2%, half of which goes back to the local government and half to the development of the village. The local government will then subsidize 50% of a village's connectivity costs. This bears further investigation, though other interviews have substantiated that as in the program in Sagaing which will be covered in the Monywa section of this report, most financial and non-technical assistance to villages is provided on a regional or local, rather than a national, level.

Scale operated by solar panel to facilitate trade when generator offline

Off-grid, Bagan/Nyaung-Oo villages typically reported having village committees to organize electricity payments. These are used to operate collectively owned generators. While most households pay the same amount, those that cannot afford to pay are often allowed to pay less. Of the villages visited this consisted of arrangements to install generators at a cost of about US$3-4,000 with local wiring under supervision froe the MOEP. Villagers then generally paid approximately 1,500-4,000+ kyats a month

depending on whether they utilized only lighting or other appliances such as television. Some individuals also installed solar panels to allow themselves access to electricity outside of the evening hours when the generators were functioning.

Two villages surveyed received help from private donors to purchase and install generators. One village received help from local monks and higher-income households. The village was able to pay back lenders at no interest once they began generating revenue from electricity sales. In some other villages, loans and gifts were received from former residents who now lived in larger cities.

Alternative Options

While only a handful of villagers in the Bagan/Nyaung-oo area used solar panels to generate electricity, due primarily to the high start-up costs and lack of technical knowledge, there seems to be growing interest. Many of the panels that were observed were installed recently and villagers spoke of its increased feasibility given declining prices for panels and necessary equipment. Given increasing talk about government programs that are designed to help finance and cover installation costs and declining prices for panels and equipment, usage is likely to continue to rise, especially if more assistance can be given and incentives developed.

The Bagan Umbra Hotel's General Manager, however, expressed no interest in alternative sources believing it was unreliable and not economically viable for his needs. As a result it is unclear whether solar should be viewed more as a mechanism to supplement small gaps in distribution, both in respect to location as well as times when electricity is not available from existing generators or the grid, or as a larger scale alternative that could provide necessary capacity to hotels and other larger users.

Interview subjects

- U Kyaw Aung (Official in Charge of Pump Irrigation Project)
- U Maung Maung Lwin (District Officer) and various farmers
- U Myint Khaing (Village Head of Mye Ne Nay), Other Villagers
- U Win Zaw Oo (Township Level Officer, Ministry of Electrical Power)
- U Sein Thar (agricultural worker in Shwe Dwin)
- U Han Win (agricultural worker in Moenat Kone)
- U Kyi Win (agricultural worker in Nat Kyo Aing)
- U Aung Thu (agricultural worker in Tu Ywin Taing)
- Other villager (name unknown)

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- Swe Win, Occupy Rice Paddy: When the Downtrodden in Myanmar Protest, *LA Times* Blog, March 5, 2013

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Monywa: Examining the Potential for Off-Grid Alternatives including Solar

Nearly 75% of Myanmar's population is not receiving electricity from the national grid, and the cost of grid extension is high, particularly in low-density areas where the population is spread out, such as Sagaing where Monywa is located. Therefore, while significant emphasis is being placed on extending the national grid, other alternatives are needed over the short- to medium-term, given the high costs of connectivity and short supply of energy in the system. The Monywa region highlights the potential for off-grid alternative energy, with solar in particular being particularly important given the high sun intensity in Upper Myanmar and efforts by the local government to subsidize access and to provide means to obtain financial assistance. This represents a potential model to help Myanmar meet electricity needs of villages located far from the national grid.

Fieldwork Team with Agricultural Ministry Officials in Monywa

Overview

Monywa is a small industrial city with a population of 182,011, located in Sagaing Region, about 136 km northwest of Mandalay along the Chindwin River. The region produces copper, gold and other minerals and is populated with hundreds of factories, foundries and mills that produce iron-based products, heavy machinery parts, rice vermicelli, and textiles. Agriculture is also an important sector. A major center for trade and commerce, Monywa is a gateway to India, and also relatively close to China. Therefore, black market and other goods, such as apparel and other goods, pass through on the way to other parts of Myanmar.

Nearby villages are populated by farmers, agricultural laborers and river traders. These occupations do not require a significant amount of electricity, which on a village-level tends to be used for lighting and entertainment. At the same time there is an industrial

zone and other factories that lack the reliable supply of electricity necessary if they are to begin meeting the challenge of Chinese and Indian competition.

Electrification needs in Monywa are also linked with the area's health and education services. Monywa is home to several universities: Monywa University, Monywa Education College, Monywa Institute of Economics, Technological University, Monywa and Computer University, Monywa. Given a scarcity of resources, village leaders expressed concern that prioritizing electrification could detract from health and education services, although several acknowledged that better electricity could also improve these services.

While Monywa does not attract substantial numbers of foreign visitors, the region has a number of tourist attractions, including a large Buddhist temple, *Mohnyin Thambuddhei Paya;* the second-tallest statue of Buddha in the world, and the nearby Phowintaung cave complex, located just over 15 miles from Monywa across the Chindwin.

MOEP/ESE Officers and Pump Station Officials in Monywa

Electricity Reach and Reliability

According to the ESE Township Officer and Head of Butalin Pump Station, four districts in the area—Monwya, Shwebo, Sagaing, and Kathar—receive electricity from the national grid. Three-eighths of Monywa's 80MW of electrical capacity, or 30MW, is allocated to 18 pump stations, a nearby copper mine and Monywa's Industrial Management Zone. This is comprised of 600 factories and foundries of varying size, including Thi Ha Tun, one of the largest foundries in Myanmar. The Industrial Zone Management Board officials said that each of the factories within the zone has at least one generator to compensate for unreliable electricity supply from the grid.

Officials said that 42MW of capacity is allocated to consumers with the remainder creating a buffer. This is different 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.

ESE Township officials said they ration electricity during the dry season, when supply from hydropower is limited and availability of electricity drops by more than half from 80MW to 30MW. During the daytime, pump stations and industrial users have priority. These are split into two groups, one of which receives electricity from 5 am to noon and another that receives electricity from noon to 5 pm. Only residential users are entitled to receive electricity at night.

According to township officials, between 50 and 100 villages in the area are connected to the national grid every year. Currently, the grid covers a reported 2,793 villages out of 5,996 in the area. Of these, only 719 are said to be fully reliant on electricity from the grid, highlighting the importance of off-grid alternatives.

Meeting with village leaders in Monywa

A meeting with four village leaders from Nyaung Thu Myar, Than Taw, Nyaung Kone, and Inna Taw—none of which use electricity from the national grid—found the majority of villagers only require only about three hours of electricity per day, primarily for household and public lighting and entertainment during the evenings. For a small number of households, however, electricity has additional economic value, as small motors can increase productivity of tasks like pumping water or grinding facilities. One household, for example, uses a solar panel to refrigerate soft drinks and water to sell cold beverages at a profit.

Cost of electricity

For households, off-grid lighting, usually consisting of a single two-foot fluorescent fixture for 2-4 hours each evening, was reported to cost between 1,500-2,000 kyats per month. Use of a television in one village is said to add an additional 1,500 kyats or more per month to monthly expenses. For example, in one village the charge for television was 1,500 kyat, more commonly it requires a larger payment, given that a television, depending on its size can consume approximately 2-4 times more electricity than a double fluorescent strip light and 4-8 times that for a low energy bulb.

Unlike Bagan/Nyaung-Oo, which appeared to have more formal cooperative structures within villages to manage use of local generators, several villages in Monywa described informally organized communal sharing programs for electricity use. One village shares seven television sets among its 40 households. In Nyaung Thu Myar, each household contributes what amounts to approximately 1-2% of their income toward fuel and maintenance of the village's generator, which provides lighting for the village pagoda, streets and school—but not for individual households. While this particular village had electrified early on, and has been able to update their generator twice over the past fifty years using this system, it has not been able spend the estimated 50 lakh it would cost to increase the size of the generator to accommodate household use beyond that which is available from batteries and individual use of solar panels.

Grid connectivity can be established at a cost of approximately 200 lakh per mile, according to ESE Township officials. That costs is all inclusive of transmission lines, lampposts, and all other necessary equipment except for the transformer, which costs about 8 lakh. In an interview with a village in another location that had successfully connected to the grid, however, it was pointed out there are also additional costs for the actual household connection, including sockets and metering, which can raise costs 20% or more. Some villagers are not aware of this when they plan their connection, which can create problems later on as this also has to be financed.

Solar panel used to power store refrigerator, lights and sound system in Monywa

Various local financing programs exist for Monywa villages. Between March 2012 and June 2013, the locally based Zayyarpadeithar Foundation, gave one-year loans at 2%

interest to 42 villages. 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. 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.

In another area in the region, it was reported local businessmen loan money to the regional government, which uses the funds to make development loans. Research must be done to determine the existence, structure and viability of these programs.

For commercial electricity users, a more reliable supply of electricity would reduce dependence on costly back-up generators and allow for less complex and more accurate projections of production costs. According to officials of the Monywa Industrial Zone board, factories would be willing to pay up to 200 kyat per kWh during the dry season—compared with the standard commercial rate of 75 kyat per kWh—or 100 kyat per kWh for an annual contract guaranteeing stable electricity supply.

In actuality it is hard to estimate how much companies could or would really pay for alternative sources of electricity given these are only self-professed estimates without adequate attention to forecasting and a bias toward stating numbers designed to either emphasize the challenge or to minimize their contribution. What was clear, however, was that the real fear of these companies was the need to pay higher costs for a source that would also prove unreliable, which then continued to necessitate their need for backup generators and other costly equipment and energy sources.

Alternatives

Solar energy holds significant promise for Monywa's households, particularly in areas where grid connectivity is not feasible or affordable in the short-term. As of the interview, 130 villages were reported to have taken advantage of a solar panel cost-sharing program, whereby the regional government pays 50% of a US$70 solar panel and converter, which are then distributed within villages to individual users. Individual households cannot apply.

In a separate interview conducted with a company named Asia Solar in Yangon that is active in Monywa, it was reported that 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 25W kit, consisting of a solar panel, three bulbs and a box that allows generation by direct current for US$73. They also market this kit directly to consumers for US$85. According to Asia Solar, the price of the solar kits has fallen from 160,000 Kyats roughly 8 or 9 years ago, and is expected to fall further in coming years.

While this type of partnership provides a short-term solution to local electricity challenges, and allows some diversification away from small village diesel generators, further research should be conducted to determine its viability over the longer term and its real cost against other alternatives.

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

Solar and other alternative energy sources were more of a challenge to industrial users. The General Manager of Thi Ha Tun foundry had looked into establishing a charcoal-based IPP in the industrial zone, but it proved unworkable as the charcoal would have needed to be transported from upper Myanmar to Monywa and they were not able to store electricity for a long time period. He was hopeful the foundry would soon be able to take advantage of expanded hydropower.

According to officials with the Monywa Industrial Zone Management Board, the zone does not have plans to use alternative energy sources. They did, however, suggest introducing a quota system could lead to more efficient energy consumption in the zone.

Interview Participants

- U Kyaw Win (Minister of Electricity and Industry, Sagaing Regional Government)
- Monywa Industrial Board Officials (names unknown)
- U Kyaw Myint (General Manager of Thi Ha Tun (foundry in Monywa Industrial Zone)
- U Win Hlaing (Than Taw Village Leader)
- U Win (Nyaung Kone Village Leader)
- U Kan Maung (Nyaung Thu Myar Village Leader)
- U Aung Than Soe (Inna Taw Village Leader)
- Ko Nay Win Hlaing (Head of Butalin Pump Station)
- U Sein Kyaw Tin (ESE Township Officer)
- U Tun Tun Ko (General Manager, Asia Solar)

- U Thant Zaw (Managing Director, Asia Solar)
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Mandalay: Balancing the Needs of Urban Industry with Rural Agriculture

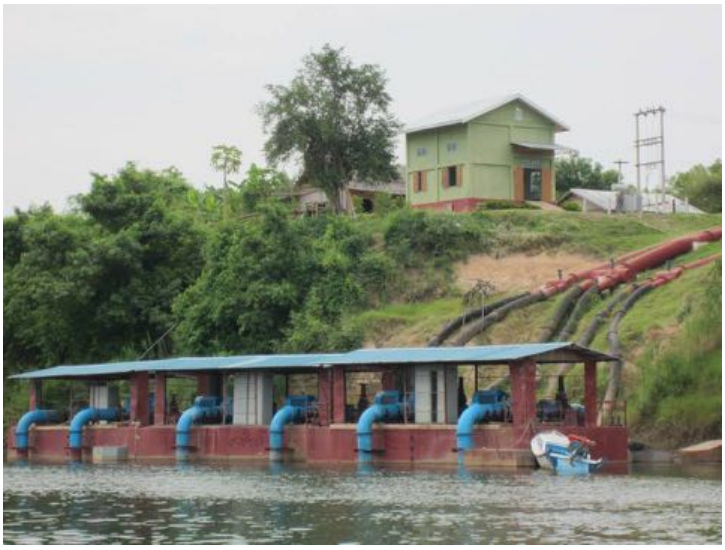
One challenge highlighted in Mandalay is the disparity between urban and rural populations. The further communities are from the city center, the more difficult it becomes to access electricity. Moreover, income inequality in the region, including that which exists between farmers and those engaged with livestock and day laborers, appears to have hindered the ability of villages to organize communal payment structures. In other areas these structures appear to have enabled more widespread access to affordable electricity. Industrial users have expressed interest in helping the government generate additional electrical capacity, but the necessary regulatory framework has yet to be developed. Moving forward, Myanmar's policies on electrification must find a careful balance among the roles and expectations of urban centers, foreign and local industrialists and the 70% of citizens that live in rural areas and have rapidly rising expectations about their ability to improve their living conditions.

Downtown Mandalay

Overview

The Mandalay Region has over 7.6 million people and is said to account for roughly 15% of Myanmar's economy. Mandalay City, its urban center, is Myanmar's second-largest city with a population of one million. It is located roughly 445 miles north of Yangon in Upper Myanmar and was the final royal capital prior to British rule that began in 1885. Mandalay City remains an economic and cultural center for Upper Myanmar and the country as a whole.

The region is considered a trading hub connecting Lower Myanmar, Upper Myanmar, China and India. Local industries include manufacturing, weaving, stone polishing, and woodcarving, brewing and distilling. Chinese immigration, which has been growing in recent decades, now represents an estimated 30% to 40% of Mandalay's total population, and this percentage is projected to grow to approximately 50% by 2025.



