Turning on the Lights: The Critical Importance of Power Development in Myanmar

Presentation to:

AMCHAM THAILAND

KWR International (Asia) Pte. Ltd.

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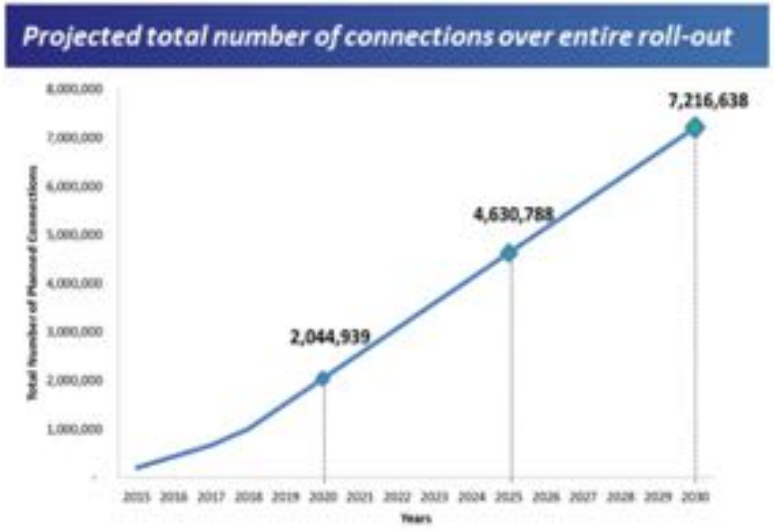
Myanmar's Electricity Dilemma

- Abundant natural resources, including hydro, gas, biomass, diesel and alternative energy
- Among lowest per capita electricity consumption in the world
- Power grid connects only about 30% of its 51 million people
- 70% of grid wiring estimated at over 70 years old
- Large rural population, difficult to reach via grid extension
- Installed capacity of approximately 3,500 MW in 2012, roughly ten times lower than neighboring Thailand of similar size and population
- Frequent blackouts and unreliable power supply
- High transmission losses (27%) due to antiquated equipment, relatively low voltage lines, and stolen power

Myanmar's Electricity Dilemma

Roadmap to 100% Electrification in Myanmar



Source: Castalia and Earth Institute estimates

- Electricity demand expected to grow at annual rate of 10% - 15%
- Rapidly rising expectations for government support
- Skepticism over energy exports that could help fund domestic electrification initiatives
- Data is inconsistent, inadequate and unreliable
- Some legislation and regulatory regimes date to the 1800s
- Lacking in human resources, regulator and institutional capacity
- Subsidies have government providing power at a loss (US$275 m in 2013)

Preliminary Research

Myanmar Comprehensive Development Vision

Beginning in 2012, initial research on Integrated Energy Development ("IED") was conducted by KWR International (Asia) Pte. Ltd. ("KWR") in cooperation with the University of Tokyo ("UT") and Economic Research Institute for ASEAN and East Asia.

This work, which served as the energy/electrification contribution for the **Myanmar Comprehensive Development Vision ("MCDV")**, published in 2013, included the identification of data gaps and further evaluation of the environment for IED in Myanmar.

Based on examination of available literature, background briefings, and the analysis incorporated into its MCDV findings, KWR worked with UT to focus its review on three main thematic areas:

- **Grid Extension and Development**
- **Off-Grid/Rural Electrification**
- **Regional Integration/Cross-Border Electrification**

This was supplemented by the identification of short-, medium-, and long-term priorities as well as resulting policy implications, concerns, conclusions and recommendations.

Grid Extension and Development

- Most efficient strategy, both economically and technically
- Cost can be prohibitive for households--in excess of US$35,000 per km or US$250+ per household, plus costs of connection into the home
- Governed by MOEP's 24 Conditions
- Requires strong local leadership and cohesion
- Additional capacity needed to connect more users
- Potential for social dislocation as grid and government subsidies reach some parts of Myanmar and not others
- Lack of power purchase agreements and feed-in tariff hinders private investment and industrial development

Off-Grid and Rural Electrification

- Remote parts of Myanmar rely on off-grid or self-help electrification solutions
- Diesel generators may be most prevalent off-grid electrification strategy
- Solar power is increasingly popular as off-grid energy source
- Hydro is important but location-dependent
- Gasification is common but requires resolution of operational and environmental concerns

