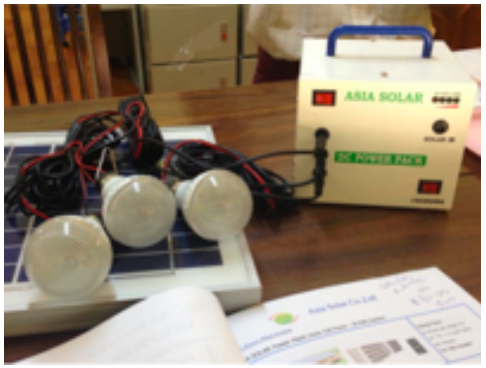


Turning on the Lights:

Integrating Mini-Hydropower into Myanmar's National Electrification Initiatives

Vehicles for Capacity Development and Knowledge Management

Presentation to:

Advancing Mini-Hydropower in Myanmar Towards SE4ALL: Opportunities, Challenges and Next Steps Workshop

KWR International (Asia) Pte. Ltd.

Naypyitaw • July 30, 2015

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.

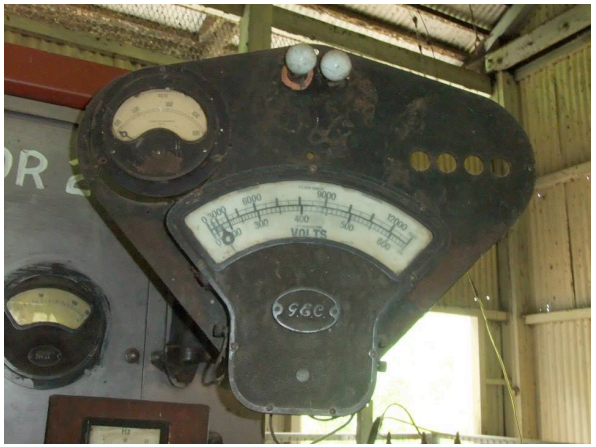
Based on examination of available literature, background briefings, and the analysis incorporated into its MCDV findings, KWR worked with UT to focus its review on three main thematic areas:

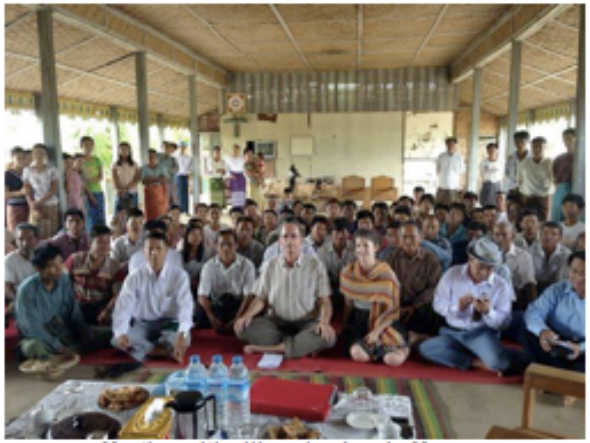
- **Grid Extension and Development**
- **Off-Grid/Rural Electrification**
- **Regional Integration/Cross-Border Electrification**

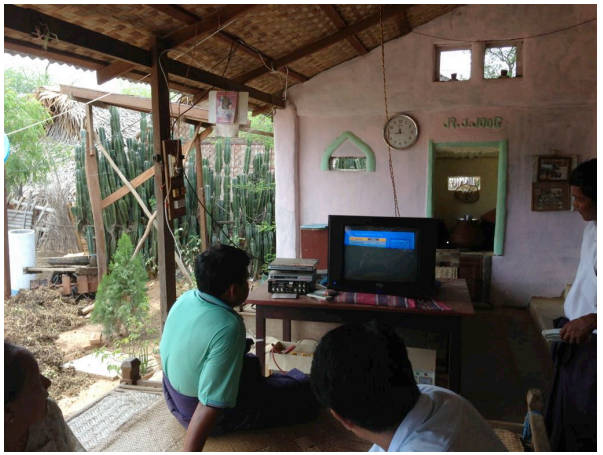
This was supplemented by the identification of short-, medium-, and long-term priorities as well as resulting policy implications, concerns, conclusions and recommendations.