Pump Station in Mandalay

According to local officials, demand for electricity in Mandalay has grown at a rate of 10% per year over the past three years. In addition to servicing the region's large urban population and strong industrial sector, electricity is used by a number of pumping stations, which provide irrigation for agriculture. In some cases, these facilities also help to electrify villages. The agricultural areas outside Mandalay produce various types of beans, sesame and cotton. The villages primarily use electricity for street and household lighting, entertainment, and charging cell phones, though there is also use of other appliances and commercial applications.

Mandalay includes some of Myanmar's best educational institutes outside Yangon, including the University of Medicine, Mandalay, the Mandalay Technological University and the University of Computer Studies, Mandalay.

Located in Myanmar’s "dry zone," this region receives far less rain than lower Myanmar. As in neighboring Sagaing, where Monywa is located, sun intensity, measured at about 6 in Upper Myanmar, presents a strong case for the use of solar power, particularly for rural areas, while Mandalay's proximity to the Ayeyarwady River also presents opportunities for hydropower.

Electricity Reach and Reliability

According to the region's MOEP Deputy Regional Electrical Engineer (DREE), which is responsible for distributing electricity within Mandalay, the entire Mandalay region possesses a total electrical capacity of 300 megawatts, about half of which is used in Mandalay City. The Mandalay District is currently using the full capacity allocated to it, but officials expect to increase capacity to 400MW over the next five years.

During the dry season, electricity supply to the region decreases to about 150-200MW. Of that, Mandalay City receives approximately 100MW with about 50 MW spread across other areas. The industrial sector is restricted to about half of its usual electricity allocation during the dry season. Further MOEP requests industrial users to not work at night during these months, as most electricity is specially allocated to consumers. When capacity is especially constrained, industrial users are asked to rotate between 6 hours on and 3 hours off. If necessary, both industrial users and consumers will be asked to rotate their electricity use between 4 hours on and 4 hours off.

Gasifier Installation in Mandalay

Because of the grid's unreliability, one company in the region, Mandalay Myotha Industrial Development Public Co. Ltd. (MMID), has opted for self-reliance as it seeks to develops an industrial park covering more than 10,000 acres. In the short-term, given that there is no feed-in tariff or ability for MMID to sell excess power back to the grid, the company is seeking to utilize a modular power supply that will allow the company to power the construction phase of the operation on an as-needed basis, adding additional capacity as tenants are located and move into the facility.

As for residential consumers, seventy percent of households in the Mandalay region are reported to have access to electricity. Of these households, roughly 70% are connected to the grid. Those without access to the grid generate their own electricity via private or cooperatively owned generators, small-scale hydropower, batteries, and solar panels.

Distance from the grid plays an important role in connectivity. The DREE said that households in Mandalay City are almost 100% electrified, while those in close proximity to Mandalay City are about 95% electrified.

Generators appear to play less of a role in off-grid villages in Mandalay than in other locations surveyed in Upper Myanmar. Interestingly, when asked why the villages that did not possess generators were not interested in developing capacity, several villagers cited the cost, as well as a belief it was unnecessary, given their belief the government would soon help them connect to the grid. Of the off-grid villages surveyed outside of Mandalay—including Me Thway Boat, Kan Aung, Kin Tong, and Sait Pyo Yay—those that are less than half a mile from the grid, like Me Thway Boat, were more optimistic about grid connection than those, like Kin Tong and Sait Pyo Yay, which were located two or more miles away.

Cost of Electricity

Aung Naing Thu Family Co. foundry in Mandalay

For the Aung Naing Thu Family Co. foundry, a foundry that has existed for well over a decade within Mandalay City, total electricity costs are about 120 lakh per month during the rainy season when the foundry is fully operational. That cost more than doubles to

300 lakh per month if electricity from the grid is not available and the foundry must use charcoal and its diesel generator.

Mr. Aung San reported production costs can increase by up to 20% to 30% when electricity supply is not stable and the foundry must at times operate at a loss to maintain customers. As a result, Mr. Aung San said he would be willing to pay more—up to 180 kyat per unit compared to the standard rate of 75 kyat per unit—for a reliable and steady supply of electricity.

For residential users, village leaders in close proximity to the national grid estimated grid connection would cost between 300 lakh for a village of 140 households and 600 lakh for a village with 310 households. In addition to the cost of wiring to individual households, however, the distance of the village from the grid represents the primary determinant of cost. One village leader estimated it would take about two years to collect the 300 lakh from households in their area.

Hydropower Turbine being installed near Mandalay

While villages surveyed in other areas of Upper Myanmar exhibited a greater propensity toward cooperative financing for grid connection or ownership of one generator that powered the whole village, in Mandalay villages seemed less organized and cohesive. None of the villages surveyed professed a collective approach and most seemed divided with a more ad-hoc approach composed of several smaller generators within a single village. It is believed this may be due to greater income diversity in the Mandalay area and existence of both small farm and livestock owners and day laborers in these communities.

Households in agricultural villages far outside Mandalay, some of which were said to have erratic income, also reported difficulties in paying for electricity. In one case, a privately owned IPP went out of business after only one year in service as its rates—100 kyat for one light per night and about 500 kyat per night for one TV set—proved to be cost-prohibitive. While nominally higher than the monthly cost in villages that possessed a cooperatively-owned generator, given the cost of installation and equipment must be amortized, this number does not include any allocation for capital and maintenance costs, which are born by the IPP itself.

Another village reported a communally organized payment system failed as too few families could afford the electricity payments. A pump station official noted that while, in some cases, the regional government loans money to villages to purchase generators and related wiring,-there are concerns about collecting money back from certain villages so financing is difficult which makes it difficult to rely on that as a solution.

One village is reportedly attempting to develop an installment plan for solar installation, whereby villagers can pay between 4,000 kyat and 5,000 kyat per month toward a total cost of 80,000 kyat. The Mandalay Regional Government reported they were planning to initiate smaller-scale solar projects, providing individuals panels and single light bulbs to villages at a cost of about 30,000 kyat. According to their Chief Engineer, a government program to supply subsidized diesel generators to the area, which had been implemented in the past, has been halted and support has been reallocated to supply this solar equipment to households.

Solar panel in village outside Mandalay

Alternatives Options

Alternative energy sources are far more challenging for commercial users in Mandalay, such as the foundry. Solar power, for instances, requires a large installation capable of handling a minimum 10kVA, and the foundry has not been able to find the necessary equipment. Mr. Aung San, the foundry's managing director, noted that, while it would be possible to diversify to other energy sources, the foundry prefers to use electricity from the national grid because of the cost savings generated from its subsidized supply.

Commercial users and the DREE expressed the need for international investors and local private sector actors to assist the government in increasing Myanmar's power supply.

One American firm, ACO Investment Group, for example, signed a Memorandum of Understanding with the Mandalay regional government in February 2013 to develop solar energy farms. The project, worth between US$1.5 billion to US$2 billion is expected to generate 1,000MW of electricity to be supplied to the national grid. Another project is reported to be under development with a Thai firm.

Similarly, MMID, over the long-term, hopes to develop a clean coal power plant with an expected output of 200MW. The industrial park would eventually require a portion of the power for its tenants, while excess capacity would be sold to the national grid.

Such arrangements, however, have been hindered as appropriate regulatory measures, such as power purchase agreements, have yet to be established.

Interview Participants

- Mr. Aung San (Managing Director, Aung Naing Thu Family Co. Ltd, Steel and Cast Iron Production Foundry)
- U Sein Win Myint (Deputy Regional Electrical Engineer, Ministry of Electrical Power (MOEP), Mandalay)
- Daw Aye Aye Min (Chief Engineer, Energy, Mandalay Regional Government)
  Jack Hong (Managing Director, Mandalay Myotha Industrial Development Public Co., Ltd.)
- Alan Tsang (Director of Administration, Mandalay Myotha Industrial Development Public Co., Ltd.)
- Stephen Hong (Finance Director, Mandalay Myotha Industrial Development Public Co., Ltd.)
- Bruce Reynolds (Project Director, Mandalay Myotha Industrial Development Public Co., Ltd.)

- Village Leaders of U Kyi Shwin, U Khin Maung Cho, and U Win Naing (names unknown)
- Pump Station Officials Unknown (names unknown)

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Pathein: Powering Economic Development through Grid Extension & Gasification

A large city west of Yangon with port facilities, Pathein is positioned to become a major industrial center in the Ayeyarwady Delta. To meet growing industrial demand for electricity, without compromising the needs of local agriculture and fisheries, supply will need to be increased drastically and rapidly. Given that Pathein is situated in the Delta, one of the rainiest areas of Myanmar, solar is less of an option, however, agricultural production is high, and gasification is seen as a more viable energy source. One village visited near Pathein also presents a compelling case for grid extension for villages that are able to do so. This village recently established connection to the national grid and has seen marked improvements in living standards as a result of affordable electricity access. This includes a reported ten-fold increase in land values.

Town and Delta Area near Pathein

Overview

Pathein is Myanmar's fourth largest city, with a population of roughly 215,600, and the capital of Ayeyarwady Region, located roughly 118 miles west of Yangon on the Andaman Sea. It is the birthplace of President Thein Sein and the site of the Myanmar Army's Southern Command.

A port city, Pathein is a center for merchants and traders of goods from the region. Ayerarwady is said to account for between one quarter and one third of Myanmar's rice paddy production. It also has a significant fishery and marine life industry. Pathein is also known for its umbrella crafts and "sweetmeat" snacks and has significant industry supporting agriculture and fishery. This includes the production of fertilizer, spare parts for milling machines, salt, ice and refrigeration.

Previously only accessible by water, Pathein Bridge opened the area in 2004, with then Lt Gen. Thein Sein in attendance for the opening ceremony. The area's transportation infrastructure has continued to improve, facilitating productive land use, trade and tourism. The Ayeyarwady Region's sown acreage more than doubled between 1988 and 2009.

Pathein, however, has a tropical monsoon climate and is susceptible to flooding. Cyclone Nargis struck the area hard in 2008. This caused significant destruction, including to farms and factories—hindering income-generating activities—and resulted in the death of 138,000 people.

This climate therefore impacts the types of electrification schemes that are viable given the need to withstand flooding and strong winds. Given the prevalence of rain and this environment solar power is also not as viable an option as in Upper Myanmar, where sun intensity is far higher. In fact, Asia Solar, the company mentioned in the Monywa section, which is supplying kits to the Sagaing government, noted that it must use more costly configurations when assembling equipment for areas in the Delta given the reduced sun power that is available. As a result, gasification, powered by rice husks and other agricultural byproducts are seen as a more viable energy source.

Pathein Industrial Park

Land prices in Pathein are reported to be about one third of that in Yangon and labor is cheaper, making it an attractive destination for industry, particularly as Myanmar opens to foreign investment. Many of the factories in Pathein are locally owned at present but the Delta Industrial Group has recently opened up a facility which presently consists of one joint venture with a Korean firm, though firms from Japan, Taiwan, Germany and elsewhere are reported to be purchasing plots to build or operate facilities.

Although electricity demand is lower in Pathein than in Yangon, it has already surpassed supply. This leads to real concerns that electricity availability may not be sufficient for its growing industrial center and that an influx of foreign manufacturers could divert power from the region's agriculture and related sectors as well as existing small-scale manufacturing operations.

Electricity Use and Reach

According to U Thet Tin Zaw, an official with the local Electrical Supply Enterprise, 20MW of electricity is distributed to the area by the A Thote Substation via two main lines: one line delivers 14MW to a fertilizer factory, while another distributes 5MW to Pathein, Kan Gyi Dount, Thar Pung and Nga Pu Taw townships. There are plans to install new lines to deliver 10MW to various nearby areas, including to the Myet Tho industrial zone.

The grid receives a portion of its power supply from the MyanAung gas turbine in Ayeyarwady Division, which produces a total capacity of 14MW and, according to U Thet Tin Zaw, and supplies five stations. The majority is allocated to the Kyan Khinn Cement Factory.

In Pathein Township, a reported 125 out of 287 villages have access to electricity. Forty-two of those receive electricity from the grid, five of which—Taungwargone, Kyi Thargonegyi, Naungwine, Pauk Kone, and Taegyigone—were able to connect to the grid in 2012. The fieldwork team visited Taungyargone, which reported having regular and reliable electricity access from the national grid, in part due to its location adjacent to Myanmar's Southern Command headquarters.

Electricity in the area around Pathein has reportedly improved since 2010 due to the regional government's attentiveness and desire to increase competitiveness. The ESE official reported providing 17 hours of electricity per day. Electricity is down four hours during the daytime and three hours during the nighttime.

Shwe Myint Mol, a factory in Pathein's No. 18 Industrial Zone, however, a small, older facility that primarily manufactures steel, aluminum and glass products, reportedly receives an average 8 to 8.5 hours of electricity from the grid per day. The factory's owner, U Soe Myint Naing, reported receiving 80% of required electricity from the grid during monsoon season and 50% during the dry season. In case of blackouts, the factory relies on a 25KW generator, which uses 4 gallons of diesel per day.

Delta Industrial Group, the investor group mentioned previously that has recently opened an industrial park is mostly composed of mid-sized Yangon-based companies and individuals, many in the construction industry. This facility is envisioned to become an ambitious modern industrial park and opened only days before the interview, in a JV between the Group and a Korean firm had begun to operate an apparel factory in a section of one building. The park at present requires 150KW of electricity out of an installed capacity of 500KW. They've experienced sporadic blackouts that have not lasted long and have not yet made much use of their generators given the small nature of the present operation, though the park will have to resolve its need for increased energy supply as more buildings and facilities come on stream.

Both Delta Industrial Group, which has the potential to become a major employer in the region, and Shwe Myint Mol, expressed concerns over having adequate electricity to expand operations.

Cost of Electricity

While Delta Industrial Group is relying on grid power for current needs, they recognize this will prove inadequate over the longer term. Generator use was said to raise Shwe Myint Mol's production costs by an estimated 10%. Delta Industrial Group also has a backup generator supply, but the manager noted plans, the details of which he was not entirely aware, for a gas line to the industrial zone, which he estimated would cost 120 kyat per kWh. He noted the company was willing to pay the higher price for a reliable supply source.

Village leaders and electricity committee members from Taungyargon reported average household bills for electricity from the grid range from 1,500 kyat per month to 5,000 kyat per month, depending on power usage. All households reportedly own television sets, 20 to 30 households have refrigeration and four or five have air conditioning.

Taungyargon village committee and MOEP official with Fieldwork team

This is significantly lower than when Taungyargon villagers relied upon a private generator and villagers paid between 3,000 kyat per month for lighting and 12,000 kyat per month for lighting and the use of electronic devices, such as television and DVD players.

