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CLEAN ENERGY-BASED POWER GENERATION AND "GREEN GROWTH" POTENTIAL IN THE LOWER MEKONG RIVER BASIN

FINAL REPORT

STUDY CONDUCTED THROUGH THE ASIA REGIONAL ENVIRONMENTAL FIELD SUPPORT TASK ORDER

DECEMBER 2014

December, 2014
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PHOTO: 73.16 MW Solar PV Power Farm at Lopburi, Thailand

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USAID/ASIA BUREAU

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Table of Contents

Glossary

ADB	Asian Development Bank
APEC	Asia Pacific Economic Cooperation
APSEI	Asia Pacific Strategic Engagement Initiative
ASEAN	Association of Southeast Asian Nations
CDCP	Clean Development and Climate Change Program
CFL	compact fluorescent lamp
DSM	demand side management
EE	energy efficiency
EEDP	Thailand's Energy Efficiency Development Plan
EGAT	Electricity Generating Authority of Thailand
ESCO	energy service company
FITs	feed-in tariffs
GEF	Global Environment Facility
GMS	Greater Mekong Subregion
GPS	Global Positioning System
GW	gigawatt
HVDC	high voltage direct current
ICT	information and communication technology
IEA	International Energy Agency
ILB	incandescent light bulb
IPP/BOT	independent power project/build-operate-transfer
LED	Light-emitting diode bulb
LMI	Lower Mekong Initiative
LMS	Lower Mekong Subregion
MOU	memorandum of understanding

MRC	Mekong River Commission
MW	megawatt
PFAN-Asia	Private Financing Advisory Network, a Climate Technology Initiative activity
PPA	power purchasing agreement
PV	photovoltaic
RETs	renewable energy technologies
RID	Royal Irrigation Department (Thailand)
ROI	return on investment
SCADA	supervisory control and data acquisition system
SEA	strategic environmental assessment
SPP & VSPP	Small & Very Small Power Producer
TW	terawatt
UNEP	United Nations Environment Programme
USAID	US Agency for International Development
USAID/RDMA	USAID Regional Development Mission for Asia

Executive Summary

Infrastructure development across Asia will influence countries' and communities' abilities to adapt to climate change. Given proposals for large-scale hydropower in the Mekong region and their potential to change the food and water supplies of about 60 million people,this study assesses the potential for clean energy development in the Lower Mekong Subregion as an alternative to large hydroelectric dams. It is aimed at assisting USAID in examining to what extent renewable technologies and energy efficiency can address the growing energy demand in the LMS, and what specific activities and investments can be made to help LMS countries develop a more balanced and sustainable power infrastructure. Water may become a limiting resource and any impacts on ecosystems may decrease the resilience of countries to climate change. This report explores the prospects are for subregional and even local power grids using local, renewable energy sources, and what kinds of assistance programs would best serve the interest of promoting the use of renewable energy resources while minimizing any potentially negative and long-term social and environmental impacts on the region. Much of the literature supporting this report is based on the GMS, which is the established regional energy planning unit rather than the LMS (see map). However, whenever possible this report disaggregates data to focus specifically on the LMS countries.

This report is intended to provide information to USAID on the prospects for investments in clean energy technology and associated policies and institutional development in the Lower Mekong Subregion (LMS), which includes Thailand, Vietnam, Lao PDR, Cambodia, and Burma. The report begins with an overview of electric power growth trends across the region and the level of grid integration and power trading. The extent of electric power access and the development of national grids are highly uneven in the LMS. Thailand and Vietnam are significantly more advanced than Lao PDR, Cambodia, and Burma and this is strongly reflected in the relative extent of electrification. Rural populations, in particular, are underserved by electrification, especially in the three poorer members of the LMS. Ironically, these same three countries have the largest hydropower resources and Lao PDR is already a significant exporter of hydropower mainly to Thailand.

This report next examines current installed and planned large hydropower development in the LMS along with its economic, social and environmental costs and benefits, which can be significant. However, there is also considerable scope for rebalancing energy supply and demand in the LMS through alternative renewable energy sources as well as the greater use of energy efficiency measures and, eventually, smart grid development. These could replace at least some of the demand for large hydropower and perhaps a significant amount of the fossil fuel use for power generation. Even more important, these alternative sources of electricity, which include solar photovoltaic (PV) arrays, wind power, small hydro and geothermal (in the cases of Vietnam and Burma) could provide a solid basis for rural electrification and the gradual development of a distributed, smart grid system that, over time, could provide the structure for more robust national grids throughout the LMS. Biomass is, of course, an important traditional as well as modern renewable energy. However, its energy applications are overwhelmingly for fuels and process heat rather than electricity and this is likely to continue to be the case in the future. Hydrogen fuel cells also could an important renewable energy source but its application to power generation (except

possibly electric vehicles) is uncertain. Some municipal solid waste combustion for thermal power generation has been investigated for cities such as Bangkok and Hanoi[1] and, though the potential could be locally significant, it does not reach the same scale as solar, wind and hydro for power generation. Finally for the rapidly growing cities and industries in the LMS, the most cost effective energy alternative remains energy efficiency and demand management through best available technology and practices.

The report provides recommendations for USAID to potentially support clean energy and green growth in the LMS region. These are summarized below and can be found in the individual sections of the report.

Report Conclusions

While any individual, large hydropower project can be developed to successfully incorporate social and environemntal mitigation measures, the planned extensive network of large dams throughout the Mekong River Basin would have, as this report demonstrates, huge, cumulative environmental and social costs for the LMS, especially because it is a densely populated and environmentally fragile collection of landscapes. In addition, the planned network of large dams presupposes the existence of a large, interconnected regional grid, which doesn't yet exist. The existing large dams primarily service large cities and industrial zones, like Bangkok and environs and mainly through power purchasing agreements (PPAs). Rural areas and the poorer countries of the LMS, i.e. Burma, Cambodia and Lao PDR do not benefit from these large dams. The combination of the large societal costs of a dense network of large dams and the lack of power access by the rural poor actually argues for a more widely distributed, lower impact network of power sources with lower cumulative and life cycle costs and greater benefits, especially to unserviced rural populations. Indeed, for this off-grid customer base, renewables are already cost-competitive with diesel and other fossil fuel sources.[2]

The policy, regulatory, institutional capacity and infratsructure to support efficient national power grids are seriously deficient in the three poorest members of the LMS, most well-developed in Thailand and partially developed in Vietnam. Currently, power trading is mainly through bilateral PPAs (especially large hydro, as noted) and the significant imbalances in levels of economic development and governance among the members of the LMS means that widespread regional power trading is a long way off. For this reason, attention should be paid to building robust national grids with primary attention to developing autonomous mini- and micro grids for underserved rural populations, especially in the Lao PDR, Cambodia and Burma. Simultaneously, policy and institutional support will be needed to enable the development of national grids in these countries in the future, including the capacity to integrate autonomous mini-grids into one large smart grid.

Clean energy resources show significant promise in all of the LMS countries. Solar PV and small hydro energy resources are the most ubiquitous and combined solar/small hydro projects could

[1] S. Udomsri, Combined Electricity Production and Thermally Driven Cooling from Municipal Solid Waste. (Doctoral dissertation), Stockholm: KTH Royal Institute of Technology, 2011.
[2] Costanza, et al. 2011. Planning Approaches for Water Resources Development in the Lower Mekong Basin, pp. 68-70.

provide reliable electricity supplies for villages and small towns. Wind energy, both onshore and offshore is especially promising for those members of the LMS with long coastlines, especially Vietnam but also Thailand and Burma.

Energy efficiency is the cheapest "energy source" insofar as it reduces overall energy demand, especially in cities and industrial estates and thus avoids the cost of building energy infrastructure and the fuel and life cycle costs entailed. Energy efficiency also has significant positive collateral impacts including a reduction of waste and pollution, reduced carbon emissions (directly or indirectly), the stimulation of new technology creation and applications and longer life cycles in particular for electric applicances.

Recommendations

Power Trading. A number of institutions are addressing power trading in the context of the Greater Mekong Subregion (GMS). In particular, a master plan for development of the ASEAN Power Grid has been agreed. The GMS consists of the five Lower Mekong nations and two of China's provinces (specifically Yunnan Province and Guangxi Zhuang Autonomous Region). In this context, power trading refers to large scale trades from surplus providers to markets where power demand exceeds local supplies. The alternative renewable power sources that are the main focus of this report would be a part of a distributed network of autonomous mini grids, at least for a while. As such, there could be instances where excess power from an individual supplier could be produced that could be fed back into a mini grid similar to how this occurs in the regional and national grids in Europe and the United States for example. While this is not the same as power trading, it does require some of the same regulatory and institutional capacity building activities as well as smart grid technologies. USAID could bring a comparative advantage of experience to these requirements or support initiatives being undertaken by other donors. This includes the developed countries' long experience with private power suppliers feeding excess power into the grid. The regulatory aspects of this experience, including standards, pricing and the technical aspects of integrating numerous small providers into a regional utility's grid would be very important.

Clean Energy Finance. The USAID Regional Development Mission for Asia (USAID/RDMA) expects to support clean energy financing in the LMS region through the Private Financial Advisory Network-Asia (PFAN-Asia) program. The ADB's Clean Energy Financing Partnership Facility's (CEFPF) also helps to finance clean energy projects in concert with participating countries throughout Asia. This report recommends that PFAN remain the primary USAID vehicle for supporting clean energy finance. However there is also considerable scope for supporting the development of clean energy service companies (ESCOs) that could develop small clean energy projects, especially in rural areas for special funds such as those set up in Lao PDR and Cambodia for that purpose. Specifically, USAID could provide business development training for ESCOs on the one hand and work with the Funds to develop project appraisal, due diligence, and transparency measures, where required and support monitoring and evaluation of the Funds' performance.

LMS Databases on Clean Energy. It is clear that there is a serious lack of data on clean energy resources and related infrastructure that is needed for planning, modelling, risk analysis and investment for clean energy in the region. This is undoubtedly a significant limiting factor for clean energy development in the LMS at least in the near term. The inadequacy and lack of reliability of data is worst in the three poorest LMS countries. This report recommends several possible activities to address this issue. First, more comprehensive and detailed data on the national and sub-national potential for specific clean energy development is imperative. This includes wind maps, solar insolation estimates, and micro and mini hydropower potentials. Second, data are needed to estimate the kinds of infrastructure needed to support a large-scale clean energy network, including mini- and micro grids. Third, assessing the internal (financial) and external (economic) costs of deploying clean energy on a large scale would help both policy makers and investors. Hence, organizing more complete supply side assessments and preferably putting this on a publicly accessible GIS are possible direction for future development assistance. On the demand side, there is a great latent demand in those populations and businesses without electricity service or serviced only through autogeneration. It would be useful to develop field studies to assess the potential amount of fossil fuel costs that could be saved through development of clean energy sources in off-grid areas.

Assistance across the Renewable Energy Subsector. Investment in clean energy is critical to develop an environmentally sustainable energy system for the LMS. USAID should work with governing entities to enhance enabling environments for renewable energy through assistance with LMS-specific applied technology research, GIS, risk-based, cost-benefit analyses, and modeling of potential development trajectories (country-specific and subregional) that illustrate the impacts of depending on large hydropower versus those that integrate solar PV, wind, small hydro and improvements to existing energy infrastructure to maximize efficiency. The goal of this research and capacity building work should be to highlight the long-term benefits of renewable energy projects despite the relatively high up-front costs. Assistance with the establishment of strong standards for environmental and social impact assessments and risk analyses can be a direct result of this work and will contribute greatly to ensuring a clean energy future for the region. Furthermore, USAID could potentially assist the government in establishing strategic public-private partnerships to these ends. This work can also highlight the importance of removing harmful energy subsidies, especially of fossil fuels and provide assistance with public consultation and awareness campaigns as well as a gradual plan for transition from them.

Currently, with the partial exception of Thailand, foreign investors in renewable energy technologies (RETs) are partly deterred by the inadequate and uncertain regulatory environment. Institutional capacity building and technical support will also be key to establishing enabling environments for foreign investment, which can provide long-term finance for a transition to new clean energy technologies, and offer price stabilization through market competition. USAID could also focus efforts on support to regional institutions that can provide and enhance cross-border activities. The above-mentioned PFAN-Asia, which USAID supports is one example in which clean energy and energy efficiency investments can find investers. Also, continuing to promote harmonization of energy standards and labeling and benchmarking clean energy and smart grid practices and performance. Continued support for the Asia Clean Energy Forum as an important knowledge exchange vehicle is a very cost effective way of building or supporting regional and broader international partnerships.

For both solar and small hydro, support for national and sub-national non-governmental organziations (NGOs) working to support rural mini- anmd micro grids may be a particularly useful investment of resources, especially for those countries with relatively weak energy/environment NGOs. In particular, USAID could usefully fund partnerships between technically experienced NGOs in countries like Thailand (or international/regional NGOs) and those in Lao PDR, Cambodia or Burma that could benefit from this experience and peer-to-peer learning opportunities. For example, the Renewable Energy Association of Myanmar (REAM) is eager to partner with donors and other developed NGOs to help bring more electric power through renewable energy to the vast rural population largely unserviced by electricity in Burma. It is planning an initial workshop with the Global Environmental Institute of China (GEI-China) but would like to do much more[3].

Clean Energy Electrification Strategy. Given the extent of the population that is rural and poor, a sensible electrification strategy, not only for Burma but also for the other mainly rural and relatively poor LMS countries, will focus on developing a dispersed, village-based system of micro grids, which can be gradually upgraded and interconnected over time. These micro grids will provide productive social and economic services, which in turn will finance further electrification investments. One proposal would use the solar power supply for remote cellular phone towers as the base for supplying additional solar PV power to immediate surrounding communities[4]. This is discussed further in the last section of this report. USAID could support the development of local/national energy service companies (ESCOs), which, combined with a dedicated low cost loan facility to support village-level investments, would be a key element to supporting a renewable energy-based rural electrification strategy. Practically speaking, loans would need to be bundled since individual village projects would likely be far too small to justify the required Fund transaction costs. This, in turn, will also require rigorous training and development of the ESCOs that would support these village projects.

LMS countries aiming to address rural energy poverty in the near-term, including Burma, Cambodia and Lao PDR can also benefit from a USAID-facilitated exchange with Lao PDR on best practices for rural electrification. That is, to focus on off-grid renewable energy solutions in the short-term. Continued efforts on this approach can include technical support for building upon existing infrastructure (such as converting to hybrid systems or connecting or scaling up mini-grids as described above).

In support of the Burmese government's target of 7.7% average annual GDP growth (which could triple current GDP by 2030, reaching US$2,000-3,000 per capita)[5], a study backed by the World Economic Forum, ADB, and Accenture in 2013 identified urgent short-term needs for Burma:

1. Creation of a governance structure to underpin long-term development with appropriate energy sector reforms and a roadmap for implementing these.
2. Provision of clean energy to supply rural communities with essential goods and services (and thus jump start the rural economy through industry, commerce, improved agricultural value chains and energy efficiency).
3. Construction of new sources of generation, transmission and distribution networks, and large-scale infrastructure to improve power supply in metropolitan areas are identified as

[3] The Irrawady (online newsmagazine) "China Environmental NGO Aims to Boost Burma's Renewable Energy Technologies" Sept. 5, 2013.
[4] Mintzer, Financing Private Sector-Led Off-Grid Electrification (Adobe Connect webinar presentation)
[5] World Economic Forum, ADB, Accenture. 2013. New Energy Architecture: Myanmar.

priority actions. For rural areas, these are small-scale hybrid renewable systems and off-grid renewable systems.

4. Development of a diversified energy sector that supports Burma's long-term growth.

While these recommendations are meant specifically for Burma, each of them could be applied to the Lao PDR and Cambodia as well.

In add ition to clean energy subsector-wide recommendations and recommendations on the enabling environment, this report proposes a number of resource-specific assistance recommendations.

Large Hydro. Research on large dams in the LMS is being addressed by the MRC, donors such as the ADB and by some of the LMS countries themselves. The most important recommendation for USAID is to focus on supporting studies on the impacts of large dams on the environment and populations in the three poorest but hydropower rich countries. In addition, supporting efforts at public education, awareness and communications on large dam impacts and a refocus on domestic power supply through clean energy alternatives should be priorities.

Small Hydro. The three scales of small hydropower: mini (100 kW to 10 MW of installed capacity), micro (10 kW – 100 kW of installed capacity), and pico (less than 5 kW installed capacity) offer very good potential in the LMS countries. In order to estimate the potential for installed small scale hydro, detailed field surveys and seasonal river/water flow mapping is required to determine potentially feasible locations. USAID support to LMS countries in the form of technical assistance and training, where needed, to assess data flows and locations of perennial streams and other fresh water bodies in relation to settlements would be of great assistance, especially for the three poorest LMS countries. This could also be a useful regional GIS project if additional data layers for demography, infratsructure and economic indicators are included. For the three poor LMS countries, engaging their governments to promote small hydro with appropriate policy incentives and institutional arrangements would be a worthwhile form of assistance, especially where it can then provide a path for facilitating public-private partnerships for rural village mini-grids. This could take the form of a policy reform project to address technical and human resource needs for developing the small hydro sub-sector.