Cross-border energy/electricity sharing

- Cross-border cooperation helps power Myanmar's outlying regions
- Enhanced cooperation provides essential capital, technology and other goods and services
- Lax regulations on private involvement and lack of enforced subsidies drive entrepreneurship and efficiency in power sector
- More reliable electricity helps to drive development and investment in periphery more than in other parts of Myanmar
- Practices on periphery could inform national policies

Site Visits

Myanmar Integrated Energy Fieldwork

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

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

Phase I: Exploratory Fieldwork

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

Objectives

- Comparison of on-the-ground realities with background data and research compiled in 2012 and 2013 for MCDV report
- Further evaluation of current environment for integrated energy development in Myanmar and identification of key issues and realities in the field
- Familiarization with, and exposure to, Myanmar's rural environment and refinement of methodology and approaches to conducting fieldwork in Myanmar

Visited Sites and Observed Themes

- ***Bagan/Nyaung-Oo: Accommodating Tourism Growth and Agricultural Viability***
- ***Monywa: Examining the Potential for Off-Grid Alternatives including Solar***
- ***Mandalay: Balancing the Needs of Urban Industry with Rural Agriculture***
- ***Pathein: Powering Economic Development through Grid Extension & Gasification***
- ***Pyin Oo Lwin: Examining the Feasibility of Off-Grid Mini-Hydroelectric Schemes***
- ***Tachileik: Obtaining Electrical Capacity Through Cross-Border Arrangements***
- ***Kengtung: Powering Off-Grid Locations Beyond the Micro-Level***

Phase 2: Comparative Cost & Technology Relating to Rural Electrification in Myanmar

Objective: *To develop a more comprehensive understanding of potential rural electrification strategies and technologies in Myanmar through fieldwork visits designed to provide quantitative/qualitative insight into geographical differences, comparative costs and trends, including:*

- **Required Generation:** providing insight into estimated demand through data generated from targeted villages and regions.
- **Cost Estimates**: evaluating comparative costs of different electrification strategies within targeted villages and regions through integration of location-specific data and estimated national assumptions.
- **Village Data:** generating village data to evaluate cost and other potential indicators that can be refined/developed through additional research.
- **Summary Reports:** construction of model/methodology that can generate/ analyze fieldwork data to support evaluation of potential rural electrification strategies and policy approaches to promote integrated energy development in Myanmar.

Village Surveys

Interviews will be conducted to survey for data points potentially including:

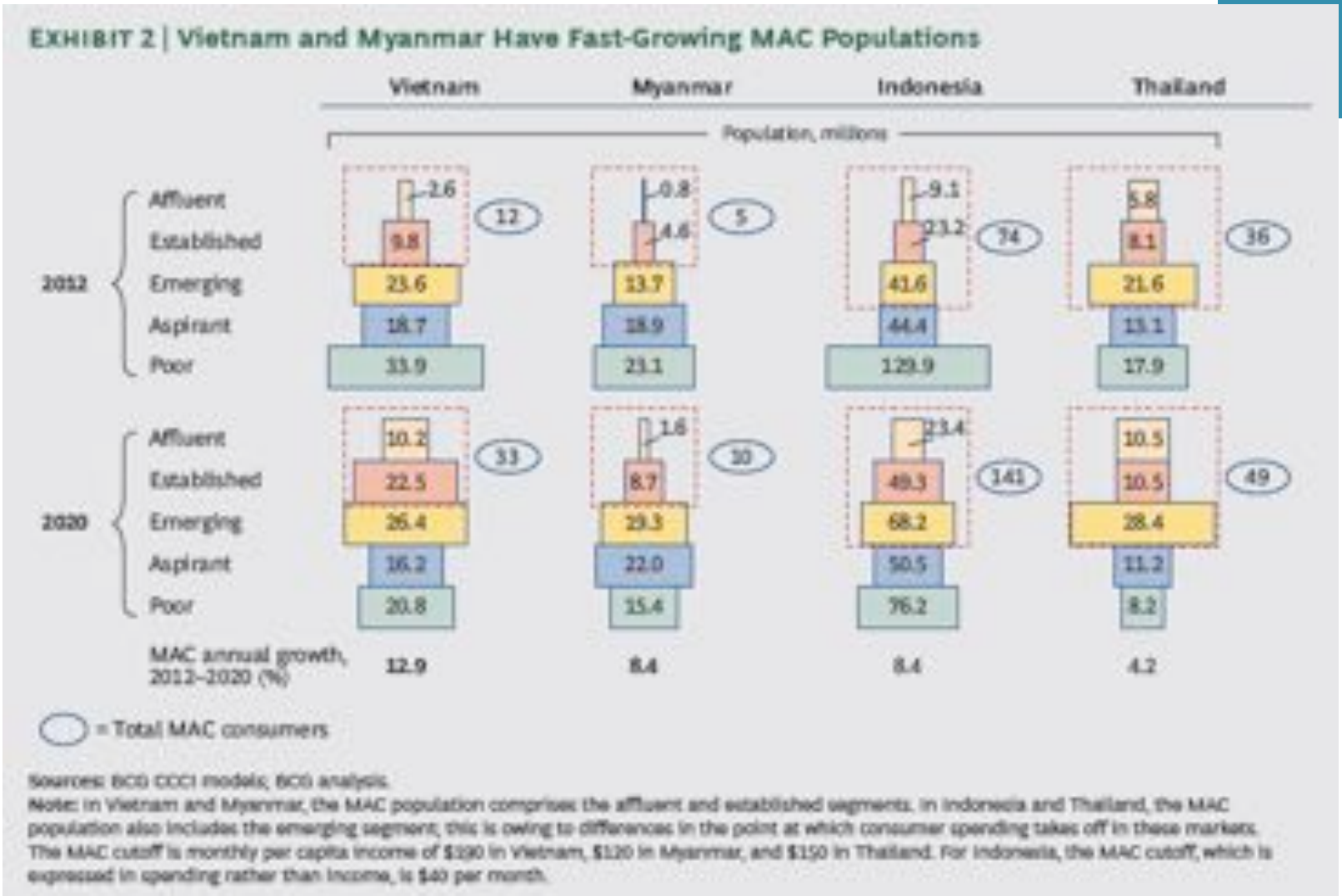
- Total Population (#) • Households (#) • Streetlights (#) • Generator (Transmission)
- Distance from City (km) • Distance from Town (km)
- Non-household demand from buildings such as

  •Schoolhouse (#) • Administrative (#) •Healthcare/Clinic (#) • Storage Facility (#) • Restaurant/Teashops/Café (#)
- Existence of Small or Medium Industry (Yes/No)
- Distance from

  • National Grid (mi) •Potential River Source (mi)
- Sources of Biomass

  •Manure Source (Yes/No) • Rice Husk Source (Yes/No) •Other Biomass (Yes/No)
- Natural Resource Access (Yes/No)
- Land Cost per square meter or square kilometer

Methodology: Demand Analysis



Source: BCG

Translating Consumer to Energy Demand in Myanmar

Demand has been categorized into the following five levels:

Poor	• 120 W*
Aspirant	• 500 W
Emerging	• 1000 W
Established	• 2500 W
Affluent	• 5000 W

*120w minimal rural electrification household target level provided by Ministry of Livestock, Fisheries and Rural Development

Cost Model with Village Data

Capital Costs

Village Name	Number of Households	Distance from National Grid (miles)	Total Village Demand (KW)	Solar Home System	Hydro Mini-grid System	Gasifier Mini-grid System	Gen-set Mini-grid System	Grid Extension
Tha Yet Taw	48	10	9	$34,285	$0	$11,610	$27,485	$451,738
Kyar Kan Daung	72	11	15	$51,738	$0	$34,610	$30,485	$451,760
Aung Mingalar	110	42	24	$79,677	$0	$30,642	$41,006	$1,557,581
U To	120	47	33	$84,026	$0	$41,362	$41,754	$1,581,752
Mezali	94	7	70	$182,618	$0	$77,839	$58,569	$104,846
Za Di Ya	520	2	269	$708,798	$0	$220,130	$177,430	$54,167
War Taung	161	13	41	$121,271	$0	$40,350	$53,714	$157,152
Myoma	600	286	421	$1,084,623	$172,552[a]	$312,776	$236,171	$8,065,329
Mu Du	700	234	352	$921,938	$0	$250,338	$205,338	$8,544,288

O&M Costs

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

* Capital cost estimate is for 100 KW mini-hydro system and does not include construction of dam or advanced engineering study. O&M costs assume same labor, maintenance and overhead cost for all capacities from 500 KVA and below. This is based on $0.01 per kWh and 60% availability per year.