Echoing a recurring theme, the village's ability to connect was highly dependent on the organization of a strong village committee, with the capacity to organize an effective local electrification strategy, as well as household income. The initial investment in connecting to the grid was 4 lakhs per household, plus auxiliary costs. Remaining

households wishing to connect to the grid will also be required to pay 4 lakhs each, which will go toward long-term maintenance of the grid system. Payments are collected at the end of every month and total installation; procurement and payment took fourteen months.

With its strong presence of merchants, shopkeepers and current and former military or government officials, income in Taungyargon is relatively high, particularly since pensions were increased in 2012 to 50,000 kyat to 60,000 kyat per month.

Grid connection is said to have dramatically changed villagers' lives for the better, as they are now able to carry out household tasks more efficiently and more safely. They also reported the value of their land to have increased ten fold upon connecting to grid.

Other nearby villages, which are predominantly agricultural, have not yet had the financial standing to connect to the grid. Some villages are reported to have attempted grid connection and to have lost their initial investment as they had trouble covering additional costs, such as wiring and plugs, which can reportedly add an extra 2 lakh, or up to 50%, onto the total cost of grid installation.

In some cases geographical constraints hindered the grid connection process, even within parts of Taungyargon itself, as grid lines could not be run through ravines and other challenging landscapes.

Alternative Options

Agricultural Ministry Gasifier near Pathein

Pathein's abundance of rice paddy makes rice husk gasifiers the preferred alternative to diesel generators. In Myaungmya Township, for example, a hybrid rice husk gasifier, which receives supplemental power from diesel, has a capacity of 8KW, about half of which is used to electrify 80 households in a nearby village and half of which is used by a pumping station.

Electricity generated by the Myuangmya gasifier is reportedly available for a total of five hours per day from 6:30 pm to 11:30 pm.

The cost of electrifying Myaungmya Township was 50 lakhs for the generators and gasifier and 18 lakhs for cables. Running the gasifier costs 237,500 kyat per month, including 60,000 kyat for rice husk, 87,500 kyat for diesel, and 30,00 kyat for maintenance. Villagers pay about 2,000 kyats per month for lighting and an additional 4,500 kyat per month if they have a television set. The gasifier operators receive 291,000 kyat per month from the electricity for a monthly profit of 53,500 kyat.

Although economically viable, the environmental impact of rice husk gasifiers is unknown and likely to face government regulation. 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. This would, however, likely add 50-60% onto the cost of the equipment. In the absence of such environmental safeguards, it is unlikely that rice husk gasifiers will be endorsed by donors and international agencies.

Wind power may be a viable alternative for Pathein, given its proximity to the ocean; however, it is not widely promoted at least in part due to the failure of a project initiated in nearby Chauntha, a beach south of Pathein. This initiative suffered from inadequate funding and maintenance and, according to some accounts, may have constructed the windmill in the wrong location or built to the wrong height. The project consequently did not deliver adequate power and its failure may have discouraged officials from pursuing the use of wind energy further.

MOEP Substation Installation near Pathein

Due to geographic constraints, neither solar power nor hydropower is as prevalent in Pathein as in other parts of the country. Sun intensity in Pathein is measured at roughly 4, two points lower than in Upper Myanmar, and the region lacks the hills necessary to

generate substantial water pressure for hydropower.

Interview Participants

- U Soe Myint Naing (Owner, Shwe Myint Mol)
- Ranil Costa (Project Engineer, Delta Industrial Group)
- U Ko Ko Lay (Executive Engineer, MyanAung Gas Turbine)
- U Kyaw Swe Linn (EE Mechanical, Rice Husk Gasifier)
- U Khin Maung Thein (Member of Taungyargon Village's Electricity Committee)
- Daw Khin Mar Thein (Member of Taungyargon Village's Electricity Committee)

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- Prof. Dr. Kan Zaw, Nu Nu Lwin, Khin Thida Nyein, and Mya Thandar, Agricultural Transformation, Institutional Changes, and Rural Development in Ayeyarwady Delta, Myanmar, Economic Research Institute for ASEAN and East Asia (ERIA), 2011
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KWR International (Asia) Pte. Ltd.

Pyin Oo Lwin: Examining the Feasibility of Off-Grid Mini-Hydroelectric Schemes

A colonial outpost in the Shan highlands, Pyin Oo Lwin, which still contains infrastructure from the first half of the 20th century, exemplifies the potential for hydropower, in particular for off-grid and small-scale use where population density and conditions allow it. Nonetheless, challenges to hydroelectricity were also visible, from a lack of surge protection to variations in supply due to weather and other factors. Further, certain consumers expressed a desire for solar panels over hydroelectric turbines, underscoring the importance of in-depth and region-specific price comparisons for various energy sources.

Traditional Horse cart in Pyin Oo Lwin

Overview

Pyin Oo Lwin, formerly known as Maymyo, is a scenic town with a population of 117,303 located in the Shan highlands north of Mandalay, approximately 1,070 meters/3,510 feet above sea level. Just as in colonial times, when the cool climate and accessibility of this “hill station” made it a location of choice for colonialists who sought refuge from the summer heat in an age before air-conditioning, it now remains a destination for Myanmar's wealthy, many of whom have second homes in Pyin Oo Lwin, seeking to escape Yangon's heat in the summer months.

The area, originally established as a military outpost during British rule, remains an important center for defense education and training. Pyin Oo Lwin hosts the Defense Services Academy and the Defense Services Institute of Technology. Certain infrastructure is left over from colonial times and has been transferred to Myanmar government control. As a result, at least one hydropower facility dates to the 1930s.

Other than these defense installations, which host large numbers of students and

officials, and tourism, Pyin Oo Lwin's major industries consist of coffee, flowers and vegetables, silkworms and medicinal plants for pharmaceuticals. The area is not particularly reliant on heavy industry, compared to places like Mandalay, and is able to meet a substantial portion of its electricity needs via hydropower.

The area also has one of Myanmar's largest populations of Anglo-Burmese inhabitants, although the population has declined over time. Chinese immigrants are also prominent, particularly from Yunan. There are also many people from Mandalay and other parts of Upper Myanmar. There are also approximately 10,000 Indian and 5,000 Gurkha inhabitants. Local attractions include the National Botanical Gardens and Pyin Oo Lwin Nursery.

Electricity Use and Reach

Paying Electric Bills at MOEP Office in Pyin Oo Lwin

According to the director of the Ministry of Electric Power office in Pyin Oo Lwin, roughly 90% of the township proper receives electricity from the national grid, and an estimated 70% of the greater Pyin Oo Lwin area, including the surrounding villages, is connected to the grid. Approximately 23,000 customers, including industry and households, are registered and the Ministry official estimates about 33,000 households in roughly 35-40 villages receive electricity from the grid, including households who share a connection. Ten villages were connected in 2013 and there are plans to connect another ten villages in 2014.

One substation, located roughly seven miles from the local MOEP office, provides 5MW of electricity to the area, while there are plans to build a secondary station with 10MW.

Pyin Oo Lwin receives a significant amount of electricity from hydropower. One off-grid hydroelectric power plant that is owned and operated by the MOEP supplies electricity to one village, several coffee plantations and farms and a shrine. The coffee plantations

supplement the hydropower with a back-up generator that provides 1KW of electricity if necessary. This hydropower facility utilizes equipment that was initially installed in 1932 and refurbished in 1966. It runs two 350-hpw generators that provide 225KW each.

Hydropower Facility with Equipment Dating Back to 1932 in Pyin Oo Lwin

Several village households and shopkeepers that are not connected to the national grid are also able to meet their energy needs using mini-hydroelectric generators. According to local MOEP officials, the average output from mini-hydro is 2KW, however, more powerful mini-hydro schemes were documented capable of 5KW output.

Cost of electricity

Hydroelectricity is a cost-effective power source in Pyin Oo Lwin. Residential and commercial users pay the standard rate of 35 kyats per unit and 75 kyats per unit, respectively, whether they receive electricity from the grid or from the Ministry's off-grid hydroelectric power plant. This compares to 100 to 200 kyats per unit for diesel.

The Ministry reportedly generates US$2,000 in revenue, and US$700 in profit, each month from the small off-grid hydropower plant noted above. Its expenses include US$560 per month for a team of attendants. The national grid, by contract, operates at a loss.

For independent off-grid projects, mini-hydropower generators are reported to cost between US$300 and US$700 to purchase and install plus US$5 to US$10 for an internal ball mechanism that needs to be replaced at least once per year, and in some cases several times a year, depending on the generator and water conditions. A local restaurant owner on the outskirts of Pyin Oo Lwin near a small waterfall that serves as a tourist attraction, for example, reported purchasing a hydro generator 10 years ago for

US$300 and replaces the ball mechanism once per year. 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

The shopkeeper 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 US$550 and was said to supply 5KW, enough to power lighting and television within an average sized village of about 100 households.

Alternative Options

Despite the advantages of hydroelectricity, 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 convenience of installing a solar panel as opposed to a hydro-generator, which can be easily washed away or subject to power surges in strong currents.

Hydroelectricity's effectiveness may also depend upon location. Certain consumers are located adjacent to a waterfall, while others may derive hydroelectricity from a nearby drainage ditch. Other consumers may need to transport water or hydropower from a more distant water supply. There are also differences in supply depending on the time of year and changing weather conditions.

Solar power poses its own difficulties in Pyin Oo Lwin, as it is a rather shaded region. Several off-grid villages and GSM Towers generate electricity via solar power, but concerns were raised about the difficulty of storing electricity for nighttime use. One shopkeeper on the outskirts of Pyin Oo Lwin who attempted to convert his power supply from hydroelectricity to solar reported eventually switching back to hydro.

Further research should be done to better understand the factors surrounding consumer preferences for solar over hydro.

Hydro-turbine in Store and Mini-hydro facility in Pyin Oo Lwin

On a larger scale, widespread and reliable use of hydroelectricity will depend upon the region's water volume, which can be impacted if water is siphoned off for agricultural purposes, and if dams are constructed upstream, causing evaporation. The situation highlights the need for coordination among ministries, such as the MOEP, the Ministry of Agriculture, which deals with irrigation, and other relevant ministries, regional governments and relevant entities.

Interview Participants

- Daw Ohn Khin (Shopowner in Pyin Oo Lwin near Pwel Kuka Waterfalls)
- U Aung Kyaw Lin (Director, Ministry of Electrical Power, Pyin Oo Lwin Office)
- Power Plant Attendants, MOEP Off-grid Hydropower Facility (names unknown)
- Nang Nu Wan (Shopkeeper in Pyin Oo Lwin that sells hydropower equipment)

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Tachileik: Obtaining Electrical Capacity Through Cross-Border Arrangements

A border city situated on an important crossing into Northern Thailand, Tachileik is one of a few areas in Myanmar that purchases electricity from a neighboring country. 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. 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, which have underpinned the relatively strong growth of this peripheral region, could have important implications and help to guide Myanmar's national policies on foreign participation in the electricity sector. These arrangements may grow in prominence and importance as ASEAN moves toward regional integration by 2015.

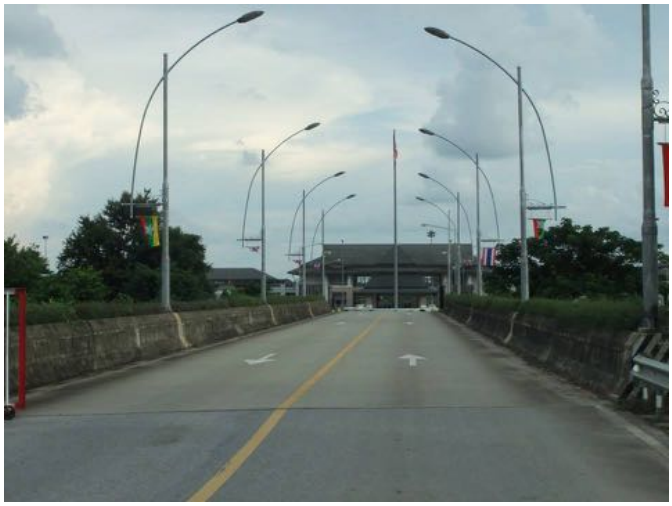
View of Tachileik

Overview

Tachileik is a city in Myanmar that borders Thailand to the South and is located roughly 29 kilometers west of the Laos border. It is an active trading zone in eastern Shan State. In addition to vast quantities of consumer goods, including DVDs, appliances, clothing, perfumes and luggage, Tachileik is also well known as an important border crossing for illicit activity, which has thrived for centuries in the mountainous tri-border area known as the Golden Triangle.

This trade is conducted across the fairly porous border, demarcated by the Mae Sai River, only a few meters wide at its most narrow point. Mae Sai, Thailand, connects to Tachileik via two bridges, the First Mae Sai Friendship Bridge and the Second Mae Sai Friendship Bridge. In 2007, about three million people entered and departed Thailand through the Mae Sai Immigration Office.

Due in part to this economic integration, as well as the relative proximity of Bangkok to Tachileik—a 12-hour drive, as opposed to the three days it would take to access Yangon by road—the area is heavily influenced by Thailand. The Thai baht is used as currency as opposed to Myanmar's kyat, which is not generally accepted, and electricity is delivered from Thailand's grid system.



Border Crossing Between Myanmar-Thailand in Tachileik

Tachileik initially connected to Thailand's grid in 1995, after two years of planning and construction. This is a notable exception, as in the rest of Myanmar, the Myanmar Electric and Power Enterprise is designated under the State-owned Economic Enterprises law of 1989 as the sole legal provider of electricity. Prior to 1995, less than 500 KW of electricity was available for the entire Tachileik area, which at the time had a population of about 20,000 people.

The power supply from Thailand, though reliable, is susceptible to political disputes. It was cut off by Myanmar's government in 2002 due to rising tensions with Thailand. For several years afterward, a private provider supplied 3MW to the area via 6 high-speed diesel generators. By the mid-2000s, power supply from Thailand had resumed under a different structure. The generators are no longer used to supply power to Tachileik and it is unknown whether they are still in existence.

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.

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. Thanks to the recent loosening of government regulations, tourists entering Myanmar via Tachileik—once required to

depart over the same border crossing within one week of entering, and prohibited from leaving the Tachileik vicinity—are now able to leave the country via international airports in Yangon, Naypyitaw and Mandalay. This will likely have a dramatic effect on the area's overall economic activity providing it can obtain adequate supplies of electricity to enable additional development in Tachileik and the surrounding region.

Meeting with Tachileik MOEP Representative and Town Committee

Electricity Reach and Reliability

According to a member of the local electricity committee, 9MW is currently transmitted to Tachileik via 22KV power lines running over the bridge from Thailand. The electricity supply is distributed over approximately 23 km of territory via 400-volt lines. This is said to provide sufficient electricity to all of Tachileik's 100,000+ inhabitants. Less than 10 percent 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 to 16MW by upgrading the cables.