Solar PV and Wind. Opportunities for USAID investment in activities in Solar PV and wind are similar to those for deploying renewable energy technologies, in general, as discussed earlier. Resource specific needs include more comprehensive and accurate wind maps by locality and season, solar insolation estimates by district and sub-district and the development of GIS data layers for these estimates to be compared with demographic, economic and physical infrastructure data layers for planning and investment purposes.

For specific USAID projects, e.g., food security, health, education, water supply, there may be opportunities to demonstrate solar PV and wind energy potential, especially in rural unserviced areas to give government and non-government counterparts a sense of the real potential for these RETs. Investment in public-private partnerships to stimulate domestic manufacturing of RET equipment, especially wind and solar PV is also a potential promising area.

Geothermal. The United States is the world leader in the development of geothermal energy comprising nearly a third of global geothermal power output. Where there is a need, USAID could provide information to the Burmese and Vietnamese governments on available sources of expertise on geothermal energy development in the U.S. private and public sector.

Energy Efficiency. As mentioned previously, energy efficiency is critical to a clean energy network as more efficient generation and end-use reduce overall energy demand and waste. Energy-efficiency measures rank high since they require considerably less investment to achieve the same amount of energy savings as would investment in supply options such as wind or solar PV, for example.

The fact that many of the same obstacles to energy efficiency are present across the LMS offers considerable scope for sub-regional collaboration and sharing of experiences. Especially for the LMS's large urban centers, USAID support for development of smart grids may be the key to turning the challenges of rapid urbanization and rising energy demand into opportunities to exploit the potential of renewables for distributed power generation, hand-in-hand with demand side management by enhancing system reliability. Sharing US experience with smart grid technology and demand side management practices will be especially valuable in this endeavour.

Because energy efficiency improvements require large scale policy reforms and institutional changes, USAID can work on a regional level to facilitate knowledge sharing and regional dialogues to achieve these goals in the LMS. Providing support and guidance in the establishment of energy efficiency regulations and/or standards will also likely be easier if done on a regional level and can help ensure that some LMS countries are not put at a competitive disadvantage, which could result in the rejection of new standards. For the demand side, regional standards can be combined with labelling regulations for appliances and implemented in tandem with regional awareness-raising campaigns. Targeting economies of scale will make more efficient new technologies such as LED light bulbs more easily accessible, and public service campaigns are likely to make adoption faster.

To support regional dialogue and advancement in policy reform and implementation around energy efficiency, USAID can fund research that provides an in-depth analysis of existing energy subsidies across the region, including expert recommendations for timeframes and strategies to build back true cost-recovery pricing, followed by a regional workshop to develop and facilitate a regional action plan and targets for implementing these recommendations.

Regional dialogues can also focus on promotion of competitive energy markets, with appropriate regulation (and plan for periodic adjustments), and deliver further technical support to LMS countries for improving technology standards, building codes, spatial planning, regulatory enforcement, public awareness and education, and socio-economic incentives.

At the national level, as mentioned previously, the establishment of and/or support to energy service companies (ESCOs) can also enhance and promote energy efficiency implementation through building capacity to conduct energy audits and develop and implement energy-saving measures in response to the audits; retrofit existing equipment and infrastructure; capacity building/ trainings to end-users and utility employees; monitoring and evaluation (M&E) for impacts of energy efficiency measures, and to identify and access funding for these activities.

USAID can also seek out and establish partnerships with NGOs and/or multilateral actors in the region that are also working on energy efficiency promotion to support country-based implementation of the LMS energy efficiency plan. For example, the Enlighten Initiative is a U.S. Environment Programme (UNEP) program with Global Environment Facility (GEF) funding that aims to accelerate "a global market transformation to environmentally sustainable, energy-efficient lighting technologies… [It] promotes an integrated policy approach to ensure that all pertinent aspects are considered as each developing country creates its National Efficient Lighting Strategy. Elements include: minimum energy performance standards; supporting policies; monitoring, verification, and enforcement; and environmentally sound management."[6]

[6] ADB. June 2013. Same Energy, More Power: Accelerating Energy Efficiency in Asia.

1. Introduction and Background on Power Demand and Supply in the Lower Mekong Subregion

The Mekong River Basin is a critical resource that provides more than 60 million people in the region with food, water, and transportation. Countries in the region want and need to develop their economies and the power requirements associated with sustained economic development, but many have not developed the institutions and procedures to assess the long-term impacts of near-term infrastructure development decisions. The resources of the Mekong River Basin will be irreparably jeopardized if near-term power generation projects are not well planned and carefully coordinated. This unplanned development will leave communities, endangered species, and fragile environmental balances exposed to very serious risks.

This study to assess the potential for clean energy development in the Lower Mekong Subregion is aimed at assisting USAID in examining to what extent renewable technologies and energy efficiency can address the growing energy demand in the LMS, and what specific activities and investments can be made to help LMS countries develop a more balanced and sustainable power infrastructure. This report explores the prospects are for subregional and even local power grids using local, renewable energy sources, and what kinds of assistance programs would best serve the interest of promoting the use of renewable energy resources while minimizing any potentially negative and long-term social and environmental impacts on the region. Much of the literature supporting this report is based on the GMS, which is the established regional energy planning unit rather than the LMS (see map). However, whenever possible this report disaggregates data to focus specifically on the LMS countries.

1.1 The Lower Mekong Initiative

Recently, the United States committed $50 million over three years to various activities under the multi-year "Lower Mekong Initiative 2020" (LMI 2020), as part of a new integrated regional platform for engaging bilateral and transnational issues called the Asia Pacific Strategic Engagement Initiative (APSEI). The LMI is part of a broader US strategy that involves encouraging the Lower Mekong Subregion (LMS) countries—Cambodia, Lao PDR, Burma, Thailand, and Vietnam— to deepen levels of cooperation and capacity building. The Lower Mekong Subregion (LMS) is itself a subset of the Greater Mekong Subregion (GMS), which includes all of the countries above as well as Yunnan and Guanxi provinces of China.

The LMI is supported by the United States, the Association of Southeast Asian Nations (ASEAN), and other partners that can provide technology, expertise, and financial resources to the Initiative's programs. Former US Secretary of State Hillary Clinton first unveiled the LMI in 2009. The LMI serves as a platform to address complex, transnational development and policy challenges in the subregion and is oriented around six transboundary pillars: Agriculture and Food Security, Connectivity, Education, Energy Security, Environment and Water, and Health and addresses cross-cutting areas such as gender. This report is relevant to two of those pillars: Environment and Water and Energy Security.

Figure 1. Map of the Lower Mekong Basin

1.2. Purpose and Structure of the Report

This report is a desktop study meant to summarize the available literature on the status of renewable energy technology and specifically their use for electric power generation. The rationale for the study is the need to provide a broader base for energy supply than the Lower Mekong Subregion's current primary reliance on large hydropower or conventional fossil fuels. The report is intended to provide information about the status and context of renewable energy development in the LMS and provide recommendations for USAID as it develops a program to support clean energy development and green growth in the region. There is the immediate concern of the potential environmental and social impacts of large hydroelectric dams as well as a concern of how the dams will affect the LMS countries' ability to adapt to climate change. Water may become a limiting resource and any impacts on ecosystems may decrease the resilience of countries to climate change.

The report begins with short contextual overviews that summarize key information that is relevant to the context of power generation and trade within the LMS. Additional detail on these contextual elements is provided in Annexes to this report. First, the report provides an overview of electric power demand and supply trends in the LMS region, followed by an overview of regional power grid development and power trading. These overview sections are followed by a discussion of renewable energy technology development in the LMS with particular attention to its use in supplying electricity. The report then presents a deeper discussion on different types of renewable energy technology options, including the background and identified generation potential for each within the LMS, a discussion on opportunities and challenges, and actionable recommendations for USAID intervention as well as support for promoting these energy technologies. Finally, the report discusses a strategy for promoting a distributed renewable energy-based electric grid in the region – one focused especially on empowering the rural, unserviced populations that large hydropower projects have not addressed. Throughout the report, recommendations for potential USAID regional activities are provided.

1.3 Trends in Electricity Demand Growth in the Lower Mekong Subregion

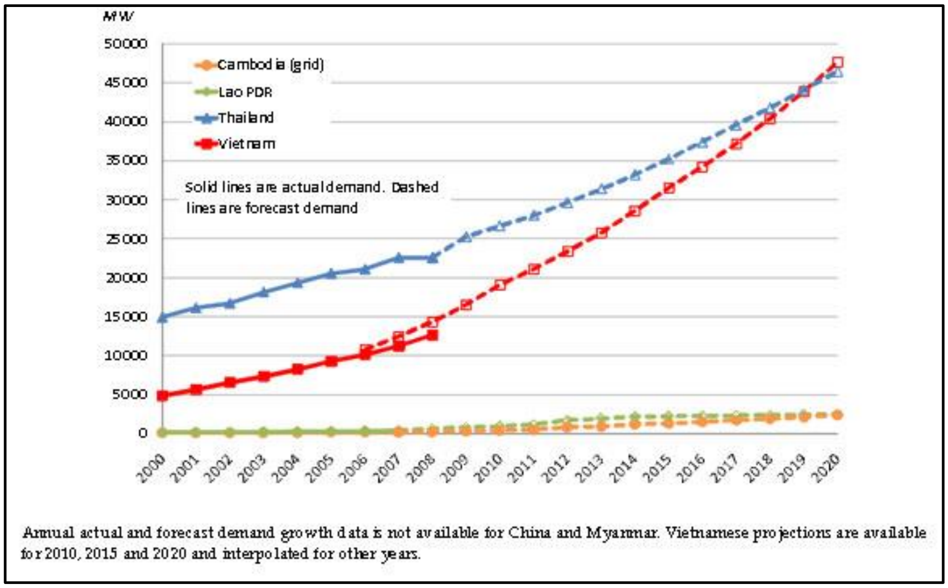
Power consumption per capita and growth rates for power demand vary considerably in the LMS. One study found that electricity consumption in the Greater Mekong Subregion (GMS) between 1990 and 2006 grew slightly faster than the growth rate of electricity production, which was 9.8% per annum for that period. Average per capita consumption of electricity in the GMS was 934 kilowatt-hours in 2006, with Thailand the highest 2,105 kilowatt-hours per capita and Cambodia, the lowest at 55 kilowatt-hours per capita, a remarkable 38-fold difference, mostly due to the vastly larger commercial and industrial sectors in Thailand as well as the difference in population sizes.[7]

Figure 2 presents a graphic view of current and projected power demand in most of the LMS. The dramatic contrast between the more developed and more highly populated countries like Thailand and Vietnam and the smaller economies of Lao PDR and Cambodia can clearly be seen. The projections out to 2020 for Cambodia and Lao PDR presumably also do not take into account the assumed high latent demand for power, which cannot be met for lack of an adequate rural power infrastructure or they assume that this infrastructure will expand only very slowly until 2020.

Increasing urbanization and economic development will increase electricity demand. However, urbanization also provides opportunities for energy efficiency improvements per capita both because of the density of populations and more efficient power infrastructure and appliances.

Figure 2 Annual Power Demand Growth in Selected LMS Countries from 2000 - 2020

[7] Energy Sector Integration for Low Carbon Development in Greater Mekong Sub-region (2010), p.2



Source: The Potential of Regional Power Integration (2010), p.12.

1.4 Existing Power Trading Patterns within the Lower Mekong Sub-region

Across Southeast Asia, country energy resource differences are quite significant and thus necessitate utilizing power resources not situated just in the country itself, but in neighbouring countries as well. This is a tremendous challenge as it requires power exchanges, institutional relationship building and coordination of all involved stakeholders to be able to take advantage of win-win opportunities. The ASEAN Power Grid (APG)[8] takes advantage of the fact that there are countries with large amounts of exploitable hydropower potential. Lao PDR, for example, is not well-developed economically and so domestic energy demand is relatively low but the country has very large potential hydropower resources.

For Lao PDR and other LMS countries like Burma and Cambodia, this supply-demand imbalance presents a major opportunity to generate income by exporting the excess capacity to supply electricity. The purchasing country benefits from relatively cheaper power purchases that can be locked in for years. To leverage this scheme, what is required is to: (1) ensure a more secure power supply infrastructure; (2) improve relationship management and bridge building between importing and exporting countries; and (3) harmonize technical standards and legal energy transport agreements (fees, contracts, etc.) for the stakeholders involved, especially governments. Only three APG interconnections have been established to date although 12 (in total) before 2015 and more still by 2025 are planned.[9] For example, Thailand has taken advantage of excess hydropower generation capacity in Lao PDR to trade electricity.[10] Thus, private, cross-border power

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[8] Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Burma, Philippines, Singapore, Thailand, Vietnam

[9] IEA (2009b) and Renewables in Southeast Asia (Trends and potentials), 2010, p.25

[10] "Power Purchase from Lao PDR: The Government of Thailand and the Government of Lao PDR have signed a number of Memoranda of Understanding (MOUs) to promote collaboration in power project development in Lao PDR as followings: 4 June 1993 to import power up to 1,500 MW; 19 June 1996 to extend import capacity to 3,000 MW; 18 December 2006 to extend import capacity to 5,000 MW; 22 December 2007 to extend import capacity to 7,000 MW. Currently, there are 2 commissioned projects namely Theun Hinboun (214 MW)

trading remains a major driver in the investment in large hydropower. A more extensive discussion of power trading patterns in the broader GMS (including LMS countries) can be found in Annex II.

1.5 Recommendations

As noted, a number of institutions are addressing power trading in the context of the GMS master plan for power trading development in the ASEAN Power Grid (APG). The APG's road map has been supported by various donors over the years, especially the European Union (EU) and Japan. Other donors include Germany, which has a long-term project to improve the preconditions for sustainable utilization of mini-hydropower (MHP) sources in Cambodia, Lao PDR and Vietnam. [11]

USAID expressed an interest in forging collaborative partnerships with ASEAN through ACE to pursue some programs in the areas of:

- Efficient Window Technology – A workshop and follow-on activities to promote energy efficiency;
- Efficient Cook Stoves – A program to develop and introduce more efficient cooking technology in ASEAN; and
- Conference on Clean/Sustainable/Alternative Sources of Energy and Technologies for ASEAN–Tied to the Ministerial meeting or some other event. [12] It is not clear if these activities have been implemented or not.

RDMA already supports the LMS clean energy financial market through the Private Financial Advisory Network-Asia (PFAN-Asia) Program. ADB's Clean Energy Financing Partnership Facility's (CEFPF) also helps to finance clean energy projects in concert with participating countries in Asia. Although PFAN's clean energy projects are in the $1 million to $50 million range, they can have a catalytic effect on stimulating further or follow on investment and this report recommends that PFAN remain a USAID vehicle for supporting clean energy finance. In addition, as discussed in Section 3, there may also be considerable scope for supporting the development of clean energy ESCOs that could develop small clean energy projects, especially in rural areas for special funds such as those set up in Lao PDR and Cambodia. Specifically, USAID could provide business development training for ESCOs on the one hand and work with Funds to develop project appraisal, due diligence and transparency measures, where required and support monitoring and evaluation of the Funds' performance. In the current LMI Plan of Action, the U.S. in fact, has proposed assisting the LMI countries in the development of ESCOs.[13]

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and Houay Ho (126 MW), and 3 PPA signed projects which are under construction, Nam Theun 2 (920 MW), Nam Ngum 2 (597 MW) and Theun Hinboun - Extension Phase (220MW). Besides, there are 2 Tariff MOU signed projects; Hong Sa (1,473 MW) and Nam Ngum 3 (440 MW)." - in: Summary of Thailand Power Development Plan 2010-2030, Electricity Generating Authority of Thailand, System Planning Division, April 2010,

[11] ASEAN Center for Energy, 2012, ASEAN Plan of Action for Energy Cooperation 2010 – 2015, p.28

[12] Ibid. p. 29.

[13] http://lowermekong.org/about/lmi-plan-action/energy-security-pillar

2. The Potential for Renewable Energy/Clean Growth in the Lower Mekong Subregion

In general, available secondary source data on energy supply and demand in Southeast Asia is very uneven, particularly for the Mekong region. The best data overall are for the largest economies, known as the ASEAN-6, which are Indonesia, Thailand, Malaysia, Philippines, Singapore, and Vietnam. Of these, only Thailand and Vietnam are LMS nations. Data for Cambodia, Lao PDR, and Burma tend to be incomplete and sometimes unreliable. This report addresses this issue in the recommendations, as there is potential for USAID to contribute to improving data integrity, availability, and use. While the focus of this section is on identifying renewable energy potential for different technologies and approaches in LMS countries, a more detailed overview of the identified renewable energy potential and development patterns for the broader ASEAN-6 region is presented in Annex I. As is discussed later in the report, while the resource potential for renewables is significant, there is considerable uncertainty about the investment climate owing to problems with policy and institutional weakness, weak or non-existent national grids, power purchasing and other transfer mechanisms and competing interests vested in the status quo.