Cost Model: Technology and Factor Analysis

Technology Factor Analysis

- Capital/Financing Costs
- Energy Resource Cost
- Operation and maintenance cost, sustainability/life-span
- Importance of local knowhow
- Ease of capacity growth
- Front-end engineering/project management
- Ease/lead-time of installation
- Energy resource availability
- Environmental impact

Broader Factor Analysis

- **Cash/non-cash** considers a village's ability to pay for various technologies, including O&M costs, with cash or resource bartering
- **Population size/density and clustering of villages** relates to energy demand and the ability to spread costs across villages and nearby communities
- **Location/geography** looks at the proximity of village to grid, road accessibility, captive power access, ease of transportation of materials, local siting locations and topographical challenges
- **Energy resource availability** looks at proximity to and viability of energy resources, as well as ease of connecting to the grid
- **Local/accessible knowhow** considers a village's proximity to knowledge and expertise needed to handle project design/management, installation, operation, maintenance and safety demands
- **Cohesion** examines a village's capacity for leadership, cooperation and planning necessary to implement electrification schemes (with the exception of solar home units)

Cost Model: Technology and Factor Analysis with Village Data

With all costs and factors considered, the Team analyzed the various electrification strategies for their viability in each village and rated them accordingly. Ratings were determined individually and then adjusted following group comparison and discussion.

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

Phase 2: Fieldwork Visits

Pathein District

- Tha Yet Taw
- Kyar Kan Daung

Chaungthar District

- Aung Mingalar Kyun
- U To
- NEDO Hybrid Facility in Chaungthar

Nyaungdon Township

Mezali

Phase 2: Fieldwork Visits (continued)

Kyaukphyu Township

- Za Di Ya
- War Taung
- Kyaukphyu Special Economic Zone

Tanintharyi Division

- Myoma
- Mu Du
- Dawei Special Economic Zone

Observations

- Maintenance, maintenance, maintenance!
- Leadership
- Entrepreneurship
- Amateur installation
- Training on systems and equipment management is critical
- Financial planning
- Potential for pilot projects

Case Studies

NEDO project in Chaungthar
The Critical Importance of Maintenance and Planning

Project went online in 2003. Systems & equipment were top of the line – Hitachi control systems, Sharp photovoltaic panels. Project fell dormant due a mismatch of well-intentioned design and local capacity to operate and maintain advanced equipment.

Kyaukpyu Mini-Grid and Special Economic Zone
Accelerated Grid Extension with Launch of SEZ

Government-led mini-grid development launched to reduce social tension in Rakhine State, site of social unrest due to high off-rid electricity prices, upwards 1,200 kyats per unit. Illustrates benefits of affordable, regular electricity access and utility of public-private partnerships, as well as potential for social discord as grid reaches some but not all populations.

Dawei Special Economic Zone
Utilizing Public-Private Partnerships to Allow Successful Electrification

While the grid will eventually make its way to Dawei, in the interim, power is provided by private company, albeit at a rate 10X that of the grid. The area demonstrates how a vibrant economy, effective local government, regional integration and public-private partnerships can lead to effective electrification strategies.

Phase 3: Cross-Border Electrification and Potential for Regional Energy Integration in Myanmar

To better understand the dynamics, best practices and potential risks of rural electrification, and to develop a greater understanding of cross-border power arrangements and potential policy responses, additional site visits and research were undertaken with emphasis on Myanmar-China energy relations. Activities undertaken between July-December 2014 include:

- Field visits to Muse and Kokang SAR or other areas near China-Myanmar border, as well as other areas in Shan State, including Lashio, that are heavily influenced by trade with, and investment and immigration from, China

- Meeting with Chief Minister in Taunggyi, capital of Shan State, who controls areas of great interest to China and Thailand for their hydro electricity potential and which are essential for regional energy integration

- Initial research concerning non-governmental organizations and other entities about potential social impact and other "costs" of ongoing and proposed energy projects, including large hydro projects on Salween River

- Continued engagement with stakeholders and peer review of research and findings. Participation in meetings on electrification hosted by donor agencies

- Training, meetings and workshops on energy issues for Myanmar officials, parliamentarians and practitioners.