When an agreement was first reached to supply electricity from Thailand to Tachileik in 1995, the Thais extended the grid all the way to the household level, though bills were collected locally. Now 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, which 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.

Cost of Electricity

Under the current agreement, it is reported that Allure Resort, a Thai-owned hotel in Tachileik, has assumed responsibility for purchasing power from Thailand and selling it to Tachileik users at a price that allows for mark-ups by both the Thai intermediary as well as the local township. Allure Resort purchases power from Thailand at a rate of 3.25 baht (about 100 kyats) per kWh and sells it to households for 6 baht (186 kyat) per kWh and to industrial users for 7.25 baht (225 kyat) per kWh.

This is, respectively, about 5 and 3 times more than electricity purchased from the Myanmar national grid. However, it is much less expensive than the electricity that was provided by diesel generators when electricity distribution from Thailand was prohibited. Then, per unit costs varied according to the price of diesel from 6.25 baht to 14 baht.

Because of the border zone's relatively strong growth and proximity to Northern Thailand, the average salary in Tachileik is high compared with national standards—about US$200 per month compared with US$100-150 in Yangon. As a result, the electricity costs are not prohibitive for locals.

Additionally, because of the high mark-up on electricity, the return on investment resulting from upgrading or expanding Tachileik's electrification supply would be realized in a relatively short period of time. Allure gives a portion of the 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. 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.

Alternative Options

Given that the region's electricity development – and overall economic viability are dependent on Myanmar-Thai relations, attention should also be devoted to alternative options that allow more self-sufficiency. Fortunately, with its proximity to multiple rivers, including the Mekong—the 10th largest river in the world by volume—Tachileik has a strong potential for the development of hydropower. This is already generating a sizeable amount of electricity for other parts of Shan State. The potential for hydropower is well known on both sides of the border and several nearby sites have undergone feasibility studies. In the case of Tarsan on the Salween River, a study undertaken by

ItalThai found there was a potential to generate more than 7,000 MW of electricity—almost enough to power the entire country.

Concerns have arisen, however, over land ownership and environmental risks, particularly if a dam were to malfunction. The issues are particularly sensitive in Tachileik, a border zone, as any negative impact has the potential to cause problems between Myanmar and Thailand.

Similar issues arose over coal. A lignite power plant that was under development in 2000 was ultimately cancelled following protests over concerns for the health and safety of Thai residents living close by.

Given the reliability and affordability of electricity from the Thai grid, there is little incentive for Tachileik inhabitants to invest in the high start-up costs associated with large-scale power generation, whether from hydro, solar or coal.

Rice Mill Powered by Gasifier Outside Tachileik

Smaller-scale development, however, particularly in areas that are relatively distant from Tachileik, and therefore would be too expensive to connect to the existing connection are now underway. For example, a local entrepreneur in Nayaung, Myanmar, roughly 45 km northeast of Tachileik, has installed a rice-husk gasifier, which powers a 50KW generator via a dual-use gas and diesel engine. In addition to powering his rice mill and a factory that manufactures tiles and other building and infrastructure-related materials, the gasifier is connected to one hundred reported electricity meters, which charges 30 baht (roughly 1,000 kyat) per kWh. Users are required to purchase a

minimum 10 kWh per month and are limited to 40-50 kWh per month for a range of 300 baht to 1,500 baht.

Electricity from the gasifier is available to the village for about 4.5 hours per day, from 6pm to 10:30pm. Electricity is available on an irregular basis during the day when the provider's rice mill and factory is operating and utilizes the supply. At that time, households and shops, including one owned by the owner of the gasifier itself, rely on small-scale solar and hydroelectricity to power lights, air conditioning, electronics and refrigerators.

Interview Participants

- U Htein Min (Local Representative of Ministry of Electric Power)
- U Maung Win (Representative of Local Electricity Committee)
- U Sai Shen (Owner and Operator of Rice Husk Gasifier in Nayaung)
- U Sai Shen's son (Shopkeeper in Nayaung)

Additional Sources

- Masami Ishida, Border Economies in the Greater Mekong Subregion, IDE-JETRO, July 26, 2013
- Myanmar blasts: Electricity one of the fuses, *The Asia Times*, June 28, 2003
- Phyu Nu, Myanmar Borders Purchasing Electricity from China and Thailand, Eleven Media Group, October 4, 2011
- Plant Fuels Pollution Concerns, *The Nation,* April 23, 2001
- Troubled History of Power Supply at Tachileik, Electrical industry of Burma Myanmar on-line compendium
- Takao Tsuneishi, Border Trade and Economic Zones on the North-South Economic Corridor: Focusing on the Connecting Points between the Four Countries, IDE Discussion Paper No. 205, July 2009

Kengtung: Powering Off-Grid Locations Beyond the Micro-Level

A relatively large but isolated township in Eastern Shan State, Kengtung highlights the potential for hydropower to provide electricity to off-grid locations on a scale beyond that of the village level. The MOEP-run projects here differ from those in other areas, like Pyin Oo Lwin, in that they are not supplementing power from the grid or small-scale generators, nor are they merely supplying niche areas, such as small, isolated and geographically challenging villages where grid connection is not feasible. While Myanmar has plans to extend its grid to all corners of the country, in the interim, off-grid Ministry-run projects, like those in Kengtung, play an important role in filling gaps in the nation's ability to supply expanded electricity distribution.

Kengtung from Lakeside

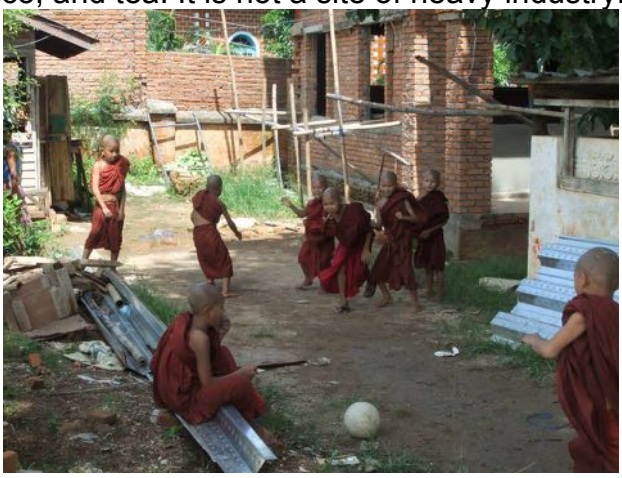
Overview

Kengtung is located roughly 163km north of Tachileik in Kengtung District, roughly 2,500 feet above sea level with some mountain peeks rising above 7,000 feet. With a population that is estimated to be approximately 78,000 within the city itself and 200,000 or more within the overall district, Kengtung is one of the largest cities in Shan State, along with Lashio and Taunggyi, Shan State's capital 456 km away.

Known as the "Walled City of Tung," Kengtung is fairly isolated in the highlands of Eastern Shan State. Separated from Yangon and other parts of Myanmar by the Salween River, Kengtung lies close to the borders of China, Laos and Thailand and, like Tachileik, is heavily influenced by its neighbors. It is a multi-ethnic environment made up of Khun, Shan-Chinese, Akha, Wa and Lahu inhabitants among others. Roughly half the population is Buddhist and a significant number are Christian owing to a history of missionary influence.

Due to the presence of rebel armies, such as the Shan and Wa insurgencies, and illicit activity, the area has been historically closed to outsiders and is considered a strategic location for the nation's defense.

In recent years, however, as roads have improved and travel restrictions within Shan State have been lifted, Kengtung has seen an increase in visitors, both traders and tourists. It is commercial region with a number of small workshops and markets for local goods and those from neighboring countries. It is rich in teak, rice, sugarcane, cotton, produce, poppy, tobacco, and tea. It is not a site of heavy industry.



Young Monks Playing in Kengtung

Often called the most scenic location in Shan State, Kengtung is midway between the Thanlwin and Mekong River valleys and is built around several lakes, Naung Tung Lake, Naung Kham Lake and Naung Yarng Lake. The city features colonial architecture and an array of Buddhist temples and monasteries, including Maha Myat Muni Pagoda and Wat Zom Kham Temple.

Its size, natural resources and distance from the national grid makes Kengtung an interesting case study for the use of off-grid hydropower on a scale beyond that of village-level. Countrywide, the Ministry of Electric Power runs 32 off-grid hydroelectric power plants with a total installed capacity of 33MW.

Electricity Use and Reach

Kengtung is home to two off-grid hydroelectric plants under the administration of the MOEP, one in Namwote, with an installed capacity of 3MW, and one in Namlut with an installed capacity of 480KW.

The Namwote plant supplies local military facilities as well as nearby villages. According to the MOEP district officer, about 8,000 consumers receive electricity from the Namwote plant. The Kengtung MOEP has no plans to establish a mini-grid and has not connected a village to the Namwote plant in several years.

Hydropower Facility in Kengtung

Although its installed capacity is 3MW, the Namwote plant has a maximum capacity of 2.5MW during the rainy season. This drops to 1MW during the dry season, at which point it is supplemented by a 500KW diesel generator. The area requires 5MW, according to the district official.

Considering most parts of Myanmar, including those on the grid, receive a limited number of hours of electricity per day, the Namwote off-grid hydropower plant is a relatively reliable electricity source for Kengtung residents. The district officer reported that the area is divided into four zones and power is rotated among these four areas..

Cost of Electricity

Both households and commercial users, the small workshops in the area, are charged 60 kyat per kWh for electricity from the off-grid hydropower plant. This compares to the standard rate of 35 kyat per kWh for consumers and 75 kyat per kWh for commercial users for electricity from the national grid. Consumers receive meter boxes and pay based on electricity use. The reason for this differential bears investigation given that other facilities visited in Pyin Oo Lwin that were managed by the MOEP and elsewhere sold their output at the standard rates.

The district-level MOEP noted it is paid by the local committee for the electricity they produce, therefore, any losses that occur due to illegal power tapping are borne by the committee, not the Ministry.

One off-grid site that was visited reportedly cost between 10.6 million kyat and 16 million kyat to construct but it was unclear how the exchange rate would have been calculated at the time of construction.

River with Hydropower Potential Outside Kengtung

Alternative Options

MOEP's off-grid projects consist only of hydroelectric plants and diesel generators.

Although they have no plans to supplement the off-grid hydroplane with alternative sources, it was noted that upgrading the system's transmission and distribution lines could help the Namwote plant meet Kengtung's power needs. The transformers and cables for off-grid projects are set to national standards, but, like those of the national grid system, are a source of transmission losses.

The district officer said that the national planning department has yet to develop a plan for Kengtung, however, he believes hydropower to hold substantial potential for the region. He also referenced proposals put forth by private companies to the regional government to develop hydropower capacity.

According to the Asian Development Bank, hydropower projects with a total of 41,276MW installed capacity are to be implemented in Myanmar by foreign direct investment. One 96MW hydropower project is planned in Kengtung with others in nearby Wantapeng (25MW), Solu (165MW), Kengyang (28MW), Heku (88MW) and Namkha (200MW). The hydroplants will supply the region and surplus electricity will be supplied to the national grid.

Interview Subjects

- Nay Ye Myint, Namwote District Officer, MOEP
- Officials at Namwote MOEP Off-grid Hydropower Plant

Solar Panel in Use in Downtown Kengtung

Additional Sources

- Masami Ishida, Border Economies in the Greater Mekong Subregion, IDE-JETRO, July 26, 2013
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- Tin Win Lay, Kengtung in Shan State (East) benefiting from smooth transport and agriculture, The New Light of Myanmar May 19, 2009
- Myanmar: Energy Sector Initial Assessment, Asian Development Bank, October 2012
- Myo Aung San, Rural Electrification in Myanmar: Policies and Recent Initiatives (Grid and Off-grid), Ministry of Electric Power, Electricity Supply Enterprise

Analysis and Areas of Future Research

While a full-scale analysis of these fieldwork results is beyond the scope of this work phase, a number of key themes have arisen as a result of the teams' site visits and additional meetings and interviews held in Yangon, Naypyitaw and other locations. While these topics should not be considered exhaustive, they bear more detailed investigation, examination and discussion moving forward. These include:

Comparative Electricity Cost Considerations and Potential of Mini-grids

While it is evident there is both a need and clear potential for renewables and energy sources, which can be used to extend and supplement the grid through off-grid supply, there is a definitive lack of information concerning the real cost of various options. This is important to evaluate the comparative cost of utilizing solar, hydropower, biogas, grid connections, generators, batteries and other potential technologies in different parts of Myanmar, with consideration given to geographic and other factors, such as distance from the national grid, village size, income level, and weather, that impact the effectiveness.

Similarly, given that optimal solutions will likely involve combining different technologies in the most effective manner, 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 and use of micro-grids as a means to extend access to electricity in Myanmar.

Role of Local Government and Community in Electrification Process

KWR's exploratory fieldwork revealed the importance of governance structures at a local and regional level in ensuring citizens' access to electricity. In terms of grid connectivity, the national government is responsible for extending the national grid to the township level, 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 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 Ministry of Electric Power.

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.

As communities appear highly dependent on village committees to determine and organize electricity access, one area of potential future research is the factors that influence the level and extent of organization of village committees. Village committees

are also an important stakeholder to be considered, particularly when sharing results of this study. Key issues include pricing or cost-benefit analyses of various electricity sources.

Developing Legal Framework & Regulation to Facilitate Private Investment

Many foreign and local investors have expressed a desire to develop power plants in various parts of Myanmar and to otherwise develop an industry that is essential to Myanmar's economic development. For industrial zones in particular, the ability to develop these plants and sell excess power to the national grid would be a useful and sound investment while they await tenants within the zone that would eventually purchase the power for their own operations. In some cases, investors reported they have already begun to negotiate agreements, generally on a build-own-operate-transfer basis, with the MOEP to be Independent Power Providers.

Yet regulations on feed-in tariffs, power-purchase agreements, as well as other issues that are essential to develop Myanmar's electrical capacity, have not been fully developed. This meaning it is unclear whether these development plans can move forward. According to an interview conducted in Yangon with a supplier of rural micro-finance and electricity solutions, $200 million in investments for power generation are held up because there is no framework for power purchase agreements or feed-in tariffs. This confusion was reinforced in a seminar held at UMFCCI by a foreign law firm which focuses on these transactions. While this event was attended by many senior public and private sector officials from Myanmar and numerous representatives of multinational corporations, trading companies and investors, yet no one was able to point to any clear guidelines or success stories that would help to facilitate the necessary inflow of capital to finance Myanmar's electrification needs.