Myanmar Integrated Energy & Rural Electrification Reports

- **Phase I**: Examining on-the-Ground Conditions and Key Issues Relating to Rural Electrification in Myanmar
- **Phase 2:** Comparative Cost & Technology Relating to Rural Electrification in Myanmar
- **Phase 3:** Cross-Border Electrification and Potential for Regional Energy Integration in Myanmar



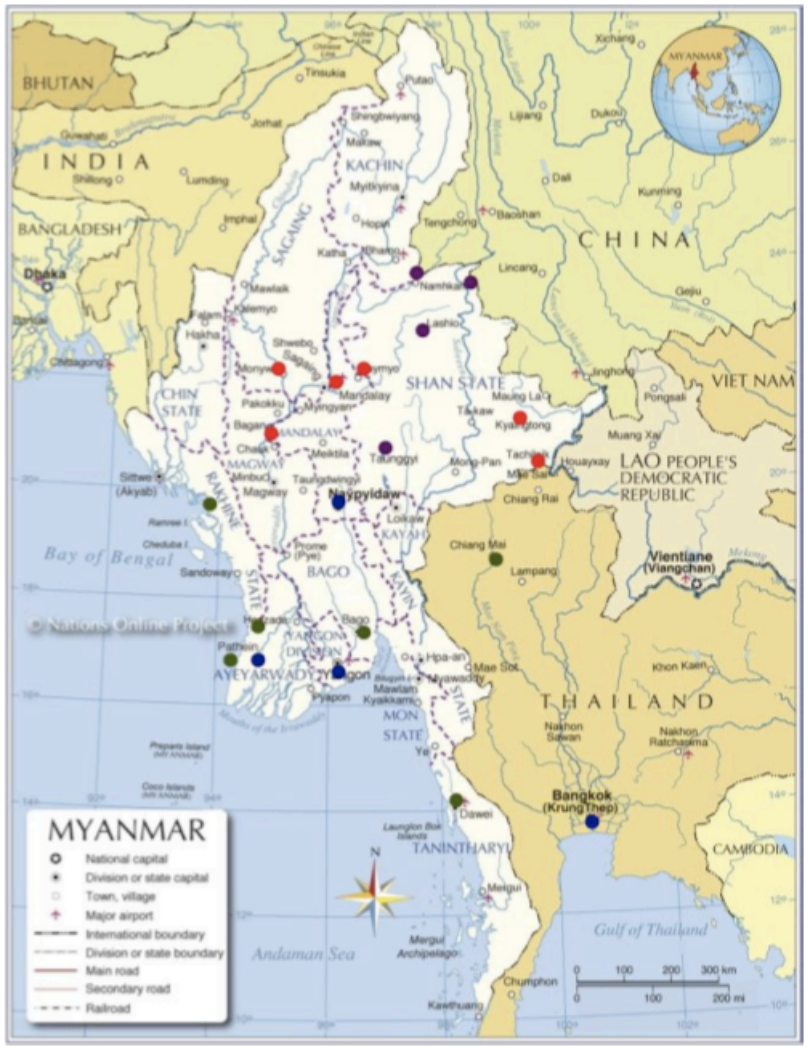




KWR International (Asia) Pte Ltd.