2.1 Deploying Renewables in the Lower Mekong Basin

Renewable energy technologies (RETs) currently contribute only modestly to the electricity supply in the Mekong region, with the exception of medium and large-scale hydropower; they consist mainly of small-scale solar, wind and micro/mini hydropower installations with a few larger turn-key projects. One of the latter, ironically, the 84MW Lop Buri solar plant in Thailand (seen on the front cover of this report), is the largest thin film solar power installation in the world (there are several concentrating solar installations that have considerably larger installed capacity). The LMS has, however, considerable potential for renewables using both relatively mature technologies (such as mini hydro, wind and solar photovoltaic) and emerging technologies (such as solar thermal and tidal power). Both Vietnam and Thailand have harnessed less than 10% of the estimated renewable energy potential that could be realized by 2030[14]. All Southeast Asian countries are experiencing rapid economic development and therefore are confronting the need to meet a corresponding rapidly growing demand for power. New policies will be required which reflect the kind of critical and effective guidelines that are identified in *Deploying Renewables: Principles for Effective Policies* (IEA, 2008).

2.1.1 Modern Energy Access in the Mekong Basin Countries

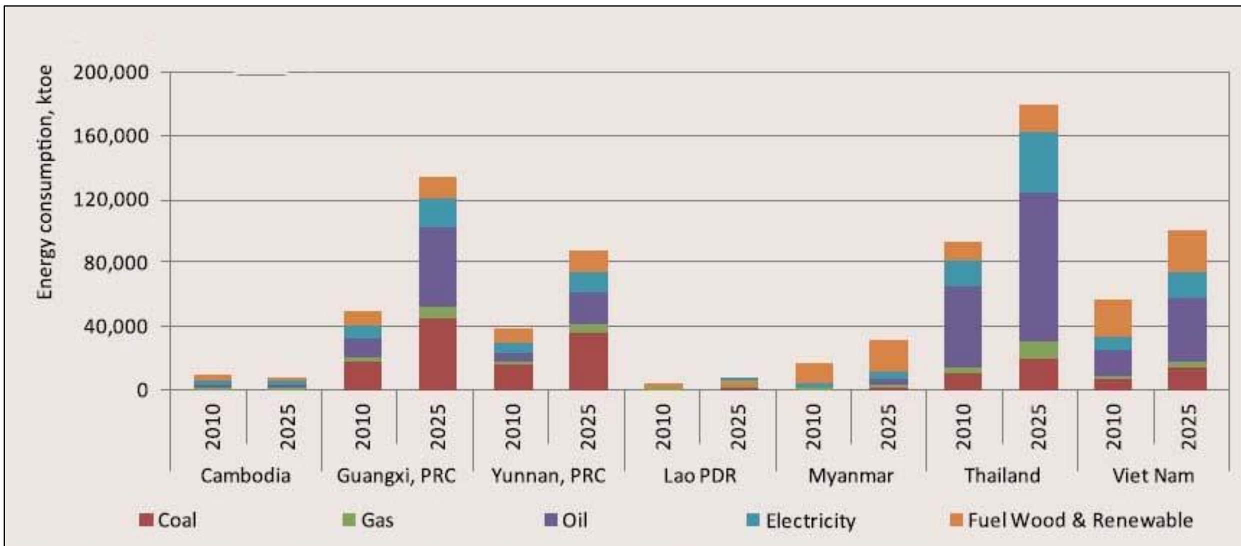
Energy access remains uneven across the LMS, with a high dependence in some countries on traditional energy sources, such as firewood and agricultural residues in rural areas. Rising energy demand without adequate access to commercial energy will add to already growing environmental pressures from unsustainable biomass use. The LMS also depends heavily on oil imports and significant increases in demand will aggravate already existing energy import concerns[15]. Indeed, a combination of environmental concerns, rising demand for power and fuel, and concerns over

[14] West, Potential for Increasing the Role of Renewables, http://mekong.waterandfood.org/archives/1397
[15] GMS Atlas of the Environment, p.187.

energy security have been some of the main drivers for exploiting the subregion's renewable energy potential, and, as we have noted, also some of the reasons for the creation of LMI in which energy security is one of the pillars.

Figure 3 demonstrates the vast difference in energy consumption between the more developed and populous LMS countries (Vietnam and Thailand) and the less developed populous ones (Burma, Cambodia and Lao PDR) and which, according to this ADB scenario will change hardly at all over the next 11 years. However, note that figure describes final energy consumption of which electric power is a subset. In addition, the table only includes commercial energy consumption whereas the three poorer countries depend heavily on traditional energy sources that are not generally measured or counted in energy consumption statistics. One of the key challenges for the LMS will be to ensure that modern energy supplies reach everyone, and electricity will be of particular importance. According to the ADB, one quarter of the GMS population (about 74 million people), currently lacks access to electricity. Although it is not clear how many of these are in Yunnan and Guanxi provinces in China, the problem is particularly acute in Cambodia and Burma, where only about a quarter of the population has access to electricity. These countries, along with the Lao PDR and Vietnam, are aiming to achieve 100% electrification by 2020. But this goal will require a significant expansion in power supply capacity[16].

Figure 3. Total Final Energy Consumption in the GMS, 2010 and Projected in 2025.



GMS = Greater Mekong Subregion, ktoe = thousand ton of oil equivalent, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.
Source: Gadde, B., K. Ganesan, and P.J. Tharakan. 2012. Status of Energy Use, Power Sector Expansion Plans and Related Policies in the GMS: Challenges and Opportunities. In H. Moinuddin and J. Maclean, eds. 2012. *International Conference on GMS 2020: Balancing Economic Growth and Environmental Sustainability. Focusing on Food - Water - Energy Nexus.* Manila: ADB.

Source: GMS Atlas of the Environment, p.185

[16] GMS Atlas of the Environment, p.187

In addition to the need for more power, dependence on traditional energy sources for process heat, especially cooking is high, particularly in rural areas: 83% of households in Cambodia, 80% in the Lao PDR, and more than 50% in Vietnam use firewood and other traditional energy sources for cooking. In addition to health problems from poor indoor air quality caused by the use of biomass, continued reliance on biomass will worsen existing local energy vulnerability as well as threaten the region's forests and biodiversity.

Many energy studies focus on renewable energy technologies (RETs) for heating, power and transport, specifically on how to overcome both economic and non-economic limiting factors, by introducing policy guidelines to motivate efficient future development of the renewable energy segment and to ensure sustainable growth in that industry in Southeast Asia and the Lower Mekong Basin, in particular. A key challenge for the whole region is the fact that energy production itself is a major economic sector in the region. In addition, renewable energy alternatives (especially biofuels) often have competing uses, e.g. palm oil and their environmental sustainability implications warrant special attention[17].

As noted, available statistics for this desktop study on primary energy supply were mainly only available for the ASEAN-6 countries. These showed a predictable pattern: fossil fuels accounted for 74%; combustible biomass and waste 22% (mostly traditional biomass technologies that are inefficient and environmentally unsustainable under current practices); geothermal at 3%; and hydropower at 1%. In terms of overall electricity generation, renewables (mostly hydro and some geothermal) accounted for 15% of electricity generation in the ASEAN-6 (12% from hydropower and 3% from geothermal)[18].

2.1.2 Prospects for Renewable Energy Development in the Lower Mekong Subregion

The opportunity to expand the usage of renewable process heat energy is based on the warm climate in South East Asia and the availability of relatively fast-growing biomass. As heat is necessary for various industrial procedures, Thailand and Vietnam have some experience using biomass in combined heat and power plants.[19] However, aside from using municipal waste to generate power, higher value uses for biomass are likely to outcompete their use for power quite aside from the carbon emissions that would be generated.

Ethanol and biodiesel production programs for transport fuels are found in a number of ASEAN countries and are expected to grow further due to specific regional factors. These include transport fuel mixing mandates from governments, price subsidies and investment incentives. Growth, however, also could be constrained by environmental and climate concerns from widespread conversion of forests to biofuel crops and the food vs. food competition. Of the LMS countries, only Thailand has a biofuels program.[20] Biofuel stakeholders and global innovations have increased the need for policy change to leverage sustainability, so that some of the countries can start research on second-generation biofuels.[21] The poor air quality in many Southeast Asian cities and other

[17] s. ibid
[18] s. ibid
[19] s. ibid
[20] AIT, Biofuels in the ASEAN, Low Emission Development Strategies (LEDS) Forum, Bangkok, Thailand, 19-21 September 2012
[21] Deploying Renewables in Southeast Asia (Trends and potentials)

environmental impacts from fossil fuel usage will be another major reason to push forward the deployment of renewable energy.

The potential growth calculations for individual RETs have to take into consideration overall energy system constraints (i.e., lacking robust data sets on relative costs of individual technologies in the country economic context and access to a least-cost technology mix comparison). The core issue preventing expansion of RETs is not so much a factor of resource availability as it is a problem of cost competition from conventional energy technology alternatives, which have well-developed supply chains, supporting infrastructure and portability (see World Energy Outlook 2009). But conventional energy's advantages, especially for fossil fuels have to be set against their "external costs" (e.g., health, pollution, climate change). Moreover, these costs have not been internalized in the market price of these fuels thus keeping their actual costs artificially low (even before government subsidies). RETs, by contrast have few or none of the above external costs. Hence, the 'non-economic' barriers (infrastructure, regulatory barriers, etc.) may pose a much bigger challenge, at least in the short and medium term to widespread adoption of RETs than the direct, financial costs, which have, for the most part been decreasing, especially over the last decade.

Analysing the primary data and comparing these over the various countries shows that individual country circumstances, e.g., living standards, demography, social, and other non-economic factors vary considerably. The relative strength of these country-specific constraints can make RET implementation more or less expensive than traditional energy technologies.

2.2 The Policy and Institutional Environment for Renewable Energy Development

2.2.1 Policy Environment for Investment in Renewable Energy in the Region

On the whole, the realizable potentials for RETs are clearly significant. There is a reasonable capacity in the LMS countries for reaching even higher rates of renewable energy investment than are currently planned. But this will only happen if governments are able to develop adequate policy frameworks that allow RETs to get established and become cost competitive. Particularly for the poorer LMS countries such as Lao PDR, Burma, and Cambodia, policy and institutional frameworks are currently far from adequate.

One of the most critical variables in the development of power markets generally and renewable energy technologies in particular is the balance between power sector liberalization and regulation. The worldwide experience in the 1980s and 1990s with power liberalization, including unbundling and fostering new, competitive market actors did increase efficiencies and increase power generation capacity often at lower prices, in many instances. However, liberalization has done little to further public goals in terms of environmental sustainability, increased transparency, reduced carbon emissions or access to reliable power by the poor, especially the rural poor in developing countries.[22] Where liberalization of energy markets has worked is where the national government (or subnational governments depending upon the country's governance structure has maintained a strong, proactive regulatory presence, especially to achieve progress in the kind of socio-political

[22] Jung-Min Yu, The Restoration of a Local Energy Regime Amid Trends of Power Liberalization in East Asia, pp. 127-129.

objectives described above. In some cases, measures such as feed-in tariffs and higher than market clearing prices for certain generating technologies have been successfully used. Other important 'ingredients' are changing the business enabling environment and structuring incentives to attract investors to finance renewable energy in those countries, which, until now, have not always faced a positive environment for long-term investments.

Evidence of a more proactive governmental presence in power markets is beginning to emerge. Cambodia, for instance, has instituted a dedicated Rural Electrification Fund through which private rural energy supply companies can expect to receive a quarter of the investment requirement in addition to support in securing private sector financing for off-grid use of RETs for rural power supply. Lao PDR is establishing a similar fund to support its off-grid household electrification program. Burma is promoting the use of liquefied petroleum gas (LPG) as a household fuel, aiming to achieve a 46% decrease in firewood dependence over the next three decades[23].

Most of the investment opportunities in mini hydro, which includes investments from 1 MW to 10 MW power (but not-including "micro-hydro" and "pico-hydro", are in Thailand and Vietnam, which have promoted their development through the Clean Development Mechanism[24]. Where a strong, implemented and reinforced policy framework for clean energy is lacking, the core driver of investment has been the revenue streams that can be generated by small hydro plants. This is not surprising since mechanical water power (e.g., grist mills and belt-driven water power machines) have been in productive use in many parts of the world for centuries.

2.2.2. Selected Donor Investment Trends in Renewable and Clean Energy Development

In 2012, the total of ADB clean energy investments, from the Southeast Asia department amounted to nearly $1.250 billion, not including large hydro investment projects. Southeast Asia includes ASEAN and not just the LMS countries.[25] These investments were mostly for energy efficiency and clean energy technologies (which includes natural gas). Meanwhile, the proportion of ADB's investments in large hydropower projects went down to 23%. This represents something of a policy shift for the bank and recognition of the powerful roles of the private sector in investment in large dams and the social and environmental impacts of large dams. However, it also represents the ADB's recognition of real opportunities for non-large dam renewable energy development. [26]

The largest investments (US$2.6 billion) from all sources in renewable energy production capacity for Southeast Asian countries overall were in biofuels, onshore wind power, geothermal, biomass/waste water generation,[27] and small hydro (2008). It should be noted that this aggregation of data on investments in renewable power generation assets does not distinguish between private and public sector financing[28]. In addition, development assistance has been provided by the World Bank Group, including for small hydropower below 10MW with investment levels recently reaching

[23] GMS Atlas of the Environment, p.188
[24] s. Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 80.
25 ADB, Clean Energy Investments: Project Summaries
[26] Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 92.
[27] Wastewater energy comes from human and organic waste (sewage, septage, food waste, restaurant grease, etc.) with biogenic carbon that can be converted to energy, as well as nitrogen and phosphorus nutrients that can be recovered.
[28] Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 94

US$1.4 billion worldwide.[29] A noticeably large increase in renewable energy technology deployment has come from investments in biofuels since the mid-2000s. Unfortunately, while some of this production is based on the use of waste, much of it is from the planting of oil palm, the production of which is then converted to biofuels. This has the perverse outcome of often leading to the conversion of high value conservation forest along with tremendous increases in carbon emissions from burning forests during the land conversion process, which also releases an unknown but estimated huge amount of soil carbon.

The result of this investment in biofuels also means that the relative proportion of hydropower in the total renewable energy mix has actually declined. Investment in geothermal also increased significantly but only in some countries. As discussed later in the report, geothermal energy is not a significant resource in the LMS. Still, despite progress this past decade, significant policy and institutional obstacles to achieving greater levels of investment in renewable energy for power exist, as discussed below.

2.2.3 Overcoming Barriers to Renewable Energy Operation

As Exhibit 2 indicates, each of the LMS nations has at least a national sustainable development or clean energy strategy and action plan and, in the case of Thailand, a much more developed policy framework for clean energy. A variety of tariff, tax and other investment incentives exist in the LMS to support investments in clean energy. However, the most developed incentive systems again are in the most relatively developed of the economies, i.e., Vietnam and Thailand. The three poorer LMS countries provide very few incentives by contrast.

Feed-in tariffs are the most common investment policy incentive, while tradable renewable energy certificates are the least common. The regional market for tradable certificates is largely undeveloped whereas feed-in tariffs are well within the legal framework of power licensing and most regulatory agencies – where these exist.

Exhibit 2. Policies in Place to Promote Renewable Energy since the Rio Conference of 1992

Thailand	**Small Power Purchase Agreements (1994); Very Small Power Purchase Agreements (2002); Strategic Plan for Renewable Energy Development (2004); Feed-in Tariff (2007 - Revised in 2009); Solar Thermal Subsidy Programme (2008); National Renewable Energies Development Plan 2008-2022 (2009)**
Vietnam	Renewable Energy Action Plan (1999); Decree on Electric Power Operation and Use (2001); Electricity Law (2004); Avoided Cost Tariff (ACT) Regulation (2008); Standardized Power Purchase Agreement for Small Renewable Energy Power Plants (2008); National Energy Development Strategy (2008); Renewable Energy Development Plan (2010); National Power Development Plan (2011)
Cambodia	Renewable Electricity Action Plan (2002); Rural Electrification by Renewable Energy Policy (2006); Signed the IRENA Statute (2009)
Lao PDR	National Strategy on Renewable Energy Launched (2011); Decree on Solar Energy Development (2011)

[29] ibid, p. 94, 95 and World Bank Group.

Burma	National Environment Policy (1994); National Sustainable Development Strategy (2009)

Source: IRENA Renewable Energy Country Profiles Asia report

Non-economic barriers are no less important than the obvious economic challenges to the spread of renewable energy technologies in the Lower Mekong Subregion countries (and elsewhere in Southeast Asia). These indirect hurdles include the policy environment, institutional capacity, education and awareness and socio-cultural factors. These non-economic constraints may be more difficult to measure as many, sometimes conflicting stakeholder interests are involved and country-specific political and institutional circumstances are often involved as well.

Some of the most important challenges are administrative obstacles, regional power market barriers (especially power trading as previously discussed), grid-related issues and complex cross-cultural differences. Non-economic limitations like non-transparent and sustainable government energy policies, combined with persisting administrative hurdles, require time to develop a consensus for real reforms, and, as a result of this delay, increase the indirect costs (for all involved parties) and may have significant negative short-term economic costs. For instance, if these kinds of issues affect an investment project from the beginning, the project will require a higher return on investment (ROI) to be financially attractive, thus making the overall project less attractive to project proponents[30]. The most challenging non-economic barriers (risks) for investors are: (1) legal security issues; (2) policy changes biased against renewables (even indirectly); (3) the financial support system; and (4) the desired rates of return on investments.