Enhancing Public-Private Sector Dialogue & Development of Partnerships

Moreover, there is need to enhance public-private sector dialogue and policy discussion. This will help to clarify and develop regulations on industrial use of electricity supply and encourage investment and expansion of industries that will generate employment, increase Myanmar's competitiveness and drive economic growth.

Failure to foster this discussion leads to an inability to develop regulations and a legal structure that benefits Myanmar as well as investors and other stakeholders. This is essential to facilitate the development of more electrical capacity. For example, while investors are seeking to find both large- and small-scale opportunities in Myanmar, regulations for projects of all sizes are presently unclear and development of captive power larger than 50MW requires additional layers of approval and cooperation from the MOEP.

The lack of a well-defined framework also leads to inefficiencies and suboptimal solutions. For example, inadequate supply from the grid has led to efforts to restrict industrial usage in favor of consumers. This discourages investment and the

development of manufacturing and other industries, which would generate employment.

Understanding Impact of Energy Subsidies and Importance of Efficiency

Perhaps no other factor has a greater impact on the long-term availability of electricity in Myanmar as the prevalence of subsidies, which dictate distribution at levels below production costs and rates seen in most other markets.

While it is understood there are political, social and economic factors that impinge upon the ability of Myanmar's government to make rapid changes to the current pricing structure, the issue of subsidies must nevertheless be examined and attention devoted to the consideration of alternatives. This includes a tiered system with provisions that allows an overall pricing structure that rewards investment and the development of the electricity supply necessary to expand and accelerate economic development in Myanmar.

Another critical issue that must be addressed is that of energy efficiency. Given Myanmar's antiquated energy infrastructure – in which it has been estimated that 70% of electrical wiring is over 70 years old – there is substantial room for improvement. This is true both in terms of updating technology, equipment and networks but also in minimizing unauthorized access and the introduction of additional organizational and operational efficiencies and structure.

Addressing Environmental Concerns and Minimizing Deforestation

Despite Myanmar's vast wealth in energy resources, the nation remains heavily reliant on woodfuel, the country's most common biofuel. A 2009 UN Food and Agricultural Organization report notes that about 70% of Myanmar's total rural population "depends heavily on forests for their basic needs" and deforestation is a real concern as are issues related to climate change.

Given Myanmar's large size and geographic diversity, no single form of alternative energy, including solar, wind and hydro, provides a definitive solution. This necessitates an integrated approach, which balances needs and resources in an optimal manner. The nation's agricultural potential, however, elevates the potential of bio-fuels and gasification, which has proven to be a viable energy source in Myanmar. The Agricultural Ministry has looked to gasification as a means to reduce its needs to draw from the grid to allow operation of its national network of irrigation pumping stations and there is at least one private company that claims it has installed over 1,000 gasification installations throughout Myanmar.

Unfortunately, however, the decentralized nature of these installations and the lack of any real control, regulation and standards raises concern over resulting pollution and environmental damage. As a result the Myanmar Engineering Society has begun to develop standards to ensure safety, however, it is believed that these will result in higher costs, which makes it less attractive to potential consumers. Much needs to be

done to ensure enforcement and adequate resolution of this and other environmental issues that stem from the development and expansion of Myanmar's energy and electricity network.

Enhancing International Collaboration and Cross-Border Cooperation

Myanmar's emergence on the world stage, as well as within regional forums such as ASEAN, has major implications both in terms of its energy as well as its overall development. Initiatives to drive regional integration such as the ASEAN Economic Community (AEC) are also important.

As evidenced in the fieldwork visit to Tachileik, however, cross-border cooperation and the development of stronger, though more balanced, relationships with Thailand and other neighboring countries could be a vital component of regional integration. Arrangements could be developed whereby Myanmar can leverage the capacity of these countries to access additional electrical capacity and, over time, to facilitate the development of a dynamic, regional energy market.

Better coordination and discussion with developed countries and donors who have the potential to contribute to the development of Myanmar's energy sector is also essential.

Promoting Intra-Ministerial Dialogue and Capacity Development

While Myanmar is presently undertaking efforts to develop a national integrated energy policy under the direction of the Myanmar National Energy Management Committee, successful implementation will depend on more effective communication and coordination between the seven Ministries that are presently responsible for different aspects of Myanmar's energy and electricity sector.

This is true not only on a formal level among high-ranking officials, but also throughout the Ministries as a whole – where communication between working-level staff within different entities can be overly bureaucratic and constrained. It is therefore difficult to engineer the ongoing discussion that is necessary to allow thorough consideration of potential policy alternatives and the definition of the details and cooperative process needed to allow the significant expansion of both on- and off-grid connectivity that is required.

Additional attention is also required to allow more fruitful discussion with representatives of the private sector –- both within and outside Myanmar. Finally, given that in many ways resolution of Myanmar's energy needs is more of a financial than a technical issue, attention should also be focused on increasing analytical capacity to deal with financial and economic issues as well as the overall skills needed to build the network Myanmar will need to achieve its economic development goals and objectives.

Recommendations

It is recommended the next phase of work on ERIA/UT's Myanmar Integrated Energy Development project take place from October 1-December 31, 2013 and include:

A) Fieldwork:

- Structured Fieldwork: Drawing on the phase-one fieldwork KWR conducted from May-August 2013, which is described in this report, KWR recommends the implementation of two structured research efforts to facilitate IED in Myanmar. These include:
    - Comparative Electricity Cost Evaluation: To obtain a more comprehensive understanding of relevant cost factors, a preliminary pricing model that compares grid extension, solar, IPPs, generators, etc. was prepared as part of the first phase fieldwork. This preliminary model will be refined and KWR will visit five locations in Myanmar to allow further examination of the three identified themes (grid extension, cross border and off-grid). In each of these locations the KWR team will input data to compare different methods of electrification.
    - Examination of the Myanmar-Thailand Energy Relationship: To further expand and gain insights into how Thailand views the Myanmar-Thailand energy relationship both from a historical and forward-looking perspective, KWR will support Chulalongkorn University ("Chula") in undertaking a research study on this subject. It is envisioned that KWR will act in an advisory capacity to help Chula undertake this effort.
- Exploratory Fieldwork: In addition to the more focused structured fieldwork envisioned above, KWR recommends continuing the "exploratory" fieldwork conducted during its first phase to allow opportunistic visits and preliminary reviews of select projects and areas. It is envisioned KWR will undertake visits to additional locations where there are functioning or contemplated IPP's, or which allow more complete examination of important technical, geographic, policy, economic and social issues.

B) Myanmar Integrated Energy Report / Information Center:

One of the main obstacles in initiating IED in Myanmar is the lack of information and communications between different parties. This leads to duplication of efforts, suboptimal use of data and lack of coordination between relevant government ministries, donors, investors and other stakeholders. To begin addressing this deficiency, KWR recommends:

- Myanmar Integrated Energy Report: KWR can update the preliminary report it helped prepare with UT for the energy section of the MCDV initiative with information it has subsequently generated from interviews, presentations and

reports received from a wide range of sources. This will then be updated again on a periodic basis for release as a comprehensive report in a later stage of this project.

- Myanmar Integrated Energy Information Center: To help improve communication and coordination among individuals and entities with an interest in IED in Myanmar, KWR will investigate the potential to create an ongoing clearinghouse and repository of information accumulated for interested parties.

C) Myanmar Integrated Energy Expert Working Group:

The complexity of initiating IED in Myanmar is compounded by the fact that seven ministries have responsibility for different facets of energy policy and activity and there is a real lack of the public-private sector dialogue needed to promote foreign as well as domestic investment and commercial activity. To help provide a structure that will facilitate ERIA/UT's fieldwork and research as well as necessary policy discussion, intra-ministerial dialogue and PPP relationships, KWR can assist UT in its efforts to move beyond the stakeholders meetings it has been organizing by holding discussions in Naypyitaw and otherwise initiating efforts to determine the feasibility of organizing an ongoing Myanmar Integrated Energy Expert Working Group.

D) Conference/Seminars/Training:

KWR recommends working with ERIA/UT to both participate in relevant conferences and seminars and to support events organized by ERIA/UT and affiliated entities similar to the one held in Bangkok last June.

Appendix I – Fieldwork Interviews and Meetings

Myanmar Integrated Energy Project
Fieldwork Interviews and Meetings

Bagan

U Kyaw Aung (Official in Charge of Pump Irrigation Project)
U Maung Maung Lwin (District Officer) and various farmers
U Myint Khaing (Village Head of Mye Ne Nay), Other Villagers
U Win Zaw Oo (Township Level Officer, Ministry of Electrical Power (MOEP)
U Sein Thar (agricultural worker in Shwe Dwin)
U Han Win (agricultural worker in Moenat Kone)
U Kyi Win (agricultural worker in Nat Kyo Aing)
U Aung Thu (agricultural worker in Tu Ywin Taing)

Monywa
U Kyaw Win (Minister of Electricity and Industry, Sagaing Regional Government)
Monywa Industrial Board Officials (names unknown)
U Kyaw Myint, General Manager of Thi Ha Tun (foundry in Monywa Industrial Zone)
Capt. Soe Win, Admin Office of Thi Ha Tun (foundry in Monywa Industrial Zone)
U Win Hlaing (Than Taw Village Leader)
U Win (Nyaung Kone Village Leader)
U Kan Maung (Nyaung Thu Myar Village Leader)
U Aung Than Soe (Inna Taw Village Leader)
Ko Nay Win Hlaing (Head of Butalin Pump Station)
U Sein Kyaw Tin (ESE Township Officer)
U Tun Tun Ko (General Manager, Asia Solar)
U Thant Zaw (Managing Director, Asia Solar)
Foundation Head, Zayyarpadeithar Foundation

Mandalay
Mr. Aung San (Managing Director, Aung Naing Thu Family Co. Ltd, Steel and Cast Iron Production Foundry)
U Sein Win Myint (Deputy Regional Electrical Engineer, Ministry of Electrical Power (MOEP), Mandalay)
Daw Aye Aye Min (Chief Engineer, Energy, Mandalay Regional Government)
Jack Hong (Managing Director, Mandalay Myotha Industrial Development Public Co., Ltd.)
Alan Tsang (Director of Admin., Mandalay Myotha Industrial Development Public Co., Ltd.)
Stephen Hong (Finance Director, Mandalay Myotha Industrial Development Public Co., Ltd.)
Bruce Reynolds (Project Director, Mandalay Myotha Industrial Development Public Co., Ltd.)
Kyi Shwin, Khin Maung Cho, and Win Naing, Village Leaders
Pump Station Officials Unknown (names unknown)

Pathein
U Soe Myint Naing (Owner, Shwe Myint Mol)
Ranil Costa (Project Engineer, Delta Industrial Group)
U Ko Ko Lay (Executive Engineer, MyanAung Gas Turbine)
U Kyaw Swe Linn (EE Mechanical, Rice Husk Gasifier)
U Khin Maung Thein (Member of Taungyargon Village's Electricity Committee)
Daw Khin Mar Thein (Member of Taungyargon Village's Electricity Committee)

Pyin Oo Lwin
Daw Ohn Khin (Shopowner in Pyin Oo Lwin near Pwel Kuka Waterfalls)
U Aung Kyaw Lin (Director, Ministry of Electrical Power, Pyin Oo Lwin Office)
Power Plant Attendants, MOEP Off-grid Hydropower Facility (names unknown)
Nang Nu Wan (Shopkeeper in Pyin Oo Lwin that sells hydropower equipment)

Tachileik
U Htein Min (Local Representative of Ministry of Electric Power)
U Maung Win (Representative of Local Electricity Committee)
U Sai Shen (Owner and Operator of Rice Husk Gasifier in Nayaung)
U Sai Shen's son (Shopkeeper in Nayaung)

Kengtung
Nay Ye Minhtikeoth (Namwote District Officer, Ministry of Electric Power)
Officials at Namwote MOEP Off-grid Hydropower Plant

Yangon
Serge Pun (Serge Pun & Associates)
Harry Townsend (Representative of Aggreko)
U Win Khaing (President, Myanmar Engineering Society)
James Taylor (Co-founder and Chief Executive, Proximity Designs)
Philip Frazer (CFO, Proximity Designs)
Min Kyi (General Manager, Myanmar International Terminals Thilawa Limited)
U Zaw Wynn (Ret. Chief Engineer, MOEP & ADB Consultant)
Minoru Nishino, Consultant to Yangon Electricity Supply Enterprise
U Soe Thint Aung (Royal Htoo Linn Mfg)
U Win Khaing Moe (Director General, Ministry of Science and Technology)
Dr. Sint Soe (Dep. Director General, Ministry of Science & Technology)
Daw Sane Sane (Central Exec. Committee, Renewable Energy Assoc. Myanmar)
U Hla Myint (Central Exec. Committee, Renewable Energy Assoc. Myanmar)
U Soe Hla Tun (Chief of Japan Dept., Myanma Economic Holdings, Ltd.)
Dr. Su Su Myat Mon (Assoc. Professor & Head, Dept. Electrical Power Engineering, Technological University Thanlyin, Yangon)
U Tun Tun Ko (General Manager, Asia Solar Co., Ltd.)

Naypyitaw
U Ye Min (Deputy Director General, Presidents Office)
H.E. U Htin Aung (Deputy Minister, Ministry of Energy)
U Khin Maung Zaw (Director General, Ministry of Electric Power)
U Pe Zin Tun, Director General, Energy Planning Dept., Ministry of Energy
U Ko Ko Latt (Deputy Director Energy Planning Department, Ministry of Energy)
U Kyi Htut Win (Director General, Ministry of Agriculture and Irrigation, Water Resources Utilization Department)
U Htay Lwin, Director Planning, Ministry of Agriculture and Irrigation, Water Resources Utilization Department)
U Maung Maung (Chief Engineer, Power Transmission Projects Department, Myanma Electric Power Enterprise, Ministry of Electric Power)
Thuya Aung Bo (Superintendent Engineer, Power Transmission Projects, Myanma Electric Power Enterprise, Ministry of Electric Power)
U Aye Aye Mon (Director, Economic Planning Department of Electric Power, MOEP)
Daw Ei Ei Khin (Director, Department of Electric Power, Ministry of Electric Power)

Appendix II – Naypyitaw: Second Key Stakeholders Meeting

Myanmar Integrated Energy Policy Project

Second Key Stakeholders' Meeting
Naypyitaw, June 2013
Activity Review and Analysis

On 17-18 June 2013, Professor Yoshikawa Hisashi, Keith Rabin and other representatives of the University of Tokyo ("UT") and KWR International fieldwork team ("the team") travelled to Naypyitaw to discuss current and future developments in Myanmar's integrated energy policy with key stakeholders. Over one and a half days of productive, engaging dialogue, the team made significant progress with various stakeholders to continue working toward development of an integrated energy policy for Myanmar.