Phase 3: Fieldwork Locations

- Taunggyi
- Yay War
- Lashio
- Mauhit
- Nan Pak Khar
- Muse
- Ho Saung
- Laukai

Select Conclusions
Primary

Reality of Energy and Electrification Issues Does Not Always Match Rhetoric

On-the-ground realities did not always measure up to media reports, data and desktop research. Although independent power providers were said to be illegal in Myanmar, the Team saw a multitude of examples of private generators and other power providers in the villages visited. By the same measure, reported foreign investments in the power sector, upon closer inspection, were not as far along as one would have believed, hindered by a lack of legislation on power purchase agreements and other aspects of private involvement.

Access to Electricity Is More Widespread than Data Suggests

While it is widely reported one third of Myanmar's population lacks electricity, the Team found that villages, while not receiving power from the national grid, had in many or most cases devised off-grid solutions either independently or help of government initiatives, donors or local entrepreneurs.

Rapidly Rising Expectations Affect Electrification Initiatives

The Team found expectations for improved electrification were rising rapidly among rural populations. These expectations, often uninformed and unrealistic, have led to discontent over grid-extension initiatives that require up-front payments from villages and may necessitate better communication and outreach between the government and rural populations.

Select Conclusions
Primary

Circumstances and Regulations Are Not Nationally Uniform
Though not widely prevalent and, for a long time against Myanmar law, purchasing power from Myanmar's more developed neighbors is a relatively common practice along the periphery. In Tachileik, on the Thai border, regular access to affordable power has underpinned strong growth, leading the Team to believe that such cross-border arrangements might inform national and regional policies.

Social Tensions are Sure to Increase as Myanmar Initiates Electrification Efforts
Tension between electricity "haves" and "have-nots" has largely existed between city dwellers and rural populations. With grid extension initiatives moving into more remote areas, this tension is likely to increase as off-grid communities see their neighbors achieve electricity access. Many communities will remain off the grid for some time, necessitating more attention to off-grid initiatives over short-term.

Social and Environmental As Well As Financial Concerns Must Be Addressed
Potential social/environmental impact from Myanmar energy projects requires greater attention and regulation. This is particularly true for projects along Salween/Thanlwin, where stakes are high in terms of potential power output and political and economic backlash were a disaster to occur. Financial considerations are also important and can intersect with social/socioeconomic impact.

Select Conclusions
Institutional

Intra-Ministerial Coordination Is Crucial to Effective Policy Making

It is difficult for ministries to communicate and coordinate internally and much for difficult to do so across Ministries. While the establishment of NEMC and NEDC are major steps in the right direction, these committees will need to become institutionalized, potentially with a secretariat or officials who can help to maximize intra-ministerial coordination, including project reviews to minimize duplication and share knowledge.

Capacity Development Is Needed to Match Ministry Intentions to Implementation

The Team's extensive meetings with Ministries demonstrate good intentions but an evident lack of capacity and ability to define, plan, finance and manage project. This applies to the management level (Director General and above) in the way institutions are structured and the decision-making process, as well as the professional level in terms of technical knowhow. Training will be vital to overcoming these challenges.

Select Conclusions
Institutional

Regulatory Guidance Must Accompany and Enhance Political Will
Leadership at the highest levels of national government is important to facilitating successful electrification initiatives, both in the case of national grid extension and rural electrification. Political will, however, should not be based purely on individual personalities or one-time stand-alone initiatives. There is a need to codify this as much as possible into longer-term and definitive regulatory guidance with an institutional framework for implementation.

Engagement with Private Sector and General Public on Electrification Is Crucial
Greater dialogue among the government, private sector and general public is needed to develop policies and tariff schemes that reward/facilitate IPPs, PPAs and other private involvement, and which are understood and supported by local communities, who have at once rising expectations for improved quality of living and skepticism over electrification initiatives and rate increases. Adjustments to policies can also be made to allow more of a market-oriented approach to electrification.

Better Coordination is Needed Among National and Regional Government
Just as better coordination is needed at the national level, the roles of national and regional governments must be better defined and coordinated in order to match policy with implementation. This will help balance local knowledge and responsiveness with the potential scale and synergies achievable at the national level. It will also allow local needs and priorities to become integrated into a national framework.