Many of the barriers identified for the ASEAN-6 countries are largely the same as those in the LMS as a whole (though they are much worse for Cambodia, Lao PDR, and Burma where governance is weak). A wide range of possible measures exist to help reduce these barriers, but to be effective these measures require coordination among all major stakeholders. Persistent non-economic barriers, such as government energy policies skewed against renewable energy technologies or heavy administrative requirements can ultimately result in high economic impacts. When such barriers affect early investment-intensive phases of the project cycle, it drives up the required return on investment and therefore the costs for deployment of the particular renewable energy technology."[31]

Thailand is probably the best example in the LMS of implementing a strategy to encourage clean energy growth through policy and institutional reforms. Between 2012 and 2030, Thailand expects to significantly expand installed capacity from all sources from the current 32,395 MW to nearly 71,000 MW. A significant part of this increase is intended to come from renewable energy and other unconventional sources as Exhibit 3 indicates.

Exhibit 3. Thailand's Planned Power Generation from All Energy Resources, 2012 – 2030, in MW

Installed Capacity	Amount (MW)
Total current capacity (as of Dec.2011)	32,395

[30] ibid, p. 99.
[31] ibid, p. 99

Total added capacity (by 2030)	55,130
Deduction of retired capacity (between 2012-2030)	-16,839
Grand Total Capacity	70,686
Classification of added capacity during 2012-2030 of 55,130 MW	
Renewable Energy Power Plants	14,580
- renewable power purchase from domestic producers	9,481MW
- renewable power purchase from neighboring countries	5,099 MW (almost certainly all large hydropower)
Cogeneration	6,476
Combined cycle power plants	25,451
Thermal power plants	8,623
- coal-fired power	4,40
- Nuclear power	2,000
- Gas turbine power	750
- Power purchase from neighboring countries	1,473

Source: Power Development Plan and Opportunities in Alternative Energy Sector in Thailand, 2012, p 7.

In addition to these additions to power supply, Thailand also expects to achieve significant energy savings from efficiency improvements. The nation's 20-year Energy Efficiency Development Plan (EEDP) has been designed with a target of reducing energy intensity by 25% in 2030, compared with that in 2005, which is the equivalent of a reduction in final energy consumption of 20% in 2030, or about 30,000 thousand tons of crude oil equivalent.32 The plan doesn't estimate total electricity generation savings as a result of the plan but does give partial examples. Hence, for small commercial buildings and residences electricity savings could amount to 23,219 GWh in 2030, which is quite significant. These savings are generated from improvements in lighting, water heating and air conditioning,[33]

The category of "Power Purchase from Neighbouring Countries" at the bottom of Exhibit 3 is estimated to amount to 5,668 MW over the planning period and includes Lao PDR, Burma, Cambodia and the People's Republic of China (note the Ministry of Energy source in the table above has a slightly lower amount of hydropower imports, which indicates that planning is still indicative at this point).

The Kingdom of Cambodia has not yet signed a MoU with Thailand's government for the sale of power across the border. However, private investors and developers are pushing ahead and have already begun selling electricity to Thailand under private power purchasing agreements as noted earlier.[34]

The Electricity Generating Authority of Thailand (EGAT) has been developing the capacity for renewable energy for power generation since 1978 and should be regarded as the leader in RET development in the entire LMS for power, fuel, and process heat purposes. At the beginning, the projects were primarily related to research and development (R&D) of generation system prototypes for all entities involved.

[32] Ministry of Energy, 2011, Thailand 20-Year Energy Efficiency Development Plan (2011 - 2030), p. 1.
[33] Ibid, p. 3-10.
[34] ibid.

After successful testing, the prototypes were integrated into public development investment decisions. To date, EGAT has several generating units based on renewable energy such as the Wind Turbine Power Plant at Lam Takhong, the Wind Turbine Power Plant at Promthep Alternative Energy Station, the Solar Power Plant at Pha Bong, the Solar Power Plant at Lop Buri (featured on this report's title page), and the Solar Power Plant at Sirindhorn dam. Furthermore, EGAT has been developing a number of small hydropower projects at existing dams of the Royal Irrigation Department (RID) since 2004 and has developed other small and mini hydropower plants unconnected with the RID. The main purpose of the projects is to maximize the utilization of water resource through hydropower generation. To pursue EGAT's renewable energy development and to respond to the policy of the Ministry of Energy, EGAT prepared its Renewable Energy Development Plan for Power Generation (Preliminary Plan), which considers four renewable resources suitable for EGAT, i.e., wind energy, solar energy, small hydropower at existing RID dams and biomass.

2.2.3 Recommendations

For USAID, the major areas of assistance for supporting clean and renewable energy technology development and investment will include: supporting policy reform, especially investment incentives (e.g., tariff reforms), transparency in planning and informed decision making, due diligence reforms and, in some cases, basic regulatory reforms; providing technical assistance and training to national and sub-national utilities and electricity regulatory bodies; planning and grid integration requirements and similar institutional development and capacity building for relevant energy regulatory agencies and others (e.g., sectoral agencies involved in infrastructure development, agriculture, industry, etc.).

Investment in clean energy is critical to develop an environmentally sustainable energy system for the LMS. USAID should work with governing entities to enhance enabling environments for renewable energy through assistance with LMS-specific applied technology research, GIS, risk-based, cost-benefit analyses, and modeling of potential development trajectories (country-specific and subregional) that illustrate the impacts of depending on large hydropower versus those that integrate solar PV, wind, and improvements to existing energy infrastructure to maximize efficiency. The goal of this research and capacity building work should be to document the long-term benefits and supply stability of renewable energy projects despite the relatively high up-front costs. Assistance with the establishment of strong standards for environmental and social impact assessments and risk analyses can be a direct result of this work and will contribute greatly to ensuring a clean energy future for the region. Furthermore, the Mekong Partnership for the Environment can assist the government in establishing strategic public-private partnerships to these ends. This work can also highlight the importance of removing harmful energy subsidies, and provide assistance with public consultation and a gradual plan for transition from them.

Currently, with the partial exception of Thailand, foreign investors in RETs are partly deterred by the inadequate and uncertain regulatory environment, as noted. Institutional capacity building and technical support will also be key to establishing stable enabling environments for foreign investment, which can provide long-term finance for a transition to new clean energy technologies, and offer price stabilization through market competition. USAID could also focus efforts on providing support to regional institutions that can provide and enhance cross-border support.

These include the Mekong River Commission, the ASEAN Power Grid, ASEAN itself and the U.N. Economic and Social Commission for Asia and the Pacific. For both solar and small hydro, providing capacity building assistance to national and sub-national NGOs that are working to support rural mini-grids may be a particularly useful investment of resources, especially for those countries with relatively weak support for energy/environment NGOs. In particular, USAID could usefully fund partnerships between technically experienced NGOs from countries like Thailand (or international/regional NGOs) and those in Lao PDR, Cambodia or Burma that could benefit from this experience and peer-to-peer learning opportunities. For example, the Renewable Energy Association of Myanmar (REAM) is eager to partner with donors and other developed NGOs to help bring more electric power through renewable energy to the vast rural population largely unserviced by electricity in Burma. It is planning an initial workshop with the Global Environmental Institute of China (GEI-China) but would like to do much more in this vein.[35]

Given the extent of the population that is rural and poor, a sensible electrification strategy, not only for Burma but also for the other mainly rural and relatively poor LMS countries, should focus on developing a dispersed, village-based system of microgrids, which can be gradually upgraded and interconnected over time. These microgrids will provide productive social and economic services, which in turn can help finance further electrification investments. For example, one proposal would use the solar power supply for remote cellular phone towers as the base for supplying additional solar PV power to immediate surrounding communities[36]. USAID could support the development of local/national energy service companies (ESCOs), which, combined with a dedicated low cost loan facility to support village-level investments, could be a key element to supporting a renewable energy-based rural electrification strategy. Practically speaking, loans would need to be bundled since individual village projects would be far too small to justify the required transaction costs for financing entties. This, in turn, will also require rigorous training and development of the ESCOs that would develop and support these village projects.

Countries aiming to address rural energy poverty in the near-term, Burma in particular, can also benefit from a USAID-facilitated exhange with Lao PDR on best practices for rural electrification. This would involve a focus on off-grid, renewable energy solutions in the short-term. Continued efforts on this approach can include technical support for building upon existing infrastructure (such as converting to hybrid systems or connecting or scaling up mini-grids as described above).

In support of the Burmese government's target of 7.7% average annual GDP growth (which could triple current GDP by 2030, reaching US$2,000-3,000 per capita)[37], a study backed by the World Economic Forum, ADB, and Accenture in 2013 identified urgent short-term needs for Burma:

1. Creation of a governance structure to underpin long-term development with appropriate energy sector reforms and a roadmap for implementing these;
2. Provision of energy to supply rural communities with essential goods and services (and thus jump start the rural economy through industry, commerce, improved agricultural value chains and energy efficiency);

[35] The Irrawaddy (online newsmagazine) "China Environmental NGO Aims to Boost Burma's Renewable Energy Technologies" Sept. 5, 2013.
[36] Mintzer, Financing Private Sector-Led Off-Grid Electrification (Adobe Connect webinar presentation)
[37] World Economic Forum, ADB, Accenture. 2013. New Energy Architecture: Myanmar.

3. Construction of new sources of generation, transmission and distribution networks, and large-scale infrastructure to improve power supply in metropolitan areas are identified as priority actions (for rural areas, these are small-scale hybrid renewable systems and off-grid renewable systems); and
4. Development of a diversified energy sector that supports Burma's long-term growth.

While these recommendations are meant specifically for Burma, many of them can be generalized to apply to the LMS as a whole.

In addition to the actions described above, USAID can address challenges that are posed by limited data availability, through funding direct field research on the local status of renewable energy technologies, including the opportunities and challenges presented within existing pilots and existing renewable energy infrastructure projects in the region. The ECO-Asia CDCP organized an assessment of regional energy trends, including RETs in 2011 (Energy Trends in Developing Asia), and identified specific policy, institutional and financial interventions that could contribute to creating enabling environments for solar PV, wind power, biomass, and energy efficiency. An immediate and key next step for developing a strategy for further supporting the potential of solar PV and wind resources in the LMS will be to organize an assessment that builds on and updates the one carried out in 2011.

In addition, funding research and activities to develop GIS-based tools that help visualize landscapes to promote informed decision-making in energy development planning (such as wind maps) will be an excellent contribution for USAID to make toward promoting renewable energy technologies in the LMS. USAID currently is helping to support the implementation of the Geospatial Toolkit (GsT), which is a map viewer developed by the U.S. National Renewable Energy Laboratory (NREL). The toolkit helps energy planners, project developers, researchers and others identify areas of a country that show good potential for renewable energy projects. At this time, geo-referenced data layers are avialable for Thailand, Vietnam and Cambodia in the LMS.[38] Continued support to add Burma and Lao PDR is recommended as well as ensuring the the GsT database is integrated with other GIS data layers (demography, infarstructuire, economic facilities, etc.).

Through capacity building of government officials and other key stakeholders, USAID can transfer technical expertise in the development and use of GIS mapping technologies. Trainings on how to use these maps to model infrastructure scenarios (that is, the potential environmental and other local impacts that would be caused by implementing different energy projects under consideration) would result in informed (and thereby improved) decision-making at the government level. These technical trainings can be built upon as needed depending on participant capacity levels and needs moving forward, such as to model and plan how microgrids will be scaled up and/or connected to local or regional grids, for instance.

[38] See: http://www.nrel.gov/international/geospatial_toolkits.html

2.3 Issues Related to Alternative Power Sources in the Lower Mekong Sub-Region

2.3.1 Power Generation Shortfall from Not Building Planned Large Dams

The estimated hydropower potential of the Lower Mekong Basin (i.e., excluding China) is 30,000 MW[39], while that of the Upper Mekong Basin is 28,930 MW.[40] In the Lower Mekong, more than 3,235 MW has been installed through facilities built largely over the past ten years, while an additional 3,209 MW are currently under construction. An additional 134 projects totalling 23,556 MW are planned for the lower Mekong, which will effectively exhaust the river's hydropower generating capacity[41]. This means that a shortfall of that amount in power generation capacity might occur if the remaining planned dams were not built. However, in reality, it is unlikely that all of the planned dams for the Lower Mekong Basin would be built since this would entail unacceptably high population displacement and environmental destruction. In addition, the amount of finance that would need to be mobilized for such an effort is unlikely to be realized. Moreover, generating capacity is not necessarily correlated to power demand, especially at the national level and, in fact, this lack of equivalence is what has given rise to power trading.

The issue of how much of a shortfall in non-fossil fuel power supply would emerge from not building large hydropower dams in the future is a difficult one to answer. Much depends upon the actual demand growth curves and these could change significantly depending upon how aggressively demand management and energy efficiency standards and measures are implemented. It also depends upon the way that clean energy power sources are deployed and supported technically and financially as well as possible economic transformation to less energy intensive industrial investment. Certainly clean energy sources for electricity and energy efficiency measures have barely been tapped to reduce dependence on large hydropower and so the potential to replace the foregone installed large hydropower installations may be quite significant.

2.3.2 Information and Knowledge Sharing on Clean Energy Sources in the Lower Mekong River Basin

Investments in the renewable energy sector in the LMS are dominated by private sector interests and foreign direct investment, especially for large hydropower projects. Projects are planned and developed by powerful private investment groups focused on the needs of urban centers and industry and, given the concession nature of these projects, host country governments will not receive very much in the way of revenues to balance the social and environmental costs of large dams.[42] Most of the external costs from building large dams will fall on the rural poor and extensive ecosystems. More information collection and analysis is needed on the environmental, social, and livelihood impacts of building so many large dams on the main stem and tributaries of the Mekong River basin, which has the second highest levels of biodiversity of any other river basin after the Amazon.

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[39] MRC, State of the Basin, 2010.
[40] J. Dore et al. 2007, pp. 55-92
[41] MRC, Overview of the Hydrology of the Mekong Basin
[42] SEA, Mekong Main Stem Dams, p. 10.

Even fewer data and information have been collected on the potential for non-hydropower renewable energy resources, i.e., solar, wind, tidal, geothermal and biomass, as well as energy efficiency. The amount of data readily available from secondary sources is very limited and, as noted above, is mainly available from Thailand and Vietnam.

2.3.3. Recommendations

Throughout Section 2, it was clear that there is a serious lack of data on clean energy resources and related infrastructure that is needed for planning, modelling, risk analysis and investment risk analysis for clean energy in the region. This is undoubtedly a significant limiting factor for clean energy development in the LMS at least in the near term. The inadequacy and lack of reliability of data is worst in the three poorest LMS countries. This report recommends several possible activities to address this issue. First, more comprehensive and detailed data on the national and sub-national potential for specific clean energy development is imperative. This includes wind maps, solar insolation estimates, and micro and mini hydropower potentials. Second, data are needed to estimate the kinds of infrastructure needed to support a large-scale clean energy network. Third, assessing the internal (financial) and external (economic) costs of deploying clean energy on a large scale would help both policy makers and investors. On the demand side, there is a great latent demand in those populations without electricity service or serviced only through auto-generation. Finally, it would be useful to develop field studies to assess the potential amount of fossil fuel costs that could be saved through development of clean energy sources in off-grid areas.

3. Assessment of Clean Energy Development in the LMS by Resource Type

3.1 Hydropower

3.1.2 Background and Current Status

The Mekong River Basin is one of the largest and most important river basins in the world. Millions of people depend upon it for transportation, irrigation, drinking water, fisheries and industrial process water. It is also the single most important source of electric power generation in the countries comprising the LMS.

At the same time, the Mekong River Basin is also a critical environmental resource and a vibrant network of ecosystems. Its high levels of biodiversity of both flora and fauna are not only of intrinsic importance but they directly support thousands of livelihoods in tourism, non-timber forest products and climate regulation. The Mekong's many and vital goods and services require a stable water regime and protected watersheds. The erection of too many large dams threatens the region as a whole including population displacement, destruction of forests and fisheries, and associated social instability.

The Mekong River Commission (MRC) was created in 1995 to help the riparian countries of the Mekong basin balance protection of the river with the need to exploit its services for economic growth. Through its Initiative on Sustainable Hydropower, the MRC has worked with a range of partners to build their capacity to conduct targeted studies and to share information to promote more sustainable hydropower in the region. At this point, a large number of hydropower project feasibility studies of varying quality have been undertaken, which, if all were realized would likely cause irreversible damage to the river basin, as has been noted above. Hence, the challenge is to diversify power generation supply in the LMS sustainably and to use demand side management to use existing power supplies more efficiently.

Definition of Large Dams. A number of international bodies (including the International Commission on Large Dams) define large dams as higher than 15 meters and major dams as over 150 meters in height. The standard definition of dams is from the Report of the World Commission on Dams (WCD) that includes in the large category, dams, such as barrages, which are between 5 and 15 meters high with a reservoir capacity of more than 3 million cubic meters.