Site Visits

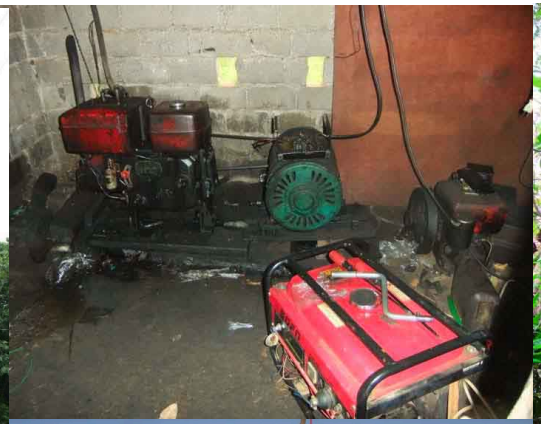
Myanmar Integrated Energy Fieldwork

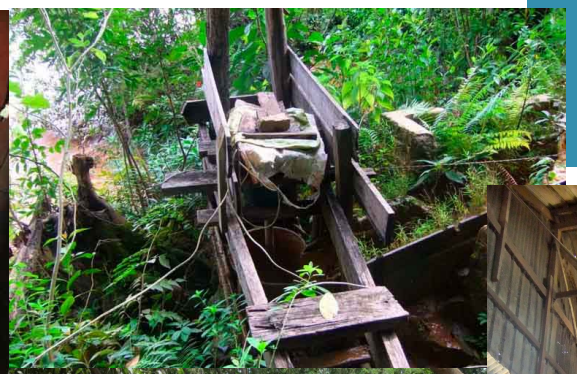


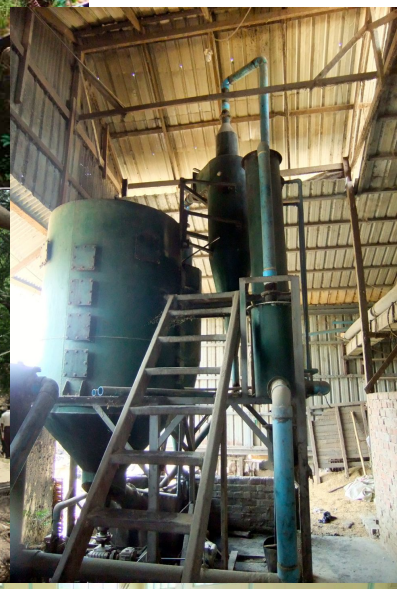
- Phase I Fieldwork Visits – May-Aug 2013
- Phase II Fieldwork Visits – Jan-Jun 2014
- Phase III Fieldwork Visits – Jul-Dec 2014
- Multiple Visits during Project – 2012-2015

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

Common Rural Electrification Strategies in Myanmar






- **Grid Extension** most efficient - costly for households
- **Diesel Generators** most prevalent off-grid strategy
- **Hydro** is important but location-dependent
- **Solar Power** increasingly popular - home units
- **Gasification** operational/environmental concerns?

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

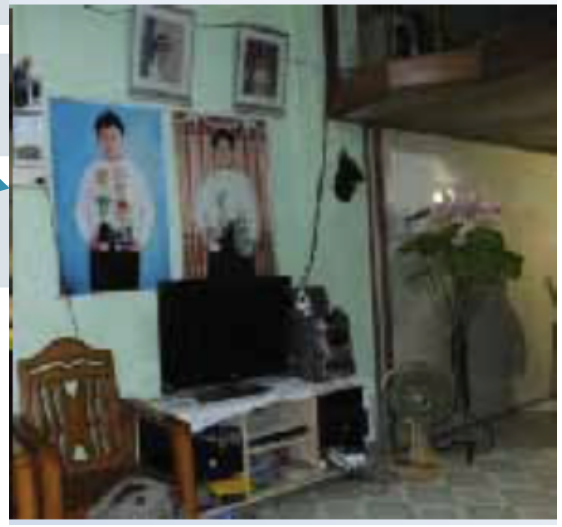
  • National Grid (mi) •Potential River Source (mi)
- Sources of Biomass

  •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

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	$31,610	$27,485	$411,738
Kyar Kan Daung	72	11	15	$51,738	$0	$34,610	$30,485	$451,760
Aung Mingalar	110	42	24	$79,677	$0	$50,642	$41,006	$1,557,581
U To	120	37	32	$98,026	$0	$51,392	$41,756	$1,381,752
Mezali	94	7	70	$182,618	$0	$77,839	$58,569	$314,846
Za Di Ya	520	2	269	$708,798	$0	$220,130	$177,430	$54,167
War Taung	161	13	41	$121,271	$0	$63,350	$53,714	$557,152
Myoma	600	246	421	$1,044,422	$172,552*	$312,776	$236,171	$9,065,329
Mu Du	700	234	352	$921,938	$0	$250,338	$205,338	$8,544,246

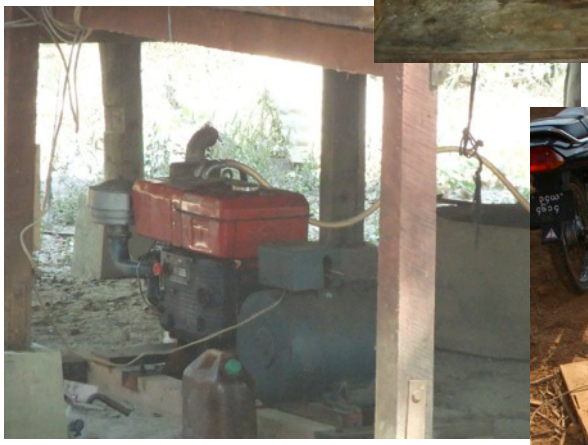
O&M Costs

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.

Observations

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



Select Conclusions
Technical - General

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 - General

Attractiveness of Mini-Hydro Impinged by Up-Front Engineering
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.