Select Conclusions
Regional Integration

Myanmar Can Play a Key Role in Facilitating Regional Integration.
Myanmar can contribute to policies on regional energy integration, as well as economic integration, to facilitate regional connectivity AND promotes growth within Myanmar and region as a whole. Shan State and the direction taken with energy projects under development with Thai and Chinese investment, can play a critical role in shaping policies.

Myanmar Is Beneficiary As Well As Contributor to Regional Energy Integration.
In addition to benefits accrued from cross-border arrangements with China and Thailand, revenues from energy exports—which are generally seen as less desirable than domestic use given country's history of poor resource management—can, if handled properly, be used in a way that will contribute to rural development and electrification, or improvements to the national grid.

Regional Energy Integration Can Catalyze Myanmar's Growth and Development.
Development of Muse area, and CBD in particular, has relied on the availability of stable power from China which provides the capacity to handle high demand projections. This project likely would not have been able to access financing or make development plans without a guarantee of stable, sufficient power, which Myanmar grid could not supply. The Team's visit to Tachileik demonstrated similar outcomes: higher incomes, greater economic activity and population growth generally follow reliable, stable power supply.

Select Conclusions
Regional Integration

Regional Energy Integration Could Take Many Forms.

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

Select Conclusions
Technical

Electrification Is Enhanced Through Convergence of On- and Off-Grid Initiatives
Current perception views off-grid electrification as largely a temporary phenomenon only necessary until full grid extension can be achieved. More emphasis should be placed on cooperation/integration between on- and off-grid power, such as mini-grids that can be connected to the national grid in the future.

Grid Extension Clearly Optimal Solution though Beyond Reach of Most Villages
Grid extension provides 24-hour electrification, dramatically raising quality of life and economic activity. It also requires a huge investment - that is beyond the reach of most villages. A Rural Electrification Act is imperative, establishing clear electrification goals and governance/financing mechanisms to achieve them.

Solar Home Units Most Suitable for Small, Isolated Villages with Little Demand
Scalability factors work against solar as demand increases. Solar home systems seem best suited for relatively poor villages of about 100 households or less. Even though installation costs are higher than with generators and gasifiers, cost differentials can be addressed within approximately one year when considering the added cost of fuel and O&M with other technologies. This does not account for financing costs.

Select Conclusions
Technical

Attractiveness of Mini-Hydro Impinged by Up-Front Engineering, O&M
Viable hydro resource require up-front engineering and feasibility studies.
This makes it difficult in rural context, except in special cases. Villages lack resources/ knowledge needed to initiate advanced work before installation can be planned/ considered. In larger hydro projects there is sufficient scale for engineering services and micro-hydro where trial and error siting can be initiated to find optimal locations.

Generators Key to Myanmar's Rural Electrification Despite High Diesel Prices
Despite having the highest O&M costs of all technologies examined and potential environmental consequences, generators rate second highest in factor analysis by a wide margin. Generators also represent the optimal "market" solution in areas such as Dawei and Kyaukpyu, although electricity rates are high. In the case of PTC, an independent power provider in Myoma, rates are 490 kyat per unit.

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

Recommendations and Next Steps

Further Research and Fieldwork

This might include: study of planned large-scale Thanlwin hydropower projects; Myanmar's energy relationship with India; potential of solar and other mini-grids; parameters of a Rural Electrification Act; O&M training and certification; standards for gasification technologies; grid conversion.

Strategic Analysis, Integration and Report Preparation

Additional attention should be focused on analyzing and integrating data through a strategic framework so that it can be refined using policy evaluation metrics and utilized in a manner that will help to give focused insight and direction into Myanmar's rural electrification needs moving forward.

Recommendations and Next Steps

Policy & Network Development, Consensus-Building & Facilitation

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

Myanmar Integrated Energy & Capacity Development Center

This entity could facilitate interactive dialogue and organize workshops and briefing sessions for stakeholders. Topics addressed could include rural electrification, tariff structure, energy efficiency, grid extension, grid convergence, renewable technologies and regional integration.

Q&A/Next Steps?

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Phase 1-3 Fieldwork Reports can be accessed on KWR Website or forward on request.