The second key stakeholders' meeting had three primary objectives: 1) to share and discuss current developments with regard to Myanmar's integrated energy policy, including recent fieldwork conducted by UT, the submission of UT's integrated energy paper to ERIA for inclusion in the Myanmar Comprehensive Development Vision ("MCDV") initiative, the upcoming seminar with Chulalongkorn University in Bangkok, as well as Ministry-specific, energy-related activities; 2) to discuss future modes and methods of cooperation between the team and key stakeholders; 3) to deepen key stakeholder relationships in order to explore opportunities for future cooperation and development of policy discussions and development; and 4) to further strengthen UT's fieldwork, other Myanmar-focused activities and development of contacts and relationships within relevant energy-related Ministries and organizations.

The team successfully achieved these objectives and identified critical next steps, for potential inclusion in future phases of UT's Myanmar Integrated Energy initiative, including:

1. Create a policy-working group across the 7 Ministries that drive Myanmar's energy policy. This working group will serve as a catalyst and clearinghouse for more detailed group policy discussions and communication across these entities;
2. Increase UT and the team's presence in Naypyitaw to facilitate real-time information exchange, capacity building, stronger linkages and intra-ministerial connectivity and communication within the 7 Ministries responsible for Myanmar's energy sector, and to expand the team's network across these and other related and relevant entities on the national, regional and local level as well as outside Myanmar; and
3. Organize a comprehensive conference and workshop with key internal and external stakeholders in Winter/Spring 2014 to present collaborative work and explore next steps.

Second Key Stakeholders' Meeting

The focal point of the team's visit, the second key stakeholders' meeting was designed to build on the momentum and interest generated during first key stakeholders meeting organized last March. It brought together 24 individuals from various government ministries, non-profit organizations, and academic institutions that are critical actors in Myanmar's energy sector. More specifically, representatives from the Ministry of Environment, Ministry of Electrical Power, Ministry of Energy, Ministry of Mines, Ministry of Industry, Ministry of Science and Technology, Ministry of Agriculture and Irrigation, and the Myanmar Renewable Energy Association attended the meeting. Please see Appendix 1 for a full participant list.

The Director General of the Ministry of Agriculture and Irrigation opened the meeting. He briefly described the goals of the Myanmar Integrated Energy Policy project and stressed the importance of the team's activities to Myanmar's evolving energy sector. He strongly encouraged all stakeholders and their respective Ministries to openly collaborate with the team and noted his support for the team's fieldwork. It should be noted that the Director General's praise was not simply rhetorical as he had previously assigned two engineers and strong logistical support both to the organization of this second key stakeholders' meeting as well as the team's fieldwork which had been undertaken the previous week. In addition, given that the second key stakeholders' meeting took place during the semi-annual Gem and Jade Trade Show and all hotels within Naypyitaw were fully booked for this event, space was made in the Ministry of Agriculture guest-house, where the UT team resided during its stay in the capital.

Next, the team shared and discussed current developments with regards to the Myanmar Integrated Energy Policy project. Professor Yoshikawa noted that the team previously submitted a draft paper to ERIA, and that this paper would constitute one chapter in ERIA's Myanmar Comprehensive Development Vision (MCDV) paper. Professor Yoshikawa offered to share the final version of the MCDV paper with the key stakeholders, once available. He also explained that the MCDV paper would serve as the starting point for the team's future research on Myanmar integrated energy policy.

Keith W. Rabin then briefly described the results of the team's initial fieldwork visit to Mandalay, Bagan/Nyaung-Oo, and Monywa.

Before opening up the floor for discussion among the participants in attendance Professor Yoshikawa concluded this first portion of the program by briefly describing the upcoming workshop in Bangkok. He noted this workshop would seek to integrate key findings from the ERIA paper and fieldwork within the perspective of how Myanmar is viewed by its neighbors, and that it would create important visibility within the ASEAN academic community.

All stakeholders responded positively to the team's updates. They requested an update after the Bangkok workshop, eagerly asked the team about future fieldwork plans, and asked for copies of the draft fieldwork presentation. Furthermore, specific stakeholders, including representatives from the Myanmar Renewable Energy Association and the

Ministry of Energy, requested follow-up meetings with the team to discuss specific topics.

After a tea break, Professor Yoshikawa briefly summarized the meeting's successes and asked the group to work together to discuss future modes, potential next steps and methods of cooperation between the team and key stakeholders. At that point, the group moved into an open-format session.

To begin, Professor Yoshikawa noted three ongoing workstreams that would already drive the Myanmar Integrated Energy Policy project into the future: 1) additional fieldwork; 2) grid expansion simulations, and 3) development of a greater understanding of how energy integration in Myanmar fits within an ASEAN and regional context. The stakeholders asked questions and after discussion, supported these future activities.

Next, the group actively discussed the importance of working closely together to create a comprehensive energy policy across the 7 Ministries that drive Myanmar's energy policy. The team added that it needs real-time information exchange with the 7 Ministries. The team also stated its desire to treat the Myanmar Integrated Energy Policy project as a joint study between the University of Tokyo, ERIA, and the Myanmar Government.

As a result of this dialogue, the team proposed several next steps to the stakeholder group: 1) more frequent policy discussions on specific topics; 2) the creation of a policy working group across the 7 Ministries that drive Myanmar's energy policy; 3) the creation of a methodology for future cooperation; and 4) the appointment of working-level counterparts in each relevant Ministry.

The stakeholders discussed and expressed support for these ideas, and the team believes they are sincere in their interest in working together on an integrated energy policy for Myanmar.

Several stakeholders also provided updates on recent energy-related activities in their respective Ministries during the open-format session. For example, the team learned about the creation of a new energy-working group to combine and harmonize the energy policies of the 7 Ministries that inform Myanmar's energy policy.

Three members of this new working group were present in the stakeholders' meeting, and they provided the following valuable information to the team:

- The working group has not been publicly announced;
- It meets in the Ministry of Energy building;
- At present there are four, inter-ministerial groups working on energy policy;
- The National Energy Management Committee, chaired by the Vice President, coordinates all inter-ministerial, energy-related activities;
- The Energy Development Committee resides under the National Energy Committee;

- Both Committees are responsible for drafting Myanmar's energy policy, but further research is necessary to more clearly delineate the different roles and responsibilities of each Committee;
- The new energy working group, as well as an energy-related think tank group, sit below these two Committees;
- Specific responsibilities for these new energy working group will be defined soon; and
- The Minister of Energy will chair the new energy-working group.

At the end of the open-format session, the stakeholders also expressed an interest in supporting the teams desire to strengthen and expand its contacts and relationships with relevant energy-related ministries and organizations in Myanmar and meetings with key representatives from the Ministry of Electrical Power and Ministry of Energy were arranged as an immediate next step.

The Director General of the Ministry of Agriculture and Irrigation closed the meeting by summarizing its objectives as well as the next steps developed during the open-format session. He warmly thanked the team for traveling to Nay Pyi Daw, reiterated the importance of the team's activities to Myanmar's evolving energy sector. In addition attention was devoted to selecting the next sites for the teams ongoing fieldwork and for the next follow-up visit.

Follow-Up Meetings

Given the next steps developed during the open-format session, two follow-up meetings were arranged for the team with the Ministry of Energy and the Ministry of Electrical Power.

Meeting with Representative of the Ministry of Energy

The team met with H.E. U Htin Aung (Deputy Minister) and U Ko Ko Latt (Deputy Director, Energy Planning Department).

The team shared current developments and future plans with regards to UT's Myanmar Integrated Energy Policy project. The team also noted its intention to form in inter-ministerial policy discussion group. The Deputy Minister and Deputy Director were supportive of this initiative. The team also asked the Deputy Minister if he would be willing to appoint a working-level counterpart from the Ministry of Energy, and he agreed to it.

Next, the Deputy Minister confirmed the creation of the new energy working group and explained the working group already has several projects underway. First, it is working with the World Bank to draft an electricity law. Second, it is integrating the policy objectives and target strategies of the 7 Ministries that inform Myanmar's energy policy into one document.

The Deputy Minister also explained that the World Economic Forum's *New Energy Architecture: Myanmar* report provides a comprehensive overview of the country's

current energy sector as well as policy recommendations. The Deputy Minister added that the Ministry of Energy served as a focal point for this report, and that it worked closely with Accenture, ADB, and the World Bank to complete the report over a 10-month period.

Next, the Deputy Minister explained that ADB and the Ministry of Industry are working together to better understand off-grid electrification in Myanmar. The Deputy Minister noted that the Ministry of Industry is responsible for rural energy access. The Deputy Minister recommended that the team meet with the ADB/Ministry of Industry team to exchange views and to share information. The Deputy Minister added that both teams should strive to coordinate their activities to avoid redundancies. He stressed that some redundancy is good, as long as it is planned and served to maintain checks and balances and positive momentum. The team agreed to speak with the ADB/Ministry of Industry team and coordinate where possible. The Deputy Minister provided relevant contact information to arrange a future meeting.

Finally, the Deputy Minister explained that the Ministry of Electricity faces sizeable pressure to produce tangible results within 31 months, or before the next election. The Deputy Minister said that as a result, the Ministry has had to take a short-term view on Myanmar's energy policy. At the same time, the Deputy Minister said that he appreciates the long-term view of UT's Myanmar Integrated Energy Policy project. Given the current political situation, the Deputy Minister believes the project can help expand and improve Myanmar's current energy policy.

Overall, the Deputy Minister was strongly receptive to the team's visit. He noted multiple times that the Myanmar Integrated Energy Policy project is a good idea and that it will help the Ministry maintain a long-term view on Myanmar's energy policy. The Deputy Minister concluded by stating that he would report our discussion to the Minister of Energy. He also encouraged the team to speak with other relevant stakeholders within his and other energy-related Ministries in Myanmar.

<u>Meeting with Representatives from Power Transmission Projects Department, Myanma Electric Power Enterprise, Ministry of Electrical Power</u>

The team met with Maung Maung (Chief Engineer) and Thuya Aung Bo (Superintendent Engineer).

The team shared current developments and future plans with regards to UT's Myanmar Integrated Energy Policy project.

The Chief Engineer explained that his Department is responsible for electricity grid operations, line construction, and geothermal generation. As such, he suggested that the team speak to representatives of the Department of Electric Power, which is responsible for policy planning and formulation. More specifically, he recommended that the team speak to:

- Director General, Department of Electric Power, Ministry of Electrical Power;

- Director, Economic Planning, Department of Electric Power, Ministry of Electrical Power; and
- Director, Department of Electric Power, Ministry of Electrical Power.

The team successfully obtained contact information for the Director and Director, Economic Planning and will follow-up accordingly. The team will also follow-up with the Chief Engineer to obtain contact information for the Director General, Department of Electric Power.

In addition, Professor Yoshikawa proposed a partnership between the UT Engineering Department and the Engineering team of the Power Transmission Projects Department to conduct grid expansion simulations. The Chief Engineer was very receptive to this initiative, and he requested that the Power System Operations Department collaborate as well. The Chief Engineer explained these two Departments are working together on grid expansion simulations and would be very happy to consider cooperation with the UT.

Next, the Chief Engineer explained the Ministry of Electrical Power plans to electrify 70% of the Myanmar population by 2030. At present, only 30% of the population has electricity. To achieve this goal, the country needs to significantly expand its electricity grid and distribution capabilities.

As a result, the team asked the Chief Engineer about specific steps the Ministry of Electrical Power has taken to achieve this goal. The Chief Engineer explained grid electricity is reliable, but that transmission and distribution costs are very high. Therefore, off-grid electricity options will be more effective for villages in remote areas, at least in the short-term. In sum, the Ministry of Electrical Power and the Ministry of Energy are working together, under the National Energy Management Committee, to improve grid and off-grid electricity options.

The Chief Engineer added that in Rakhine State, there is no electricity from the grid so the Ministry of Electrical Power is working quickly to build transmission and distribution there. At present the Ministry is constructing 4 substations. The Chief Engineer stressed that Rakhine State is an electricity priority right now.

The team also asked the Chief Engineer for electricity cost estimates. The Chief Engineer explained that Yangon is profitable but everywhere else is not profitable. He estimates that each unit of electricity costs about 100 kyat to produce. At the same time, it would be politically difficult to change fixed energy prices which are generally sold to consumers and state-owned enterprises at 35 kyat and to businesses for 75 kyat. The Chief Engineer said that the Ministry is trying to gradually raise prices but recognizes there are political obstacles.

Finally, the team asked about electricity provisions in Myanmar's border areas. The Chief Engineer explained that some villages receive electricity from China, Thailand, and India, but that the Ministry does not necessarily encourage these activities. Rather, the regional government will decide whether or not to allow this activity. The Chief

Engineer added that Myanmar does not yet belong to the ASEAN or Greater Mekong electricity grids. He said that Myanmar will officially connect to Thailand's electricity grid in 2016. At present, Myanmar is connected to China's electricity grid via a large hydropower plant.

Participants in Stakeholders' Meeting

1. Mr. Kyi Htut Win - Director General, Ministry of Agriculture and Irrigation, Water Resources Utilization Department
2. Dr. Su Su Myat Mon - Associate Professor and head, Department of Electrical Power Engineering, Technological University (Thanlyin)
3. Daw Sane Sane - Central Executive Committee, Renewable Energy Association Myanmar
4. Daw Wah Wah Thaung - Executive Officer (Planning Department), Myanma Oil and Gas Enterprise, Ministry of Energy
5. Mr. Htay Lwin - Director (Planning), Ministry of Agriculture and Irrigation, Water Resources Utilization Department
6. Mr. Keith Rabin – President, KWR International
7. Ms. Courtney Lutterman – Analyst, KWR International
8. Professor Yoshikawa Hisashi – Project Researcher, Graduate School of Public Policy, Todai Policy Alternatives Research Institute, The University of Tokyo
9. Mr. Michael Thar Htoo – Project Assistant, KWR International
10. U Thein Myint – Deputy Director (Account), Ministry of Agriculture and Irrigation, Water Resources Utilization Department
11. U Maung Maung Gyi – Assistant Research Officer, Ministry of Agriculture and Irrigation, Water Resources Utilization Department
12. U Aung Kyi – Deputy Director, Ministry of Mines
13. U Myo Thant Hun – Chief Engineer, Electricity Supply Enterprise, Ministry of Electrical Power
14. U Aung Zaw Hein – Head Officer, Hydropower Department, Ministry of Electrical Power
15. Daw Ni Lar Nyo – Deputy Assistant Director, Ministry of Electrical Power
16. Daw Yee Yee Khin – Assistant Director, Ministry of Energy
17. Daw Soe Soe Nyein – Head Officer, Energy Planning Enterprise, Ministry of Energy
18. Daw Wint Thira Swe – Head Officer, Energy Planning Enterprise, Ministry of Energy
19. U Aye Chafing – Deputy Director, Ministry of Mines
20. Daw Aye Kay Khaing Soe – Assistant Director, Central Research Department, Ministry of Energy
21. U Maung Maung Than – Director (Retired), Ministry of Forestry
22. Dr. Aung Ko U – Assistant Professor, University of Technology (Mandalay)
23. U Bo Ni – Director, Ministry of Forestry
24. U Min Zaw Oo – Senior Officer, Ministry of Forestry

KWR International (Asia) Pte. Ltd.