In the available databases on dams, especially in the ASEAN region, only medium and large dams are included. Information on mini, micro, and pico-hydro installations is much more difficult to obtain on either an aggregated (basin-wide) or disaggregated basis (country by country). For example, the program of micro hydro facilities built in Thailand in the 1960s to provide power to rural areas is not included in that country's list of hydro facilities. The focus on medium and large dams is an unfortunate oversight since it probably considerably understates the actual contribution of hydropower in at least some of the LMS states.

All of the members of the LMS have exploited hydropower resources for electricity generation though the contribution of hydropower to total electricity generation varies significantly from country to country.

In the Lower Mekong River Basin, new dams are being planned on both the mainstream and tributaries. The estimated hydropower potential of the lower Mekong is around 30,000 MW, of which less than 10 per cent has been developed; all of it on the Mekong's tributaries (see Exhibit 4 below and Figure 5). Of the total of 124 existing, under construction and potential/proposed tributary projects identified in the Mekong River Commission (MRC) hydropower database in 2009, more than 70% is in Lao PDR and 10% is in Cambodia. Private sector proposals for new hydropower schemes include at least 11 dams on the Lower Mekong mainstream.

Exhibit 4. Installed capacity of existing, under construction and planned/proposed hydropower projects in the LMB

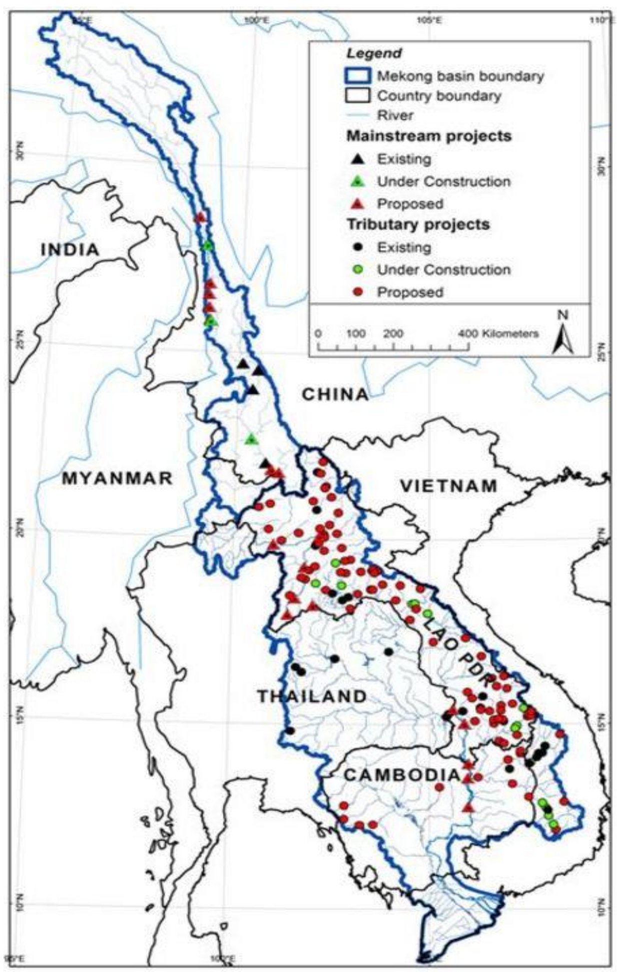
	Installed capacity (MW)			
Country	Existing	Under construction	Planned / proposed	Total
Cambodia	1	-	5589	5590
Lao PDR	662	2558	17,686	20,906
Thailand	745	-	-	745
Viet Nam	1204	1016	299	2519
Total	2612	3574	23,574	29,760

Source: MRC 2010. State of the Basin Report 2010 Summary, p. 20.

The MRC's role has been to help the governments of the Lower Mekong Basin to sustainably manage the basin's water and related resources and to use these resources to lift the region's population out of poverty.

About 60 million people live in the Lower Mekong Sub-basin and most of this population is directly or indirectly dependent upon the Mekong River and its tributaries. As Figure 5 graphically illustrates, the principal suppliers of hydropower in the Lower Mekong River basin are the Lao PDR and Cambodia while the principal consumers of this power are Thailand and Vietnam. This neatly demonstrates the relative levels of modernization and economic development as well as relative levels of urbanization of the supplier and consumer nations.

Figure 5. Planned and Existing Large Dams in the Mekong River Basin



Not only do the hydropower supplying and consuming nations have different roles in regional hydropower development, they also have different risk exposures from this development. There are 11 planned mainstream dams on the Thai/Lao border and 85 proposed tributary dams (all in the planning process), but the evaluation of these proposed projects varies from professionally planned ones to poorly undertaken feasibility studies (both with and without environmental impact assessments).

Currently, Lao PDR plans 71 additional dams. Thailand has seven hydropower dams in the north with no plans for expansion beyond this point. Vietnam has seven hydropower dams plus five dams that are in construction. In addition, Vietnam plans to add small and medium-sized hydropower plants as the country has good hydro resources and the greatest potential for development of these resources in ASEAN. Forty-three percent of Vietnam's total electricity generation came from hydro power in 2008.[43]

Source: Mekong River Commission

According to the MRC's Planning Atlas of 2011 (see Exhibit 5 below), the lion's share of planned large hydropower development was expected to be in Lao PDR. However, the environmental and social impacts of such a large concentration of large hydropower projects as well as the management challenge for a small and poor country makes the prospect of this development very unlikely.

Although rapid development of hydroelectric power in the LMS has raised concerns about adverse environmental, economic, and social impacts, hydropower is generally expected to continue to be the predominant source of electricity growth in developing Asia in the coming years, primarily from mid-to large-scale power plants."[44] For example, nearly 50 hydropower plants are planned to be built in Vietnam's Son La Province alone by 2015[45].

Exhibit 5. Lower Mekong Planned and Existing Hydro Dams by Country

Country	Mekong River Main Stem	Mekong River Tributaries				Total
Cambodia	2	1	--	11	12	14
Lao PDR	9*	11	9	71	91	100
Thailand	--	7	--	--	7	7
Vietnam	--	7	5	3	15	15
TOTAL	11	26	14	85	125	136

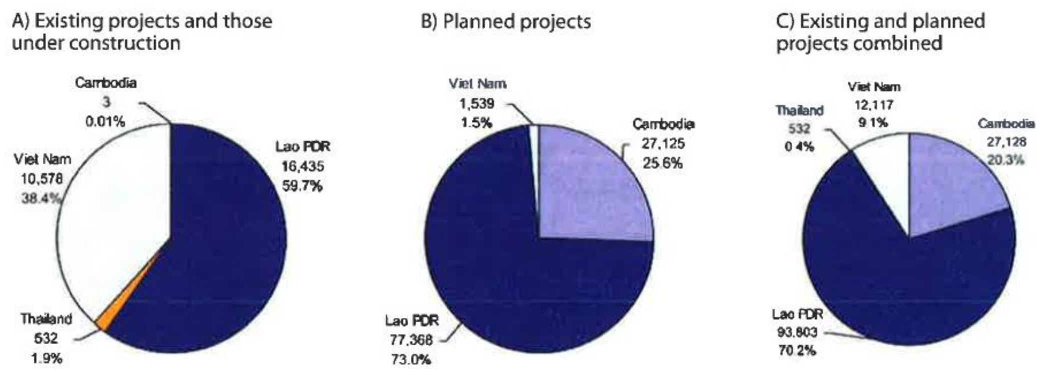
***** Lao PDR and Thailand share borders on two of the proposed mainstream dams. These projects are included in the Lao PDR in this table.

Source: MRC, 2011, Planning Atlas of the Lower Mekong River Basin, p. 79

The following chart represents the distribution of mean annual energy production from hydropower for each of the four Mekong countries in three different phases. Currently, Cambodia's hydropower development is miniscule but is expected to significantly expand. In contrast, Vietnam's current hydropower is significant and expanding but it has few projects left in the planning phase. Relatively, Thailand remains the least important potential hydropower supplier in comparison to the other basin countries but is, by far, the most significant energy consumer and so probably the greatest real gains from energy efficiency would arise from that nation. Again, these projects all refer to large hydropower projects. Thailand's profile would look very different if the small hydro category was included, but as noted statistics for this category are lacking.

[43] s. USAID/Asia: Energy Trends in Developing Asia: Priorities for a Low-Carbon Future, 2011, p. 31 and s. http://iea.org/country/index_nmc.asp
[44] USAID/Asia: Energy Trends in Developing Asia: Priorities for a Low-Carbon Future, 2011, p. 62.
[45] USAID/Asia : Energy Trends in Developing Asia: Priorities for a Low-Carbon Future, 2011, p. 62.

Exhibit 6. Distribution of Hydropower Development in the Lower Mekong River Basin by Project Phase



Source: Planning Atlas of the Lower Mekong River Basin; Mekong River Commission, p. 85

Figure 6 below shows geographically the planned mainstream dams of the Greater Mekong Basin. It should be noted that the dams constructed by China in the upper part of the basin are mostly already in operation.

Figure 6: Geographical Outline of Operational Dams and Dams under Construction in the Mekong River Basin

Source: http://www.bbc.co.uk/news/world-asia-20203072 (Nov., 6th 2012) and Challenge Program on water and Food, Mekong River Commission

As noted, while plans and feasibility studies have been done for many or even most of the proposed projects, there are significant differences in the quality of these studies and disagreement over which ones should proceed with development. This is especially true for the main stem dams but is also the case for many of those on the tributaries of the Mekong. The main stream dams would negatively affect the many species of migrating fish since they all have different strategies for swimming upstream, which could not be mitigated through engineering solutions for the dams. Also, the main stream dams would significantly affect vitally important river transport, adding to the costs of transporting both cargo and people up and down the Mekong.

3.1.3 Opportunities

Justification for the design and construction of large dams often rests on a range of inter-related products and services they provide. Humans have controlled the flow of water for thousands of years, including the construction of very large dams. The principal benefits of large dams include the following.

Flood Control. This is a critical requirement for communities lying in fertile flood plains and has been an important justification for dams on major rivers.

Irrigation. Probably the oldest rationale for damming rivers and streams, controlling the storage and delivery of water supplies for dry season agriculture or drought-prone areas is probably the single most common use of large dams.

Power Generation. If the use of dams and barrages to regulate water flows for mechanical energy is included, this end use has been widely exploited for hundreds of years for grist mills and presses as well as lathes and other simple manufacturing. Nowadays, the power generated is, of course, mainly electricity. A clean and renewable source of energy, hydropower also has the additional benefit of being non-polluting, unlike fossil fuel-based power generation. Another benefit is energy security, especially for fossil fuel-importing countries.

Fisheries. Many dam reservoirs are stocked with fish for commercial or subsistence food purposes.

Drinking and process water supply. In addition to supplying water for irrigation, many dam reservoirs supply process and drinking water, especially for cities or water-intensive industries.

Recreation. Although usually not a prime reason for dam and reservoir building, recreation (boating, swimming, recreational fishing) can be an important benefit stream and justification for building some small dams and associated reservoirs, especially in developed countries where recreation can generate significant income streams.

Climate change adaptation. It has been noted recently that abrupt changes in rainfall regimes, especially leading to alternate flooding and drought can make dam building be considered a kind of climate change adaptation since the reservoirs have the effect of stabilizing the flow of water for affected populations.

3.1.4 Challenges

The environmental, economic and social costs of large dams are well-documented from studies of many large dam projects around the world. Existing and planned large dam projects in the Mekong likely have a similar profile of costs.

Habitat loss. Large dams often displace a large amount of area for live storage. This is especially true for dams across the main stems of rivers where the geographical profile is usually relatively flat compared with upstream dams that may lie across steep canyons or hillsides. Downstream dams may be more likely to be in areas with more complex habitats including some areas of high conservation value.

Species loss. Sometimes associated with habitat loss, locally endemic species of flora and fauna may be severely reduced in number or even made extinct by large dam-reservoirs. Of often greater concern, migrating fish simply cannot get past the very high walls of large dams (fish ladders are only practical on low head dams).

With respect to climate change, the potentially negative impacts from hydropower development on the high conservation value forests and fisheries are only somewhat offset by making a great amount of stored water available in cases where climate change may reduce rainfall.

Loss of fertile sediments and erosion of river deltas. This can be a serious cost to large dams, especially for rivers with large and actively cultivated deltas. The building of the Aswan Dam in Egypt has had a noticeable impact on the erosion of the Nile Delta as well as requiring a significant increase in the use of artificial fertilizers to replace the loss of the nutrient rich river sediment that made Egypt a major breadbasket for generations. In the Mekong, the building of giant dams, e.g., the proposed Xayaburi Dam in Laos has already triggered protests from Cambodia and Vietnam, which are concerned about very serious damage to fisheries and loss of sediment to the Delta, respectively.

Dam failures. This is an obvious cost of dams and, while much rarer than the other costs of large dams, can be truly catastrophic in terms of the cost to human life as well as economic damage and financial costs. Because of the huge costs entailed in dam failures, far greater investment in dam design and siting is required than for small dams or run-of-the-river schemes.

Population displacement. Population displacement is one of the most costly impacts of large dams. Again, this is primarily an issue of dam siting, especially with respect to the size of the active storage area. Population displacement is not only costly to the people that must be moved but, for many countries, it also results in a "pyramid effect" wherein populations are moved to other settled areas, which cause additional problems in terms of strains on local natural resources (land, water, forests, and available agricultural land) but also local economic infrastructure (roads, schools, hospitals, etc.). In addition to the displacement of populations and loss of natural habitat and livelihoods, displaced populations also may lose important cultural artefacts, historical structures and other items of high social and cultural value.

Threats to livelihoods. In Cambodia, Burma, and Lao PDR, populations are overwhelmingly rural and dependent upon forests, fisheries, and agricultural resources for their livelihoods and these also are integral to their culture. If all of the planned projects were developed, the ecology and existing natural habitats would be fundamentally transformed potentially affecting the livelihoods of millions of people as well as the natural resource base and biodiversity.[46]

An especially important issue for large hydropower projects is "land tenure" since dam reservoir projects frequently result in population displacement and resettlement elsewhere. This may require compensation for land lost to inundation as well as providing title to displaced persons in the lands in which they are later settled. In countries with unclear land tenure systems, this can cause both costly delays and socio-economic instability in some cases. This could be a threat to some extent for mini hydro, which can be as large as 10 MW of installed capacity, but is much less likely. In addition, land development for large hydropower can become problematic in special conservation areas or areas set aside for indigenous peoples (e.g., in the Philippines where such lands are protected by the Indigenous Peoples Rights Act.[47] For most large projects, these are likely to be financed under the Equator Principles requirements (based on IFC's Environmental and Social Performance Standards) In addition, for hydropower, the "technical infrastructure"-related limitations are very important barriers to consider.

As described above, one of the significant costs of large dams is the area of live storage, i.e., the reservoir footprint. Of the existing hydropower dams in the Lower Mekong Basin, Nam Ngum 1 has the largest reservoir area of 294 square kilometers (km). The recently constructed Nam Thuen 2 dam has a similar reservoir area. While most planned hydropower dams, including the mainstream dams have predicted reservoir areas of less than 200 square km, there are six planned dams in Cambodia with much larger estimated reservoir areas (i.e., >300 square km). Two of these: Sambor dam on the Mekong mainstream just upstream of Kratie and the Lower Se San 3 dam on the middle reaches of the Se San River will each have a reservoir area of more than 1,000 square km, which is more than three times the size of the existing Nam Ngum 1 dam and just under half of the area of the giant Tonle Sap lake during the dry season. The large reservoir area but relatively small live storage of these two dams compared with Nam Ngum 1 dam reflects that these dams will be shallow due to the low lying topography of the planned inundation area.[48]

3.1.5 Recommendations

Research on large dams in the LMS is being addressed by the MRC, donors such as the ADB, and by some of the countries themselves. The most important recommendation for USAID is to focus on supporting studies on the impacts of large dams on the environment and populations in the three poorest, but hydropower rich, countries. In addition, supporting efforts at public education, awareness, and communications on large dam impacts and a refocus on domestic power supply through clean energy alternatives should be a priority.

The numerous environmental and social costs of building many large hydropower projects, especially in a densely populated and environmentally fragile landscape, as discussed in this section

[47] Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 114
[48] Planning Atlas of the Lower Mekong River Basin; Mekong River Commission, p. 85

provide a clear rationale for a more widely distributed, lower impact network of power sources with lower cumulative and life cycle costs and greater benefits, especially to unserviced rural populations. Indeed, for this off-grid customer base, renewables are already cost-competitive with diesel and other fossil fuel sources[49]. A useful study could focus on which populations or end users generally benefit from the power generated by large hydropower projects. It is likely that the main beneficiaries are large cities and industrial end users.

3.2 Mini, Micro, and Pico Hydro

3.2.1 Background and Current Status

These three forms of hydro are grouped under the general term "small hydro". Small hydro is considered to include projects under 10 MW of installed capacity. Mini hydro projects are those ranging from 100 kW to 10 MW of installed capacity. Micro hydro is a type of small hydro that typically produces up to 100 kW of electricity. Pico hydro is a term used for hydroelectric power generation of under 5 kW. It is useful in small, remote communities that require only a small amount of electricity, for example, to power one or two fluorescent light bulbs and a TV or radio in 50 or so homes.