Select Conclusions
Technical – Mini-Hydro

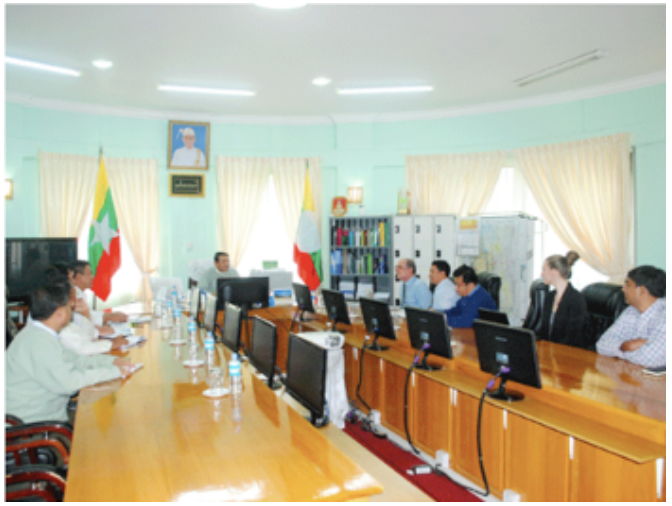
Mini-Hydro Installations Dependent on Identification of Viable Energy Source
Hydropower potential is site specific and installation of viable facilities requires identification of an adequate energy source. This usually requires locating facility close to the point of consumption, and this can be a challenge in rural environments.

Mini-Hydro Usually Generates Capacity Beyond Needs of Single Towns/Villages
As installations often have generating capacity beyond the need of individual towns or villages, the high up-front costs associated with mini-hydro development could be offset if a group of towns/villages join together to achieve sufficient scale. This creates greater need for coordination to facilitate this activity.

Mini-Hydro Generation Can Vary Significantly Depending on Seasonal Factors
Mini-hydro feasibility varies considerably between rainy and dry season. This problem is borne out on a national level as the grid, which is highly dependent on hydropower plants, suffers supply inadequacies during the dry season.

Mini-Hydro More Sensitive to O&M Than Other Platforms.
Small mini-hydro projects, with exception of home-use micro-hydro projects, require a basic level of maintenance that places resource beyond reach of even small groups of towns and villages. Lacking scale of larger installations they are more expensive on a relative basis. This need for coordination, capacity building and O&M training.

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.

How to Utilize Stakeholder Discussion to Facilitate National Electrification Process?

What to do until the grid comes?

Investment in rural electrification on anything beyond home unit or very small scale units is difficult in current environment given inability to predict timing of ultimate grid access AND whether it will be possible to interconnect when grid access finally arrives. This is important both from maintaining pricing competitiveness against grid-supplied power as well as the reduced project risk if a feed-in tariff and ability to sell power back into grid is in place.

How to get to necessary policy, regulatory and business environment while addressing immediate needs and connectivity demands?

Negotiating all the important issues will take time and Myanmar has immediate needs and electrification demand that must be addressed. This requires immediate action though moving forward without initiating adequate initial attention to how issues such as grid connectivity, tariff reform, energy efficiency, certification and standards will be addressed will create long-term problems. Attention must also be focused on public education.

Who will take ownership and manage needed stakeholder discussion?

The size and complexity of Myanmar will require ongoing cooperation and discussion across a wide range of public and private stakeholders. At present there are no institutions or platforms that successfully engage major public and private stakeholders and provide a forum that will allow these entities to freely interact to study, examine, analyze and discuss key issues and work to build consensus around potential policy and regulatory solutions.

Recommendations and Next Steps

Myanmar International Energy Center

- Establishment of a Myanmar International Energy Center (**MIEC**) can help to facilitate energy and electrification development by building broad awareness and interactive dialogue among the many stakeholders whose input is either essential or desirable to this sector. Development of this resource center will facilitate discussion and development of the capacity and consensus needed to deal with many important policy and other important issues. It will also promote public-private partnerships and dialogue, inter-ministerial cooperation as well as to provide continuity and an ongoing forum that will help Myanmar to better face the many challenges presented by national and rural electrification. Objectives include:
- Create a central information clearinghouse, resource center, capacity development and support structure to build broad awareness of opportunities, evaluate effectiveness of alternative technologies, issues and information relating to energy in Myanmar;
- Facilitate interactive and ongoing dialogue among key internal and external stakeholders whose input is essential or desirable on a range of important issues;
- Promote public-private partnerships/dialogue, inter-ministerial cooperation as well as research, study and a forum that will help Myanmar to better face the many policy, technical, social and other policy and other challenges presented by national and rural electrification;
- Support expansion of training, human and institutional resource capacity and structures; and
- Help Myanmar navigate path that encompasses mini-hydro and other technologies and draw from energy and electrification plans proposed by World Bank, ADB, JICA and other entities entrusted to advance, or private entities which seek commercial involvement in, this sector.

Q&A/Next Steps?

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Phase 1-3 Fieldwork Reports and information on plans to establish Myanmar International Energy Center will be forward on request.