Stakeholders' Meeting Agenda

Event	Myanmar Integrated Energy Policy Stakeholders' Meeting	
Theme	Current and Future Developments on Myanmar Integrated Energy Policy	
Venue	3S Lab, Ministry of Agriculture and Irrigation, Office No. 50, Naypyitaw	
Date	17 June 2013	
Time	10:00 – 13:30 hours	
Item	**Time**	**Description**
Opening Session		
1	09:30 – 10:00	Meeting registration
2	10:00 – 10:05	Opening Remarks from Kyi Htut Win, Director General, Ministry of Agriculture and Irrigation, Water Resources Utilization Department
3	10:05 – 10:10	Stakeholder Self-Introductions
4	10:10 – 10:20	Opening Remarks by Yoshikawa Hisashi, Project Researcher, Graduate School of Public Policy, Todai Policy Alternatives Research Institute, The University of Tokyo
5	10:20 – 10:30	Fieldwork Update by Keith W. Rabin, President, KWR International
6	10:30 – 10:45	Tea Break
Presentation Session		
7	10:45 – 11:00	Presentation on Future Plans for Myanmar Integrated Energy Policy by Yoshikawa Hisashi, Project Researcher, Graduate School of Public Policy, Todai Policy Alternatives Research Institute, The University of Tokyo
8	11:00 – 11:45	Discussion with Stakeholders on Current and Future Plans for Myanmar Integrated Energy Policy
9	11:45 – 12:00	Closing Remarks from Kyi Htut Win, Dir. Gen., Ministry of Agriculture & Irrigation, Water Resources Utilization Department
Stakeholders Lunch		
10	12:00 – 13:30	Informal Discussion with Stakeholders on Current and Future Plans for Myanmar Integrated Energy Policy

Appendix III – Bangkok Conference: Energy Integration in Myanmar

ERI-UT Joint Conference
Energy Integration in Myanmar: A view from abroad
June 24, 2013, The Sukosol Bangkok

Co-hosted by

Energy Research Institute (ERI), Chulalongkorn University

And Todai Policy Alternative Research Institute (PARI), the University of Tokyo

Supported by Economic Research Institute for ASEAN and East Asia (ERIA)

1. Objective:

Regarding the Energy development in Myanmar, this conference aims:

- to understand the energy integration in Myanmar in the ASEAN context;
- to share neighbor's viewpoints toward the Myanmar energy; and
- to draw implications for the further energy integration in 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 neighboring countries such as China, India, and Thailand, this conference tries to reveal neighbor's views toward the Myanmar Energy, the Myanmar's expectation for those countries, and the gap in between.

How could we achieve the Myanmar Energy development with this gap? For this achievement, what kind of energy integration strategy is needed? How could this strategy contribute to the course toward the coming ASEAN Economic Community? By answering those questions, we will draw implications for our further research.

5. Conference program (June 24, 2013)

09:00-9:30; *Registration*

9:30-9:40; **Welcome Remarks**

Prof. Bundhit EUA-ARPORN

Energy Research Institute, Chulalongkorn University

9:40-9:50; **Opening Remarks**

Prof. Hideaki SHIROYAMA (The University of Tokyo)

Brett Jacobs (ERIA)

Session 1: Myanmar Energy in ASEAN

10:00-10:30; **Keynote Speech**

Prof. CHOU Siaw Kiang (National University of Singapore)

10:30-11:00; **IEA's view: ASEAN Focus**

Mr. Florian Kitt & Ms. Yerim Park (International Energy Agency)

11:00 -11:20; *Coffee Break / Photo Session*

11:20-12:00; **Panel Discussion; Myanmar Energy from ASEAN Perspective**

Prof. Hideaki SHIROYAMA,

Prof. CHOU Siaw Kiang

Mr. Florian Kitt,

Prof. Bundhit EUA-ARPORN,

Moderator: Prof. Hisashi Yoshikawa

12:00-13:00; *Lunch*

Session 2: Myanmar Energy Integration

13:00-13:20 **Overview of Myanmar Situation and Future Development**

Prof. Ichiro Sakata (The University of Tokyo)

13:20-13:30 **Special Remarks**

Mr. Setsuo IUCHI (Executive Director, JETRO Bangkok Center)

13:30-13:45 **Keynote Speech**

Mr. Zaw Wynn (Consultant, Asian Development Bank)

13:45-15.30; **Myanmar Energy Integration: Perspectives from China, India and Thailand (Including Q&A)**

Speaker

Dr. Li Tao (The GMS Center of Yunnan University, China)

Prof. Lawrence Surendra (Mysore University, India)

Assoc. Prof. Sunait Chutinatharanon

(The Institute of Asia Study, Chulalongkorn University)

Prof. Supang Chantaranich / Assoc. Prof. Suwattana Thadaniti

(Social Research Institute, Chulalongkorn University)

Moderator: Dr. Achariya Suriyawong

15:30-15:45; *Coffee Break*

Session 3: UT's research on ASEAN Energy Roadmap

Parallel Workshop A: Simulation

15:45-16:00; Prof. Ichiro Sakata

Japan and UT's Perspective

16:00-16:30; Prof. Tanaka /Mr. Sasaki/ Prof. Esaki

UT's Research "Simulation"

Parallel Workshop B: Fieldwork

15:45-16:00 Prof. Hisashi Yoshikawa

Japan and UT's Perspective

16:00-16:30; Mr. Keith RABIN/Mr. Yamaguchi/Dr. Weerin

UT Research "Fieldwork"

16:30-16:45; **"Presentation & Q&A"**

16:45-17:00: **Closing Remarks**

Appendix IV - 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 V: 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[1], which was better than Cambodia and the Philippines but still very low[2]. 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[3], 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.

[1] By now, it increases to 21.7 percent
[2] According to the ministry of construction, paved roads reached 21.7% for whole country in March 2012.
[3] Data was not available for Singapore.

Table 6-1: Connectivity Related Indicators in ASEAN[4]

	Railway density	Road density	Paved road	Passenger cars	Air passengers carried	Port container freight	Asian Highway	
							Total	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

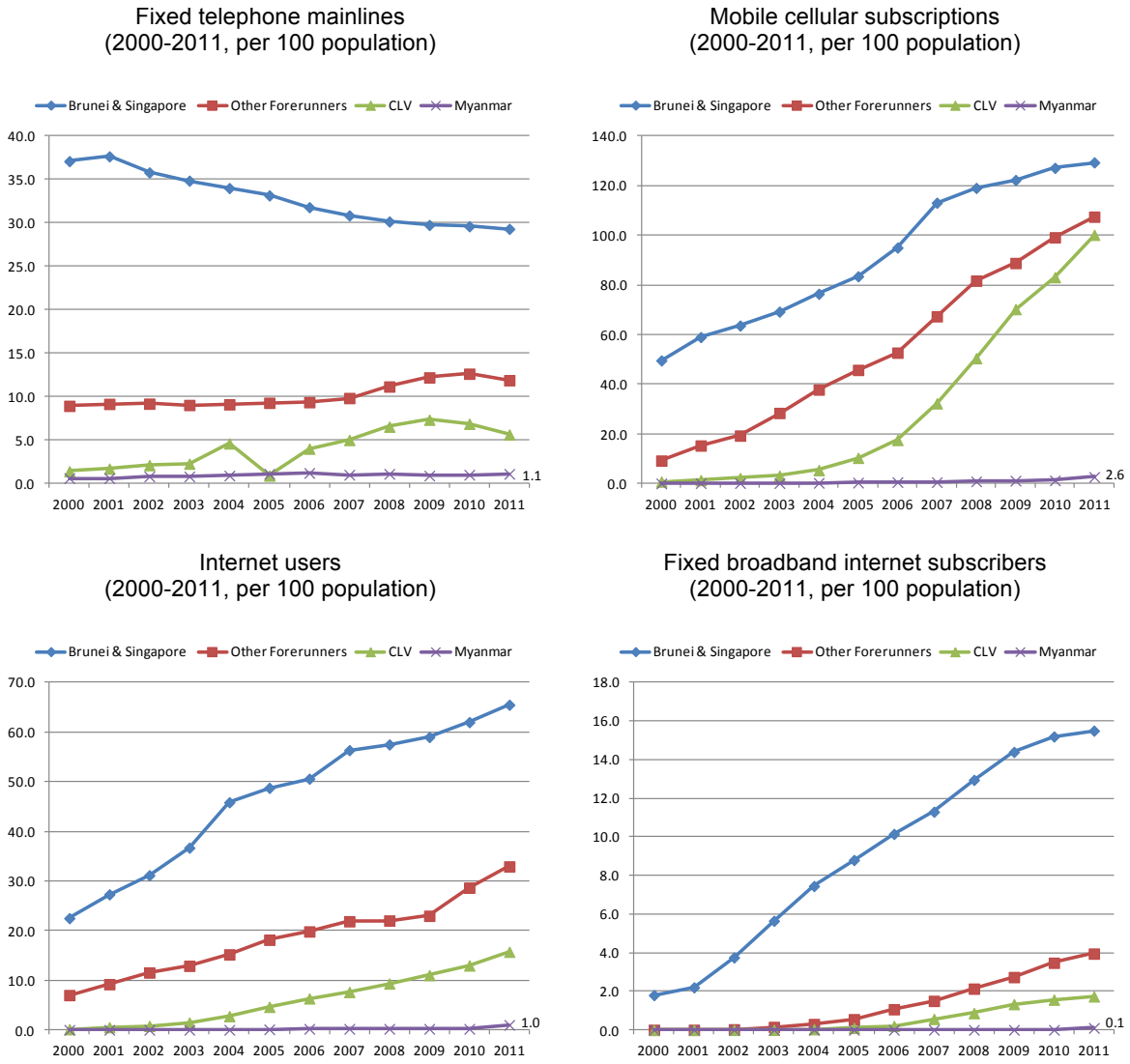
Source: UNESCAP (2012) and database on the UNESCAP website

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

[4] 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 Transport Administration), Air passengers carried is 2074 (Dept. of Civil Aviation) and Port container freight is 0.3034 (Myanmar Port Authority)

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.

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

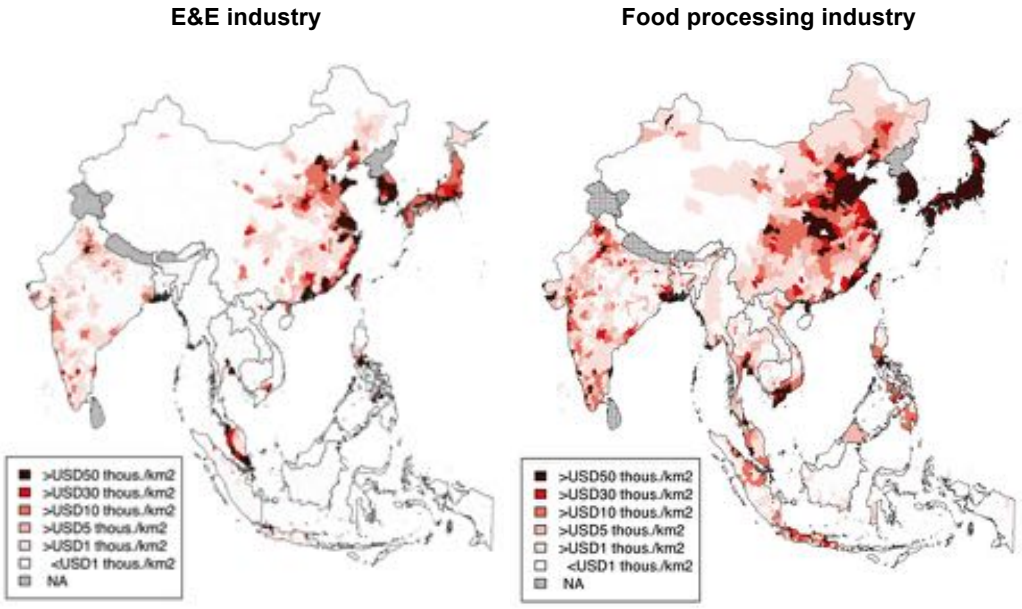
Given the circumstances, Myanmar needs all-round reforms. We need new roads, and existing roads need to be paved and upgraded. Passenger and commercial cars will increase and it will require new roads. There is a need to reduce road traffic deaths. Ports and airports need to be upgraded. Railway needs 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 '2nd 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

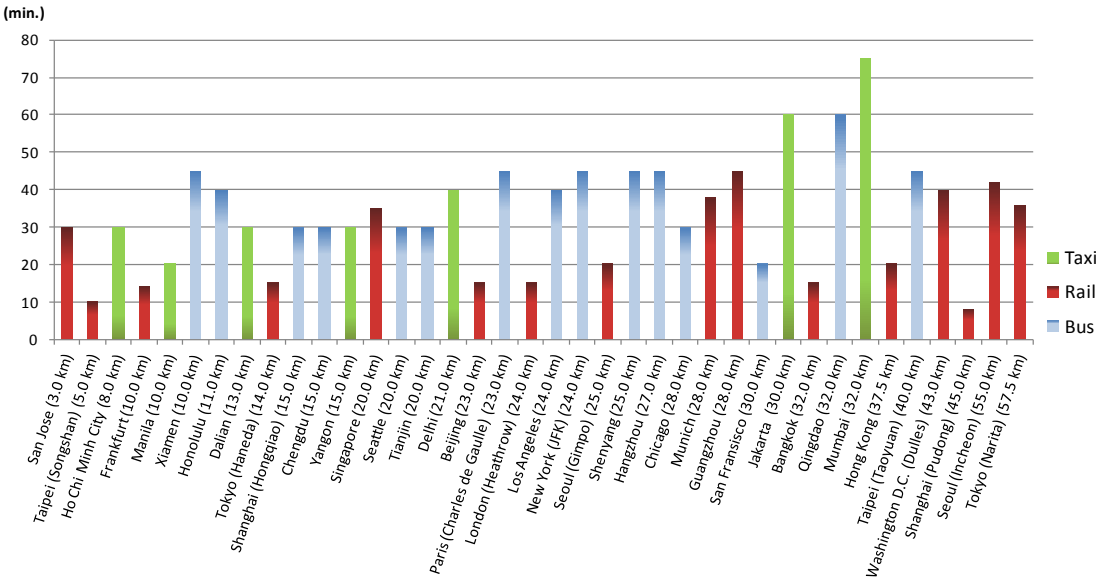
million[5]. There should be continued upgrading of current roads and urban railways, build new bridges, plan for new urban railways such as subways, and develop a ring road. And the territory of Yangon City should be expanded so that urban functions work smoothly.