There is increasing interest throughout the developing world in micro hydropower projects in particular. However, all three scales of small hydropower offer good potential in the LMS countries. In order to estimate the potential for installed small scale hydro, detailed field surveys, and seasonal river and water flow mapping is required to determine potentially feasible locations.

3.2.2 Opportunities

Nine out of eleven countries in South-Eastern Asia use small hydropower. The region has an estimated small hydropower potential of about 6,682.5 MW (for plants up to 10 MW), of which 1,252 MW has been developed.[50] However, the upper limit of what constitutes small hydropower vary among countries (from 10 MW to as much as 30 MW). Lao PDR has a draft Renewable Energy Development Strategy that promotes small hydropower of up to 15 MW. Thailand also has a small hydropower target of 0.04 per cent of the total generation mix by 2015. Viet Nam has an avoided cost tariff specifically for small hydropower.

Thailand has set one model for mini-hydro by integrating some of these into existing low-head irrigation infrastructure. Micro-hydro can comprise one resource base for rural mini-grids, depending upon the seasonality of rainfall and water flows. Pico hydro (less than 5 kW installed capacity) may be suitable for small villages wanting to get basic power access. The advantages of pico power are that it is very cheap, relatively easy to manage, and the technology can be (and is being) manufactured in the region. In Thailand, in particular, NGOs are developing simple pico hydropower projects that can be easily operated and maintained by rural villagers without the need for imported equipment. While these very small installations cannot readily be integrated into mini grids, they provide a basis for poor and isolated villages to build value-added to their local economic activities and allowing them to get to the next stage of clean energy capacity.

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[49] Costanza, et al. 2011. Planning Approaches for Water Resources Development in the Lower Mekong Basin, pp. 68-70.

[50] Liu, H., Masera, D. and Esser, L., eds. 2013, **World Small Hydropower Development Report 2013**, p. 14.

3.2.3 Challenges

In addition to a lack of comprehensive data on small water sources in the region, the principal problem is identifying a funding source for small hydropower projects Financial problems range from the lack of financial sources in Cambodia to financial institutions that are unfamiliar with assessing risks for small hydropower projects in Thailand. High costs for the development of small hydropower are reported in Cambodia, More subsidies are actually available in Thailand for importing electricity to rural areas than for building small hydropower plants. In Lao PDR, only large hydropower projects attract foreign investors.. As with some of the other clean energy sources discussed below, projects could be developed in feasibility and cost studies by ESCOs and funded through a special clean energy fund in some cases combined with other clean energy sources such as solar power. The other challenge is overcoming a lack of knowledge and knowledge sharing of the practical experience and best practices from other countries for small hydro projects. The lack of field expertise and technical skills is the largest single barrier impeding the development of small hydropower and this has been reported in many countries.

3.2.4 Recommendations

These three scales of hydropower offer good potential in the LMS countries. In order to estimate the potential for installed small scale hydro, detailed field surveys and seasonal river/water flow mapping is required to determine potentially feasible locations. USAID support to LMS countries in the form of technical assistance and training, where needed, to assess data flows and locations of perennial streams and other fresh water bodies would be of great assistance, especially for the three poorest LMS countries. This could also be a useful regional GIS project if additional data layers for demography, infrastructure, and economic indicators are included. For the three poor LMS countries, engaging the governments to promote small hydro with appropriate policy incentives and institutional arrangements would be a worthwhile form of assistance, especially where it can then provide a path for facilitating public-private partnerships for rural village mini-grids. This could take the form of a policy reform project to address technical and human resource needs for developing the small hydro sub-sector.

3.3 Solar PV and Wind

3.3.1 Background and Current Status/ Detail

Solar energy is an abundantly available clean energy source that can be deployed widely in both rural and urban areas, though the greatest benefits will likely come to rural, off-grid producers and consumers. A supply of reliable electric power has long been shown to support improved social services (e.g., health and education) as well as enable significant improvements to rural value chains, especially in post-harvest processing activities. This section primarily discusses direct generation of electric power from the use of photovoltaic cells (PVs) assembled into arrays. However, other systems employing solar thermal conversion to electricity (via a steam turbine), such as concentrating solar power and hybrid solar-waste heat systems also exist in the LMS region, but are much less common. The estimated potential for solar energy for all LMS countries is relatively high though variable by subregion[51].

Exhibit 7. Solar Power Potential in Various Parts of the LMS

Solar Power Potential Ranges	**Locations in the LMS**
Good quality solar resources ranging from 5.5 to 6.0 kWh/m2/day annual average	Southern Laos, Northern Cambodia, and northern and central Thailand
Fair quality resources (5.0–5.5 kWh/m2 /day annual average)	Throughout the rest of the LMB
Direct normal resources 4.5 to 5.0 kWh/m2 /day annual average	Southern Laos, Northern Cambodia and east and Central Thailand

Source: Planning Approaches for Water Resources Development in the Lower Mekong Basin, p.74

Though country-specific data availability on estimates of solar energy potential varies, research, development, and deployment activities are underway in all five countries.

Thailand has a potential for 50,000 megawatts of solar-photovoltaic power and has targeted 2,000 megawatts for electricity development by 2022. Thailand dominates the Southeast Asia market for solar PV and ranks 5th in the Asia-Pacific region[52]. As of 2012, Thailand had approximately 550 MW of installed solar PV capacity. Thailand also has 5 MW of concentrating solar [thermal] power capacity, but did not add any additional capacity in this subcategory in 2012. Instead, Thailand increased the capacity of subsidized hybrid (solar-waste heat) systems by 13% in 2012[53].

Burma has potential solar energy of 51,974 million MWh per year. Both solar PV and wind are in the early stages of research, development, and implementation in Burma, with solar pilot projects running in rural areas (without access to the national grid), and for battery-charging stations and water pumping. No statistics are available for total installed capacity but until recently it has been quite small. However, in October, 2014, Green Earth Power, a renewable developer based in Thailand, completed negotiations with the Government of Burma for a 210 MW solar project with Burma's electric power ministry. Burma will invest US$275 million to support the development of this large solar power plant to be located in Minbu. The government's share will especially focus on an HVDC transmission line to carry the solar-generated power into the national grid. The project's power purchase agreement is expected to be signed within three months. All electricity generated by the solar plant will be sold to the Myanmar government for a period of 30 years.

In 2012, **Cambodia** had 1.5 MW of installed solar PV capacity for electricity and has announced an additional 500 MW of solar PV capacity addition, which is currently under feasibility study.

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[51] IRENA's Renewable Energy Country Profiles Asia report (January 2013) ranked solar energy potential for Lao PDR, Cambodia, Myanmar, Thailand, and Vietnam as high, which indicates occurrence of areas with global horizontal irradiation levels above 1800 kWh/m^2 per year.

[52] After China, Japan, India, and Australia (source: IMS Research, "Thailand and Indonesia to Drive South East Asia PV Market." (2011)).

[53] "Most Thai government commercial solar thermal subsidies are going to process heat applications in the industrial sector, followed by hotels, farms, and hospitals. The subsidy covers commercial solar thermal installations that are combined with waste heat from air conditioners or boilers, per Thailand Department of Alternative Energy Development and Efficiency," cited in Renewables 2013 Global Status Report.

Vietnam still has few large utility-scale solar installations; due primarily to the lack of a feed-in tariff for solar projects in the country, and so total installed capacity is very small. Nevertheless, household and rural solar PV installations are growing rapidly[54].

Lao PDR has seen significant advancements in the past decade in rural electrification through off-grid installations such as small solar home systems (SHSs) developed under the Rural Electrification Program. In 2011, approximately 20,000 households were supplied with electricity through these SHSs, and larger solar PV systems with capacities ranging from 40-100 peak kilowatts (kWp) or rated capacity were being piloted through hybrid power systems with micro hydropower in remote rural areas[55].

With the cost of solar PV having fallen drastically in the last decade, the potential for large grid-connected solar (as opposed to distributed small scale installations) has improved. This report provided the example of Germany in which large scale renewable energy implementation can be integrated into the national grid through smart grid and demand side management. With extensive solar resources available in the Lower Mekong Subregion and with solar PV being highly scalable (from one PV array for light poles, health clinics, and small household lighting, to very large arrays for large power production right into the national grid), there is large potential for solar power to reduce dependence on large hydropower, which has mainly served cities and industrial users rather than rural, off-grid populations. In that respect, its biggest immediate payoff is likely to be in the three poorest LMS countries: Lao PDR, Cambodia, and Burma.

Similarly to solar PV, data availability on wind energy potential varies for LMS countries, and despite some preliminary sub-regional level assessments, there appears to have been little work done to date to develop robust estimates of wind potential across most of the GMS as well. The IRENA Renewable Energy Country Profiles Asia report classified wind potential for Lao PDR, Thailand, Vietnam, and Burma as High, meaning the countries have several areas with average wind speeds above 7 meters/second at 50 meters above ground level. Cambodia has Medium wind potential, indicating wind speeds between 5-7 meters/second. That said the Wind Energy Resource Atlas Report on Southeast Asia (World Bank 2001) estimated a theoretical wind energy resource potential for Cambodia to be equivalent to 1,380 MW. Potential wind resources in Thailand and Vietnam alone are each more than 100,000 MW and Thailand has targeted 1,200 MW of wind power development by 2022. Although Vietnam has very little installed capacity for wind energy, it has more than 60 registered projects under development to add a total of 6GW of capacity. In the near term, Vietnam has 325 MW of capacity to be added by 2014 (from three projects)[56]. Burma has three wind projects currently operating, and Chinese-funded feasibility studies investigated potential development of 4,032 MW of wind energy in 2011[57].

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[54] Peron, Jeff. 26 July 2013. Wind and Solar Opportunities in Vietnam. http://www.eco-business.com/opinion/wind-and-solar-opportunities-vietnam/

[55] Lao 2011 Renewable Energy Development Strategy.

[56] IRENA. 2013. Renewable Energy Profile: Vietnam

[57] World Economic Forum, ADB, Accenture. 2013. New Energy Architecture: Myanmar.

3.3.2 Opportunities

With a 3,000 km coastline and wind speeds above 7 meters/second, **Vietnam** has the best potential for wind power in the LMS, although financial and institutional barriers continue to impede progress. Wind resources have been identified as commercially viable in the case of **Cambodia** along the coast and near the Tonle Sap. Offshore wind installations are also a viable option though they will be considerably more expensive per unit of installed capacity because of the offshore platforms and underwater electrical cables required. For offshore wind energy platforms, an additional potential risk is the increased likelihood of climate change-induced strong storms and storm surges, which is already a problem for Vietnam.

Burma is one of the LMS countries with a very low rural electrification rate and with a national reliance (estimated at 75%[58]) on traditional biomass for cooking and heating.[59] As the country emerges from 50 years of isolation from the global economy (under which the GDP has depended on a natural gas export industry that suffers from outdated infrastructure and supplies that are not sufficient to meet domestic need), opportunities are also emerging to collaborate with the government to transform its energy infrastructure to an integrated, renewables-based system. Like Vietnam and Thailand, part of the country has a long coastline where wind energy potential could be high though assessments are lacking. The country has a newly formed National Energy Management Committee (NEMC), supported by a new Energy Development Committee (EDC), which can also benefit from assistance with its goals to implement new laws and institutional arrangements, through capacity building and decision-making support, and private sector engagement. The country's geostrategic location between India and China, its high potential for wind and solar PV, and its large and overall young population (60 million estimated for 2013) present additional opportunities to transform the country into an energy leader in the region[60]. The government recently announced a plan to draft a "new energy policy based on the current Japanese model," and has received support from Japan for a feasibility study of implementing similar policies, incentives, and infrastucture development approaches.

3.3.3 Challenges

With rapid economic growth targets as the driving force for energy development projects (and, for renewable energy, the benefits of avoided carbon emissions and reduced fossil fuel dependence), the likelihood that large hydropower projects will subsume the role and investment potential in solar PV and wind resources is high. For large scale PV installations, there is also some risk that siting may become an environmentally-sensitive issue as well as a security one. Financial, institutional, infrastructural, and human capacity-related challenges present barriers to achieving the renewable energy development potential in LMS countries. Siting is likely to be less of an issue for small-scale, residential (and especially rural) electrification systems, including the use of hybrid systems such as combined solar and micro-hydro.

In **Thailand**, a reported lack of clear legal bases for renewable energy policies presents a clear challenge to implementation of sustainable renewable energy development. In addition, Thai

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[58] World Economic Forum, ADB, Accenture. 2013. New Energy Architecture: Myanmar.
[59] Renewables 2013 Global Status Report.
[60] World Economic Forum, ADB, Accenture. 2013. New Energy Architecture: Myanmar.

energy policy has been known to change with little warning, causing confusion and resulting in a lack of compliance. In **Burma**, while the country shows great potential for wind and solar PV and is in a promising position to update its infrastructure to a more sustainable, integrated, renewable energy-based economy, pressures from regional demands (China, Thailand) and ambitious economic growth targets may lead to a primary focus on large hydropower development in lieu of cleaner options. For instance, as of January 2013, the Ministry of Electric Power had identified 300 potential new hydropower projects with a combined capacity of 46,331 MW. While it is unlikely that all or even most of these projects would be realized due to insufficient foreign investment, social and environmental costs, and inadequate infrastructure, the pressure to earn foreign exchange from large hydropower projects is still very strong.

The regional pressures on Burma to focus on fast development of less sustainable energy infrastructure will likely have a large influence in decision-making around energy infrastructure. Additional challenges include: the lack of transparent institutional and legal frameworks, from exploration through deployment; lack of financial capacity for R&D, infrastructure, and private-sector investment; limited human resource capacity; and subsidized petroleum prices[61]. Burma's hydropower and natural gas production potential are likely to impel Burma to promote regional power trade in the LMS and implement the approved pipeline of activities for the new GMS Strategic Framework (2012-2022), which are to be endorsed and finalized in December 2013.

Similar challenges are present in **Vietnam**, which, to capitalize on its rich wind energy potential, must overcome barriers such as a lack of wind maps, competing interests at project sites rich in mineral resources, and delays caused by transportation and installation issues, such as a lack of roads suitable for turbine and blade transportation, limited availability of cranes, etc. "One of the main hurdles for investment in the Vietnamese wind farms is still the low interest from investors due to the low wind Feed-in-Tariff (FiT) of 1,614 VND/kWh. The Vietnamese wind projects receive a tariff comparable to the Chinese wind FiT, but with an average Capex [capital expenditures] estimated to be twice that of the Chinese."[62]

In **Lao PDR**, the lack of renewable energy policies and lack of coordination among stakeholders on renewable energy projects are key barriers to successful implementation of these initiatives. In addition, key responsible government entities for renewable energy policies and financial infrastructure need to be identified and supported through capacity building efforts. There is a general lack of awareness of the potential for REs, especially for small and medium-sized businesses or energy companies wishing to expand their business into the renewable energy sub-sector. However, without clear energy pricing regulations, risk-adverse investors are less likely to engage in renewable energy investments. Furthermore, information is still lacking on actual renewable energy resource potentials at provincial and local levels, as noted[63].

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[61] World Economic Forum, ADB, Accenture. 2013. New Energy Architecture: Myanmar.
[62] Peron, Jeff. 26 July 2013. Wind and Solar Opportunities in Vietnam. http://www.eco-business.com/opinion/wind-and-solar-opportunities-vietnam/
[63] Lao 2011 Renewable Energy Development Strategy.

3.3.4 Recommendations

Opportunities for USAID investment in activities in Solar PV and wind are similar to those for deploying renewable energy technologies, in general, as discussed earlier. Resource specific needs include more comprehensive and accurate wind maps by locality and season, solar insolation estimates by district and sub-district and the development of GIS data layers for these estimates to be compared with demographic, economic, and physical infrastructure data layers for planning and investment purposes.

For USAID sectoral projects, e.g., food security, health, education, water supply, there may be opportunities to demonstrate solar PV and wind energy potential, especially in rural unserviced areas to give government and non-government counterparts a sense of the real potential for these RETs. Investment in public-private partnerships to stimulate domestic manufacturing of RET equipment, especially small hydro, wind and solar PV is also a potential promising area.

3.4 Geothermal Opportunities and Challenges

Only two countries in the LMS have measurable geothermal resources: Vietnam and Burma. Geothermal energy resources are relatively widespread in Burma, and have a considerable potential for commercial development mainly for power. Ninety-three geothermal locations have been identified throughout the country. Forty-three of these sites are being tested by the Burma Oil and Gas Enterprise (MOGE) and MEPE in cooperation with Japanese and American companies. Vietnam has recorded more than 300 natural geothermal sources and six geothermal regions have been identified across the country. Northwest Vietnam is eyed as the most plausible region for geothermal exploration and expansion. In 2012, Vietnam broke ground on its first geothermal installation rated at 25 MW in Quang Tri Province.[64]

Although not technically a renewable resource, most geothermal sites are very long-lived, making them effective alternatives to non-renewable energy sources. The energy conversion technology using steam turbines is quite mature and rated power is often quite large though this varies quite widely with individual sites. The challenges are: (1) the resource is not portable and so the power generation plant needs to be relatively close to the source, which could make for long transmission lines for some remote locations (or use HVDC lines); and (2) the brine associated with geothermal is generally very toxic to the environment and also requires special protection, reinjection or safe disposal for the associated physical plant, which adds to the total generation cost.

3.4.1 Recommendations

The United States is the world leader in the development of geothermal energy comprising nearly a third of global geothermal power output. Where there is a need, USAID could provide information to the Burmese and Vietnamese governments on available sources of expertise on geothermal energy development in the private and public sector.

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64 EcoSeed, "Vietnam building its first geothermal power plant", Sept. 27, 2012.

3.5 Energy Efficiency

3.5.1 Background and Current Status/ Detail

As noted previously, energy efficiency will be a very important component of getting widespread adoption of a renewable energy-based power network in the Lower Mekong Subregion and, indeed for fuel uses as well. At present, energy efficiency is a relatively low priority in LMS countries, but is widely regarded as a key part of the broader energy strategy in the Greater Mekong Subregion. It is mainly a priority for Thailand currently. The reason for this is that the vast majority of the populations in the other LMS countries have relatively undeveloped power sectors, especially for the majority rural populations. So, the scope for conservation gains from energy efficiency is relatively modest at this point. On the other hand, the three poorer LMS countries and parts of Vietnam can take advantage of the lack of rural power to invest in energy efficient and smart grid technologies and associated infrastructure rather than having to replace existing facilities, structures and equipment as Thailand does.

Energy efficiency is also a promising and effective strategy for non-renewable energy systems. As has been noted by many energy specialists, the cheapest power plant is the one that never has to be built. However, significant energy efficiency improvements will require large-scale policy reforms and institutional changes (i.e., technology standards, building codes, spatial planning, regulatory enforcement, public awareness and education, and socio-economic incentives). Many of the key barriers to improving efficiency, such as fossil fuel subsidies, lack of awareness, and the absence of investment incentives, are common to most LMS countries, as they are in many other parts of the world. Energy efficiency extends across many aspects of power generation, both on the supply side (generation, transmission, distribution, transportation) and the user side (building efficiency, municipal infrastructure, mass transit, irrigation, equipment standards, and household energy use improvements) for both grid-connected and off-grid renewable energy installations[65].

The GMS Road Map for expanding GMS energy cooperation emphasizes the promotion of renewable energy and energy efficiency, as well as enhancing environmental sustainability of regional energy plans and programs[66]. As mentioned previously, neither Burma nor Lao PDR currently have clearly established and operating energy regulators. With a national load dispatch center currently under construction in Lao PDR, this added capacity for monitoring and control over power stations throughout the country presents an upcoming opportunity for improvements in energy efficiency[67].

Efficient lighting can also reduce end-use energy demand. Figure 7 shows a comparison of technical and financial parameters of incandescent light bulbs (ILBs) and compact fluorescent lamps (CFLs) in the GMS. Light-emitting diode (LED) bulbs, though not included in the comparison below, have a service life of 50,000 hours and use 6-8 W and the price per MWh is approximately half that of CFLs, although the total cost of acquisition is still higher per unit than ILBs or CFLs.

Figure 7. Comparison of Efficiency between Conventional and Compact Fluorescent Light Bubs

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[65] Building a Sustainable Energy Future: The Greater Mekong Subregion. ADB 2009.
[66] ADB. 2012. Overview: Greater Mekong Subregion Economic Cooperation Program
[67] ADB. June 2013. Same Energy, More Power: Accelerating Energy Efficiency in Asia.

Efficiency Comparison of ILB and CFL Technologies

	ILB	CFL
Power (W)	60	15
Lumens per watt (lm)	20	100
Output in terms of lumens (lm)	1,200	1,500
Utilization (hours per day)	5	5
Service life (hours)	1,000	8,000
Cost of one bulb ($)	0.5	2.75
Time horizon	8,000	8,000
Units for total time	8	1
Electricity use (MWh)	0.48	0.12
Energy Costs in $/MWh	60	60
Total costs of acquisition ($)	3.18	2.75
Total energy costs ($)	22.86	5.72
Total discounted costs[a]	26.04	8.47

CFL = compact fluorescent light bulb, ILB = incandescent light bulb, MESSAGE = Model of Energy Supply Systems Alternatives and their General Environmental Impacts, MWh = megawatt-hour, W = watt.

[a] 10% discount rate.

Source: Integriertes Ressourcen Management (IRM). 2008. *Economics of Energy Integration: Application of MESSAGE Model in the GMS.* Austria.

Source: Building a Sustainable Energy Future: The Greater Mekong Subregion. ADB 2009.

3.5.2 Opportunities

Energy efficiency has to be a key priority for reducing power demand growth. The greatest opportunities at this time, as noted, are in Thailand and Vietnam since they are economically much more advanced than the poorer members of the LMS. At the same time, working on energy efficiency and conservation in Cambodia, Burma, and Lao PDR, to the extent politically feasible to develop good energy efficiency standards may be especially productive because standards can be implemented during upcoming anticipated periods of rapid infrastructure development. In this setting, the opportunity to "leapfrog" to higher efficiency industrial equipment and systems (which may come at a lower cost than neighboring countries are willing to pay to upgrade or replace outdated energy infrastructure) will present considerable potential for further economic gain through investment and prioritization of energy efficiency. Furthermore, for poorer countries that will only slowly be able to develop significant levels of investment in renewable energy technologies, implementing efficiency standards across the energy sector will allow for more immediate gains in supply-side efficiency.

"Higher standards of energy efficiency support demand-management and mitigate problems of inadequate supply... They also help avoid the potential dumping of poor quality and inefficient products, an issue that may be of increasing concern to consumers in the face of rapid economic growth. Lastly, lower energy consumption reduces emissions and supports environmental sustainability."[68] Burma is already taking steps toward energy efficiency measures through building standards and codes and the Yangon Master Plan being supported by JICA, which promotes the

[68] World Economic Forum, ADB, Accenture. 2013. New Energy Architecture: Myanmar.

Japanese model for implementing energy efficiency. Vietnam also has standards for industrial buildings, and energy efficient building standards are partly mandatory for Thailand[69].

Through regional collaboration on renewable energy production in the LMS, infrastructure planning, and capacity building, the opportunity for enhancing energy efficiency is ever present. Improvements in energy efficiency contribute to moderating demand growth as well as improving energy security (and reducing emissions). In addition to reducing overall power demand and waste, prioritization of energy efficiency practices can help stimulate rapid technological innovation.

3.5.3 Challenges

Challenges to energy efficiency in the LMS are the same as the challenges to energy productivity improvements. These include management and organizational constraints, technical and informational limitations, financial and economic constraints, and policy and market-related limitations. Most countries in the LMS have begun formulating targets and programs for energy efficiency, though they are in the very early stages of implementation.

Because energy prices in the GMS are often set below cost-recovery levels, the financial benefits of energy efficiency are less apparent. Because of this, "potential beneficiaries of energy efficiency investment may face price distortions and high transaction costs, or they may lack sufficient information to understand or proceed with energy effiency projects. A lack of commercially attractive financing, high capital costs, and concerns about project risk can also dampen enthusiasm for energy efficiency uptake."[70] The proclivity toward addressing demand through expansion of generation capacity in LMS countries instead of implementing energy efficiency measures is directly attributed to a lack of government leadership or centralized agency to oversee wide-scale implementation.

3.5.4. Recommendations

As mentioned previously, energy efficiency is critical to a clean energy network as more efficient generation and end-use reduce overall energy demand and loss. Energy-efficiency measures rank high as they require considerably less investment to achieve the same amount of energy savings as would investment in supply options such as wind or solar PV, for example.

The fact that many of the same obstacles to energy efficiency are present across the LMS offers considerable scope for sub-regional collaboration and sharing of experiences. Especially for the LMS's large urban centers, USAID support for development of efficient mini grids may be the key to turning the challenges of rapid urbanization and rising energy demand into opportunities to exploit the potential of renewables for distributed power generation, hand-in-hand with demand side management by enhancing system reliability. Sharing American experience with efficient grid technology and demand side management practices will be especially valuable in this endeavour.

Because energy efficiency improvements require large scale policy reforms and institutional changes, USAID can work on a regional level to facilitate knowledge sharing and regional dialogue to achieve these goals in the LMS. Providing support and guidance in the establishment of energy

[69] ADB. June 2013. Same Energy, More Power: Accelerating Energy Efficiency in Asia.
[70] ADB. June 2013. Same Energy, More Power: Accelerating Energy Efficiency in Asia.

efficiency regulations and/or standards will also likely be easier if done on a regional level and can help ensure that some LMS countries are not put at a competitive disadvantage, which could result in the rejection of new standards. For the demand side, regional standards can be combined with labelling regulations for appliances and implemented in tandem with regional awareness-raising campaigns. Targeting economies of scale will make more efficient new technologies such as LED bulbs easily accessible, and public service campaigns are likely to make adoption faster.

To support regional dialogue and advancement in policy reform and implementation around energy efficiency, USAID can fund research that provides an in-depth analysis of existing energy subsidies across the region, including expert recommendations for timeframes and strategies to build back true cost-recovery pricing, followed by a regional workshop to develop and facilitate a regional action plan and targets for implementing these recommendations.

Regional dialogue can also focus on promotion of competitive energy markets, with appropriate regulation (and plan for periodic adjustments), and deliver further technical support to LMS countries for improving technology standards, building codes, spatial planning, regulatory enforcement, public awareness and education, and socio-economic incentives.

At the national level, as mentioned previously, the establishment of and/or support to ESCOs can also enhance and promote energy efficiency implementation through building capacity to conduct energy audits (and develop and implement energy-saving measures in response), retrofit existing equipment and infrastructure, capacity building and trainings for end-users and utility employees, M&E for impacts of energy efficiency measures, and identifying and accessing funding for these activities.

USAID can also seek out and establish partnerships with NGO and multilateral actors in the region that are also working on energy efficiency promotion to support country-based implementation of the LMS energy efficiency plan. For example, Enlighten is a UNEP initiative with GEF funding that aims to accelerate "a global market transformation to environmentally sustainable, energy-efficient lighting technologies… [It] promotes an integrated policy approach to ensure that all pertinent aspects are considered as each developing country creates its National Efficient Lighting Strategy. Elements include: minimum energy performance standards; supporting policies; monitoring, verification, and enforcement; and environmentally sound management."[71]

A final recommendation is to support research, in the region, on how climate change adaptation planning and measures will affect renewable energy technologies, including technology type, installation, construction requirements and other contingencies.

3.6. Smart Grid Development in the Mekong River Basin

3.6.1. Definitions, Scope and Potential

Although closely related to energy efficiency, this report treats smart grid development as a separate topic because its scope extends not only to energy saving but also to energy generation. The U.S. Department of Energy defines a *smart grid* as a modernized electrical grid that uses

[71] ADB. June 2013. Same Energy, More Power: Accelerating Energy Efficiency in Asia.

analogue or digital information and communications technology to gather and act on information, such as information about the behaviors of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.[72]

With the development of widespread electrification in the developed world during the 20th century, engineers and utility managers became increasingly concerned about the stability and reliability of the expanding electrical grid and, later about the efficiency and costs of electrical generation, transmission and end-use. Finally, and most recently, the power sector has become concerned with reliance on the old model of highly centralized, large-scale generation of power, which can pose pollution (including large CO^2 emissions) and security (terrorism) concerns. Smart technology and associated management practices addresses all three of these concerns in different though related ways.

Smart grid technology was made possible mainly by rapid advances in information and communication technology (ICT) from the 1980s until the present, especially the Internet, the global positioning system (GPS) and mobile telephony. For example, emerging transmission and distribution infrastructure is becoming better able to handle possible bi-direction energy flows, enabling a distributed generation system such as that which has been discussed in this report from photovoltaic panels on building roofs, wind farms, the use of fuel cells, charging to/from the batteries of electric cars, pumped hydroelectric power, and other sources.

The classic power grid was designed for the one-way flow of electricity from large, central generation installations (mainly using fossil fuels, large hydro or nuclear). If a local sub-network starts to generate more power than it consumes, this reverse flow may raise safety and reliability issues. A smart grid is designed to manage just these types of situations. The improved flexibility of the smart grid supports greater integration of highly variable renewable energy sources such as solar and wind power, even without the addition of energy storage. However, the current power network infrastructure, in most countries, is not designed to support many distributed feed-in points. Even if some feed-in is allowed at the local (distribution) level, the transmission-level infrastructure cannot accommodate it. Rapid fluctuations in distributed (usually renewable energy) generation, such as due to cloudy or gusty weather, also present significant challenges to power engineers. They will need to stabilize power levels by varying the output of more controllable generators such as gas turbines and hydroelectric generators to match the fluctuations in the distributed generation sources. Realistically, smart grid technology is a requirement for very large amounts of renewable electricity to feed into the grid from widely distributed sources. However, as we noted earlier, this is being done in Germany, among other countries already. Smart grid technology also is used to incorporate grid energy storage for distributed generation load balancing and eliminating or containing failures such as widespread power grid cascading failures by rapidly monitoring transmission and distribution line failures and making nearly continuous automatic adjustments.

The smart grid discussion above has focused mainly on the generation and transmission of electricity. Smart grid also covers technology that has the ability to reduce power consumption at

[72] US DOE. 2014. "Smart Grid/Department of Energy, **www.energy.gov**

the consumer side especially during peak hours, assuming a modernized power network is in place. This is called demand side management (DSM). The utility can directly exercise DSM adjusting end use heating and cooling, for example, during peak hours, especially in commercial buildings. Consumers, too, increasingly can manage their use of power with new computer or mobile applications enabling grid connection of distributed generation power, as described above but also enabling consumers to save money by reducing their power demand during peak hours or seasons through programming. The increased efficiency and reliability of the smart grid is expected to save consumers money and help reduce CO^2 emissions. Finally, this section will discuss the development of micro grids, based on distributed, renewable energy generation. Micro grids are likely to have the most likely immediate impact on rural electrification for many developing countries.

3.6.2. Smart Grid Development at the Country Level

Many large-scale renewable energy sources, e.g., off-shore wind farms, large solar arrays and large hydroelectric dam/reservoirs, are also relatively far from end users such as cities and industrial centers. Thus, the development of high voltage direct current (HVDC) transmission lines that can carry very large amounts of power with only small line losses is critical to the development of a distributed power generation network and the smart grid. An HVDC transmission line carrying thousands of megawatts might lose only 6 to 8 percent of its power over 1,000 miles. A similar AC line can lose 12 to 25 percent over the same distance. HVDC lines also can better manage the variable output from renewable power plants.

For the Mekong Basin countries, several policy drivers are supporting the development and use of the smart grid. For transmission improvements, the regional agreement to develop an ASEAN Power Grid requires common standards and greater reliability between cooperating countries. A common desire to increase economic competitiveness and improve ICT capacity to support both social and economic development objectives are also important policy drivers. Most Mekong Basin countries want to continue moving away from reliance on mostly imported fossil fuels and diversify into renewables while reducing GHG emissions at the same time. Countries like Thailand and Laos are already attracting foreign investment to build out HVDC transmission lines usually for large hydro purchases and developing the standards and related investments to support this investment.

While decentralized power delivered through micro grids with energy storage will likely play a fundamental role in meeting the demand for rural electricity in these countries, this development will still exist alongside the continued use of centralized power generation linking to long-distance transmission lines. Thus, HVDC transmission will be important for both conventional and renewable energy transmission.

Southeast Asia generally, including most of the Mekong Basin countries is predicted to have strong GDP growth of nearly 6% through 2018 and a corresponding growth in electricity demand. This demand will help lay the foundation for investment in the smart grid. Rural electrification programs and continued growth in renewable resources will also drive investment in this field.[73]

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[73] Northeast Group, LLC., "Southeast Asian Countries to Invest $13.6bn in Smart Grid Infrastructure"

Several countries in the region have drafted or are planning to develop smart grid roadmaps and pilot projects are emerging[74]. Regulatory frameworks are still developing but momentum will grow over the next several years. Both utilities and vendors are already working together to ensure preparedness when regulations are finalized.[75]

Most importantly, Southeast Asian countries, most of which are not endowed with large domestic supplies of traditional energy resources, except large hydro, will face severe energy challenges in order to sustain industrial development. These challenges can be met through both traditional resources (such as new coal and hydro power plants and even liquefied natural gas (LNG) imports) as well as non-traditional resources such as renewable energy, energy efficiency and smart grid. Countries that are currently looking more towards renewable energy and energy efficiency are likely to set regulatory frameworks to support smart grid in the near term. These regulations are likely because of the direct role that smart grid infrastructure plays in supporting these as described above.[76]

Pike Research forecasts that the earliest smart grid growth in Southeast Asia will likely occur in transmission upgrades – both increases in the load capacity of transmission lines as well as the use of HVDC. Most nations in the region are developing power plants: hydro, thermal, natural gas and even some coal-based plants. They foresee transmission upgrades experiencing strong growth throughout the forecast period (2011-2020) and that these grids will be well-suited to the use of smart grid technologies.[77]

As noted in the previous section, Thailand is a regional leader in the development of renewables for power generation. It is also the leader in smart grid development. As with several other Mekong countries, it is beginning with pilot projects. One of the most interesting is in the tourist city of Pattaya. This pilot is part of the "Thai Smart Grid-Roadmap". The three-year Pattaya pilot project started in 2014 involving 26 communities to supply a 300 megawatt power demand through an "optimized demand-response-system" using smart meters and the integration of solar and other small renewables as well as efficiency improvements. Smart Grid development with renewables integration is also being developed for the northern province of Mae Hong Son. Other business opportunities under the Roadmap framework include substation and distribution automation, utility enterprise applications, micro-grid systems (for remote islands) and electric vehicle charging stations.[78]

In Vietnam, power demand and supply is expected to increase four-fold in the next 1- 12 years. Vietnam is currently introducing electricity market reform and openings for investment to be completed by 2022. These reforms will include most of the critical steps for efficiency: automation of grid infrastructure, the introduction of SCADA (supervisory control and data acquisitions) systems, HVDC, quality improvements in the distribution network, expansion of underground cable

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[74] Thailand is the most advanced country in this sector. EGAT developed the Thailand Smart Grid Policy Plan and Roadmap, which is being implemented by the Provincial Electricity Authority.