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.

[5] 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 e-procurement 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	• Implementation of the Intelligent Transport System in Nay Pyi Taw and Yangon • Implementation of international road

		• Construction of roads and bridges	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 International Airport • Allow private sectors to operate the airports • Upgrading airline services	• Operation of four International Airports in full swing • Upgrading the existing domestic airports • Expansion of domestic and international airlines and air routes	• Upgrading the existing domestic 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 shipping lines • Extend cargo ships for inland water	• Upgrade all shipyards of the inland water transport

	• Improve inland water transportation especially Yangon-Mandalay-Bhamaw route • Formulation of the national integrated transport master plan	transport • Introduce routes to connect international maritime routes • Implementation of the national integrated transport master plan	• 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[6], 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[7] so that it can fully utilize the agreement should it want to.

2. Integrated Energy Development

[6] There are 9 Protocols. Five were ratified. Protocol 2 & 7 are to be signed and 1 & 6 are to be ratified.

[7] 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.

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[8]—is placing further strains on capacity and increasing generator failure[9].

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 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[10].

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.

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[8] 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.

[9] David Dapice, Electricity in Myanmar: The Missing Prerequisite to Development, Harvard University, May 31, 2012

[10] Patrick Winn, Myanmar's Real Power Struggle? Keeping on the Lights, *Global Post,* June 23, 2012

(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.[11]

Of total electricity generation in 2009, production from hydroelectricity climbed to 72 percent, from 62 percent in 2008 and 57 percent in 2007.[12] Production from oil, gas and coal declined to 29 percent, from 39 percent in 2008 and 43 percent in 2007.[13] Natural gas produced 1,146 million kWh in 2009, or 20 percent, down from 29 percent in 2008 and 30 percent in 2007.[14] 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.

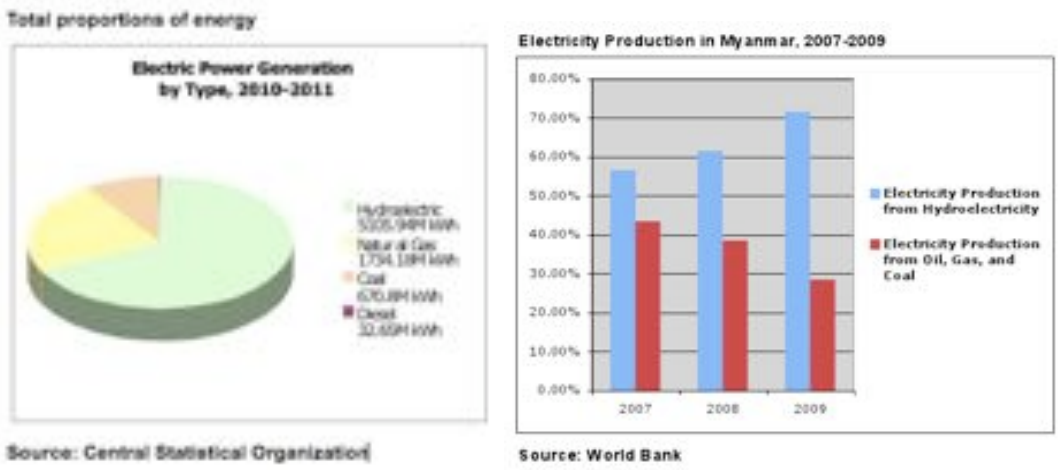
[11] Wah Wah Thaung, Oil and Gas Sector in Myanmar: The energy related issues and challenges from the perspective of Ministry of Energy, Myanma Oil and Gas Enterprise, Ministry of Energy, Republic of the Union of Myanmar. Presented at "Energy challenges in ASEAN: Implications for Myanmar" workshop, February 2013

[12] Electricity Production from Hydroelectric Sources (% of total), The World Bank Group, accessed: June 29, 2012

[13] Electricity Production from Oil, Gas and Coal Sources (% of total), The World Bank Group, accessed: June 29, 2012

[14] 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 .[15] Of natural gas produced, more than 80 percent is exported to Thailand.[16] 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.[17]

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[18]. The country's

[15] 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)

[16] Myanmar's Power Struggle Endangers Economic Boom, *op.cit.*

[17] Thailand to Supply More Gas to Meet High Demand in Myanmar, Arakon Oil Watch, June 21, 2012

[18] Jacob Gronholt-Pedersen, Myanmar to Launch Offshore Oil, Gas Bidding Round in April, Dow Jones, Mar. 4, 2013

gas exports are expected to reach a record USD4 billion for 2012-2013[19]. A new discovery, block M-3, will be entirely used for domestic supply[20].

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.[21] 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.[22]

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[23]. Bidding firms are, however, required to enter a production-sharing agreement with MOGE[24].

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.

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[19] Myanmar Gas Export May Touch $4bn, Natural Gas Asia, March 27, 2013.
[20] Wah Wah Thaung, *op.cit.*
[21] Foreign oil companies ink exploration deals, Agence France Presse, June 21, 2012
[22] Daniel Ten Kate, Myanmar Oil Veteran Rebuffs Suu Kyi a Shell, Chevron Weigh Bids, Bloomberg, Sept. 18, 2012
[23] Myanmar open to foreign energy bids, Bangkok Post, March 6, 2013
[24] Myanmar opens keenly awaited oil and gas auction, Agence France Presse, April 10, 2013

Coal: Myanmar produced an average 416 thousand tons of coal per year between 1988 and January 2009[25]. 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, 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[26].

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.[27] 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.

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[25] Myanmar Energy Sector Assessment, Asian Development Bank, October 2012.
[26] Harnessing Energy from the Clouds, *The Myanmar Times*, August 20-26, 2007
[27] Government Will Prioritize Hydropower Projects Over Gas, *The Myanmar Times*, July 10, 2006

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 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[28].

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.

[28] Renewable Energy Sector, Myanmar Ministry of Energy, accessed: June 29, 2012

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[29]. 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."

Solar energy also holds promise. Myanmar's Ministry of Electric Power reports available solar energy is about 51,974 tTWh per year.[30] 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[31]. 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[32].

(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

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

[30] 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.

[31] Electricity in Myanmar, *op.cit.*

[32] Delta Holds Great Potential for Tidal Power Generation, *Voice Weekly*, February 13, 2006

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 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[33]. 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[34].

(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[35]. 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

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[33] Burma Eyes Private Power Producer, *Nation (Bangkok)*, February 13, 1996

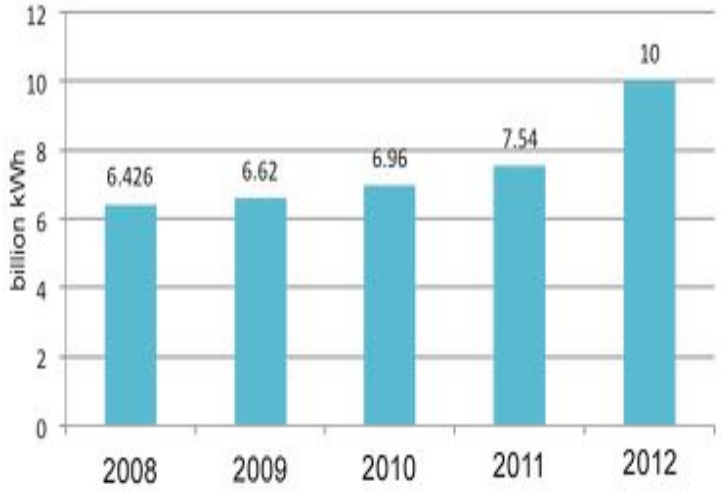
[34] Myanmar: Summary of Asian Development Bank's Initial Sector Assessments, Asian Development Bank, June 2012

[35] Electric Industry in Burma/Myanmar, Online Compendium, Burma Library, accessed: June 28, 2012

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



Source: CSO, 2012.

Electrical Capacity: Myanmar produced roughly 10 billion kWh of electricity, consisting of hydroelectricity, gas, coal, and diesel in 2011-2012[36]. 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[37]. This follows an increase in electricity generation from 5.804 billion kWh in 2005 to 6.426 billion kWh in 2008[38].

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.[39] If accurate, this suggests the already inadequate power grid is being worked more intensively, increasing potential generator failure risk and power outages. Blackouts,

[36] David Dapice, Electricity Demand and Supply in Myanmar, Proximity Designs, December 2012
[37] Electric Power Generated and Sold by the Myanma Electric Power Enterprise, *op.cit.*
[38] Country Analysis Brief: Myanmar (Burma), U.S. Energy Information Administration
[39] Electric Power Generated and Sold by the Myanma Electric Power Enterprise, *op.cit.*

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[40]. 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 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[41].

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[42]. 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[43]. 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[44]. 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[45]. 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[46]. Given the state of Myanmar's

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[40] The Republic of Union of Myanmar, Country Report, Myanmar Ministry of Agriculture and Irrigation, presented May 26, 2011-July 6, 2011
[41] International Energy Statistics, U.S. Energy Information Agency
[42] Electric Power Consumption (kWh per capita), The World Bank Group, accessed: June 29, 2012
[43] Dapice, Electricity in Myanmar: The Missing Prerequisite to Development, *op.cit.*
[44] Asian Development Bank, Myanmar Energy Sector Assessment, *op.cit*.
[45] Dapice, Electricity in Myanmar: The Missing Prerequisite to Development, *op.cit.*
[46] Myanmar Set for Economic Takeoff With Right Policies, IMF Growth Survey, May 7, 2012

power system, the growth rate of electricity demand could be 2.5 times international norms[47].

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 [48]. One consulting firm states households account for 70 percent of Myanmar's electricity consumption[49]. 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[50].

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[51]. 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[52][53].

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[47] 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.[47] Dapice estimates electricity consumption for 2012 will be roughly 160 kWh per capita.[47] 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.

[48] Myanmar Forest Department, presented at Stakeholders Meeting on March 25, 2012

[49] Electricity in Myanmar, Thura Swiss Research, April 12, 2012

[50] Asian Development Bank, Myanmar Energy Sector Assessment, *op.cit.*

[51] Myanmar's Electric Power Generating Capacity Reaches 2,256 mw, *Xinhua*, January 1, 2001

[52] Burma to Halt Myitsone Dam Project: Media Reports, *Mizzima News*, September 30, 2011

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 capacity[54]. 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[55]. The country has 4,793.24 miles of transmission lines, comprised of 39 230 kV, 37 132 kV and 117 66 kV lines.[56] 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[57]. 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[58]. 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

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[53] Myanmar Scraps Coal-fired Power Plant at Dawei, *Reuters*, January 10, 2012

[54] David Dapice, Electricity Demand and Supply in Myanmar, Proximity Designs, December 2012

[55] 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)

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

[57] Asian Development Bank, Myanmar Energy Sector Assessment, *op.cit.*

[58] Addressing the Electricity Access Gap, Background Paper for the World Bank Group Energy Sector Strategy, The World Bank Group, June 2010

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 annually, an optimistic assumption, it would take more than 40 years for networks to reach the majority of Myanmar's towns and villages[59].

(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[60].

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[61]. 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 [62]. 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

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

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

[61] 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

[62] Dr. Dolly Kyaw, Proposal for Rural Development and Poverty Reduction in Myanmar

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[63].

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[64]. 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.[65] A Thai solar power company, SPCG, is also planning to enter Myanmar, with initial plans to establish 2 MW of solar power capacity[66].

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[67]. 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

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[63] Myanmar's Power Struggle Endangers Economic Boom, *Reuters*, April 16, 2012
[64] Integrated Household Living Conditions Survey in Myanmar 2009-2010, Poverty Profile Report, UNDP Myanmar, June 2011
[65] Winn, *op.cit*.
[66] Mridul Chadha, Off-Grid Solar Power Projects For Myanmar, Clean Technica, January 13, 2013
[67] Entrepreneurship Development in Solar Energy Sector for Rural Area in Myanmar, ARTES/SESAM Alumni Regional Level Workshop, May 2008

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.

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[68].

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[69]. 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

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[68] Myanmar's Power Struggle Endangers Economic Boom, *op.cit.*
[69] Electricity Prices to Be Doubled, *op.cit.*

subsidies covering only the very poor, most of which do not currently have access to electricity[70].

(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

[70] David Dapice, Electricity Demand and Supply in Myanmar, *op.cit.*

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[71].

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 warming[72]. Black carbon emissions from burning biomass in open fields are the third largest contributor to global warming[73].

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.[74] 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.[75]

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

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[71] Carbon Dioxide Emissions (CO2), Thousand Metric Tons of CO2, Millennium Development Goals Indicators, United Nations

[72] Greenhouse Gas Emissions from Dams FAQ, International Rivers, May 1, 2007

[73] For more information on the carbon footprint of electricity generation, see: http://www.parliament.uk/documents/post/postpn268.pdf

[74] Burma Infrastructure > Energy, Asia Trade Hub, accessed: June 29, 2012

[75] ASEAN Countries' Presentation on Renewable Energy Projects and Business Opportunities (Myanmar), *op.cit.*

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.[76][77]

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.[78] 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[79].

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.[80] 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-

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[76] Than Htike Oo, Villages Near Twante See the Light, *The Myanmar Times*, January 14-20, 2008

[77] 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

[78] Opinion Poll on Ayeyawady Myitsone Hydropower Project, MyanmarAffairs.com, accessed June 28, 2012

[79] TheMyitsone Dam on the Irrawaddy River: A Briefing, International Rivers, September 28, 2011

[80] Poison Clouds, *op.cit.*

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.

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.[81]

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-

[81] US official sees 'real commitment' in Myanmar's EITI efforts, *Myanmar Times,* March 4, 2013

	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.

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[82]. 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, 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.

[82] Kitti Limskul, Toshihiro Kudo, and Hiroyuki Taguchi, Border Area Development Strategy, Myanmar Comprehensive Development Vision Strategy Paper presented March 25, 2013

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