[75] Ibid., p. 1

[76] Northeast Group, LLC, Southeast Asia Smart Grid - Market Forecast (2012 – 2022), n.p.

[77] Kaften, "Indonesia, Thailand, Cambodia Lead Southeast Asia's 'Light Brigade'", p. 1.

[78] Kirsch, Smart Grid in Thailand and Vietnam, n.p.

and electric transport systems as well as a systematic project and tender design for smart grid solutions.[79]

In Cambodia, the electricity authority is building a pilot project to test a smart grid solar power generation system on its own grid for now but one that would be larger than a micro grid. The rationale for a solar smart grid installation is: 1) the system can be installed anywhere, unlike other types of renewable power generation e.g., wind power, which has to be installed at places with a constant strong wind; 2) A solar smart grid system can be designed to corresponds closely to an immediate adjacent demand source (in this case, an industrial estate) and can be scaled upwards in modular fashion as demand increases; and 3) It enables a stable supply of high-quality electric power when combined with a power storage facility. This pilot will be located just to the north of Phnom Penh.[80] Laos and Burma are both interested in similar pilots using smart grid and renewables in local grids.[81]

One of the most interesting applications of ICT and renewable energy that is a variant on the smart grid is the emergence of micro grids. Currently, many mobile phone transmission towers are unconnected to national grids and so have relied on diesel generation sets for their power, which has become quite costly as the number of towers has multiplied. However, recently, mobile phone companies are erecting solar arrays to supply auto-generated power for their towers. In some cases, the mobile phone company owns both the tower and the solar array and battery backup. Increasingly, the mobile telephone companies (or telcos) are using a third party outsourced model often using an energy service company (ESCO). In this model, the mobile telco outsources the energy supply aspect of telecom network operations to a third party which specializes in the energy business and has sufficient investment capital as well as operational expertise to provide uninterruptible power supply to telecom sites. In this model, the ESCO would completely own the onsite power generation as well as the supply of power to the base station sites, thus reducing the burden of deploying and managing the power plant which currently is the responsibility of the network operator or (in some cases) the company that owns the tower, if separate from the mobile telco.

The ESCO model also provides an opportunity to focus on **community power models** with the transmission tower essentially acting as an "anchor tenant" would in a shopping mall. With a very low electrification rate, countries like Burma present an excellent opportunity to leverage the growing telecom tower infrastructure to provide energy to surrounding communities. But this model is being embraced by other Mekong Basin countries as well. With the recent focus on rural electrification, led by various

Mobile Communications Tower and Associated Solar Power Array in India

[79] Ibid., n.p.

[80] ITOCHU Corporation, Feasibility Study for Promotion of International infrastructure Projects in FY2014: Study on the Smart Grid Project in Outskirts of Phnom Penh, p.1.

[81] Burma is developing a large 200 MW solar power plant that will need to be integrated into the existing conventional grid using smart grid technology and Laos' Electricite du Laos is currently developing ICT technology to address the deficiencies of its very outdated control system for transmission and distribution, in particular.

government programs, the ESCO run micro grids are better positioned to provide power to a telecom tower as well as providing access to affordable energy services to the communities on some kind of a fee for service basis.

3.6.3. Challenges and Opportunities

The challenges facing smart grid development are similar to those facing the regional grid development or renewable energy generation in this region. In most countries, standards (both ICT and generation and transmission standards need to be modernized and made uniform across the region. Policy incentives, especially those for attracting domestic and foreign investment need to be developed though most of the Mekong Basin countries readily recognize the high benefit/cost ratio of investing in smart grid, while recognizing that the process will necessarily be gradual given the scale of the transformation involved. However, a more distinct challenge for the smart grid is that it can often be difficult to quantify smart grid investment's benefit to the overall economy, because there are, as yet, no commonly accepted and/or robust methodologies to translate smart grid benefits into economic value-added. The result is that some utilities are struggling to move their smart grid initiatives, such as smart metering and distribution automation projects, beyond the pilot phase. This is especially the case for the poorest Mekong Basin projects but progress in Vietnam also has been slower than expected in part because of the scale of investment required.

As described in this section, smart grid was greatly enabled by the development of ICT, especially mobile telephony and the Internet. Probably, the greatest immediate investment opportunities lie in the development of micro grids and associated community power utilities whether based on the mobile telco tower model or a modular development (starting with solar-powered schools and clinics or small businesses) that may include a micro-payments system for household power.

3.6.4. Recommendations

Smart grid technology and associated best practice is a rapidly emerging field worldwide not just in developing countries or the Mekong Basin in particular. This is especially the case for integration of distributed renewable energy generation and transmission using the smart grid. This situation provides an opportunity for USAID to support the development of communities of practice among professionals working in this field in the United States and the Mekong Basin countries. The objective of these communities would be to exchange knowledge, case studies, replicable models and best practices. In addition, as is the case currently with USAID climate change activities, these communities might also help identify opportunities for joint field activities, training, policy reform and institution building including both the public sector utilities and regulators and private sector generators and users of power.

A second recommendation focuses on the role of the private sector in foreign investment. Currently, European companies, especially German companies are making investments throughout the Mekong Basin in smart grid technology. In part, this reflects the widespread use of the smart grid in Germany itself. In this context, USAID might consider assisting U.S. companies and American ESCOs investing in smart grid technology to become better acquainted with potential market opportunities in the Mekong Basin where opportunities for investment exist. There are also potential opportunities for combining climate mitigation and low emission development strategies assistance activities with smart grid assistance.

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ANNEXES

INTRODUCTION TO ANNEXES

The following annexes include additional background information that, while relevant for attaining a complete understanding of the context for introducing clean energy technologies to the LMS, was deemed too detailed for the intents and purposes of this report overall. For instance, more information is readily available on renewable energy development across the Greater Mekong Subregion as a whole, which includes all LMS countries plus China. As was referenced in the report, progress and planning of the GMS has direct implications for development planning in LMS countries, including that of renewable energy production and trade. The most relevant GMS-related information is therefore provided in this annex to broaden and deepen readers' contextual understanding of power generation, purchasing and trading, and integration across the LMS as part of the GMS. Additional LMS-specific information is also included. The annex is broken into 5 sections and labelled according to topic or theme. For readers' ease of reference, annexes also include a link to the section in the above report with which it most directly corresponds.

ANNEX I. OVERVIEW OF RENEWABLE ENERGY POTENTIAL AND REGIONAL DEVELOPMENT PATTERNS

Worldwide, in 2009, renewable power accounted for more than three times as much installed capacity as nuclear power, and roughly 38% as much installed capacity as fossil fuel-burning power plants. Hydropower (of all sizes) accounted for an estimated 990 GW and 16.5% of global installed capacity. Excluding hydropower of all sizes, other sources of renewable energy-based installed electrical capacity totalled 480 GW in 2012 and made up 5.2% of total power generating capacity.[82]

Worldwide, renewable energy currently supplied more than 26% of global generating capacity at the end of 2012[83]. Developing countries account for 33% of renewable energy generation (not including hydropower) and 50% where hydropower is included as well. However, this level of capacity is dominated by the BRICS countries and in Asia, by China and India[84]. Hence, renewable power sources are becoming increasingly important in the total power mix but with large-scale hydropower still by far the single dominant resource.

By 2030, installed electricity generation capacity is expected to double from current levels in Southeast Asia, India and China: This increase in generation capacity includes all available energy sources:[85] including electricity from coal (up 77%); natural gas (3x); nuclear (12x); biomass (50x); hydroelectric power (up 44%) and oil (down 15%). Overall coal's share decreases from 69% to 59%. For East and Southeast Asia, hydropower is a major source of energy (supplying over 42% of Vietnam's primary energy demand, over 26% for Indonesia and India, 20% for the Philippines, 19% for Thailand, and 10% for China)[86]. Moreover, production of hydropower is predicted to rise by 44% over current levels (i.e., from 2008 to 2030), but the share of hydroelectric power in overall

[82] Renewables 2013 Global Status Report, p.13
[83] ibid., p.13
[84] ibid., p.13
[85] USAID/Asia : Energy Trends in Developing Asia: Priorities for a Low-Carbon Future, 2011, p. 17
[86] ibid. p.27.

electricity production will drop from 18 to 13% due to an increase in other conventional and unconventional sources of electricity[87].

Exhibit A1 summarises the total realizable mid-term potential for renewable energy technologies (RETs) in the ASEAN-6 countries according to the IEA (published 2009).[88] As the table indicates, a sizeable power potential exists over a variety of sources notably solar, wind and water. However, biomass resources for power and heat are also considerable. Geothermal energy has the most skewed distribution since it is directly related to the extent of a nation's geotectonic activity. With the exception of large-scale hydropower, these resources are by nature distributed and, in many cases, intermittent without significant storage systems. Occasionally, different power sources can be combined, e.g., using solar or wind power to pump water into an upstream reservoir and then releasing the water to power a turbine and generate electricity when the solar and wind resources are not available.

Even though the opportunities for renewable energy technologies (RETs) are significant in the Mekong River Basin, actual investment, construction and operation lags far behind this potential with the notable exception of large hydropower installations. The cumulative potential for the LMB is enormous with 30,000 MW of installed capacity just for large hydropower alone. Unfortunately, with the exception of Thailand and Vietnam, data are lacking for the non-large hydro, renewable energy potential of the LMB and even the data for Vietnam and Thailand should be regarded cautiously. Nevertheless, the data in Exhibit 15 gives some order of magnitude sense of clean energy potential in the region.

The overall realizable potential covers the exploited potential and the potential to be realized until 2030. The share of individual non-hydro RETs is relatively small. However, if it was possible to use all of the energy potential in the above table to its full extent, the realizable potential could be nearly double (minimum of 1.8 times for 2030) as much as the ASEAN-6 combined electricity demand in 2007.[89]

It is most likely that many RET promoters are going to pursue a best-practice-strategy of technology diffusion after 2020. "A best-practice path of technology diffusion is characterised by high levels of annual growth often associated with the implementation of effective policies, as in many of the current market-leading countries."[90]

Figure A1 represents the "dynamic contribution to realizable [renewable energy source – electricity] RES-E generation potential" in the timeframe of 2007 to 2030 as a share of the total gross electricity demand for the ASEAN-6 countries.[91]

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87 ibid, p.26.
88 Deploying Renewables in Southeast Asia: Trends and potentials, IEA, 2010, p. 61

89 ibid, p. 62
90 s. Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 62:
" Underlying the high realisable RES-E potential in 2030 is accelerated growth in additional deployment after 2020, as many RETs are anticipated to follow a best-practice path of technology diffusion only in 2020 or shortly thereafter."
91 ibid, p. 63.

Exhibit A1: Overview of Absolute Realizable RET Potential (mid-term perspective) by Country and Technology

Total realisable generation potentials for RE to 2030 (in TWh)	Indonesia	Malaysia	Philippines	Singapore	Thailand	Vietnam	ASEAN-6
Renewable electricity							
Biogas	55.43	7.41	20.23	1.14	17.90	21.64	**123.75**
Solid biomass	69.58	25.95	15.19	0.11	25.91	38.68	**175.41**
Renewable municipal waste	7.71	1.06	3.02	0.21	2.41	2.85	**17.26**
Hydropower	60.80	50.34	17.83	0.00	14.66	74.21	**217.83**
Onshore wind	41.75	22.77	15.65	0.08	37.97	29.09	**147.31**
Offshore wind	21.34	13.39	6.96	0.22	19.42	14.87	**76.21**
Geothermal electricity	84.66	0.00	28.96	0.00	0.02	0.00	**113.63**
Solar photovoltaics	61.70	12.37	20.44	0.02	32.95	27.26	**154.75**
Solar thermal electricity	0.44	0.04	0.08	0.00	0.13	0.01	**0.69**
Tidal and wave energy	0.66	0.14	0.22	0.00	0.12	0.11	**1.25**
Biofuels (domestic)*							
1st generation biofuels*	25.74	5.56	1.55	0.00	3.11	1.66	**37.62**
2nd generation biofuels*	43.87	11.20	12.79	0.00	24.00	16.74	**108.61**
1st generation bioethanol	24.90	5.24	1.55	0.00	2.66	1.66	36.01
2nd generation bioethanol	33.78	8.04	8.28	0.00	16.29	11.13	77.51
1st generation biodiesel	25.74	5.56	1.06	0.00	3.11	0.14	35.60
2nd generation biodiesel	43.87	11.20	12.79	0.00	24.00	16.74	108.61
Renewable heat							
Biomass heat (CHP, mainly autoproducers)	42.73	13.91	13.26	0.69	17.35	19.67	**107.61**
Biomass heat (small-scale, off-grid)	8.82	7.02	3.61	0.15	1.37	22.35	**43.32**
Geothermal heat	14.48	0.36	3.60	0.00	1.62	1.89	**21.95**
Solar thermal heat	24.10	7.81	2.09	0.09	12.19	5.91	**52.18**

Note: Expressed data refer to the biofuel option characterised by the highest yield – depending on the specific feedstock – among the competitive pathways (*i.e.* biodiesel versus bioethanol). It is important to note that the potentials for the alternative pathways are not additive.
Source: Based on IEA calculations and Resch, 2009.

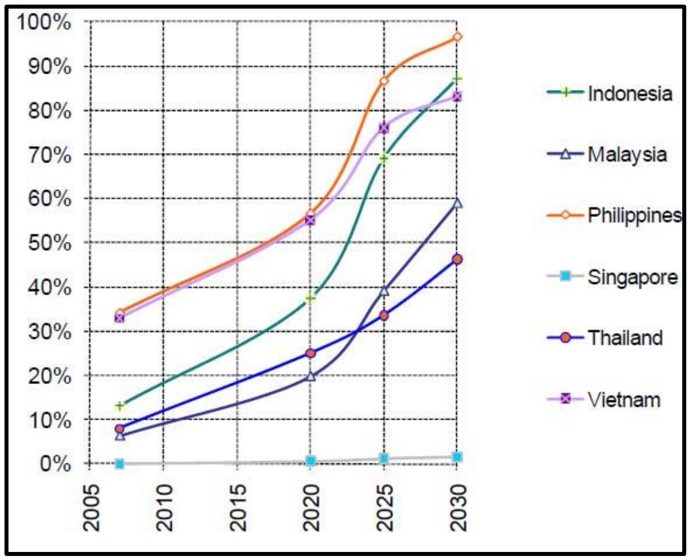
Source: Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 61

For Indonesia, Malaysia, Philippines, Thailand, Singapore, and Vietnam, the sum of the realizable potential in 2020 corresponds to a sizable share of projected electricity demand. Over the subsequent decade to 2030, as the deployment of renewables accelerates, renewables' share of electricity demand increases by at least half in all countries, and even doubles in the case of Indonesia and triples in Malaysia.[92] As noted, this report does not provide equivalent estimates for the poorer LMB countries; though there is certainly a significant non-hydropower potential and small-scale pilots and investments have been occurring. Given the mostly rural nature of the population and low current access to electricity, renewables could actually play a much greater

[92] s. Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 63 and based on the IEA World Energy Outlook 2009

share of total electricity generation than for Vietnam and Thailand during this timeframe if adequate policy and institutional reforms and investments are realized. Certainly, these rural areas represent a very significant latent demand for power.

Figure A1: Realizable RES-E Generation Potential as a Share of the Total Gross Electricity Demand for the ASEAN-6 Countries, 2007-2030



Source: Deploying Renewables in Southeast Asia (Trends and potentials), 2010, p. 63 and IEA calculations and Resch, 2009

ANNEX II. EXISTING POWER TRADING PATTERNS WITHIN THE GREATER MEKONG SUBREGION

In 2005, through a memorandum of understanding (MOU) (which was reinforced by a second MOU in 2008), the GMS countries committed themselves to a roadmap for phased development of a sub-regional power interconnection, which is comprised of four stages[93]. The goal of the GMS regional power network agreement, called the Inter-Governmental Agreement on Regional Power Trade (IGA) is to create a low carbon, stable and reliable power grid for the region that will meet the future power growth requirements of the region's countries. Currently, the GMS countries are still at Stage 1, which corresponds to the regional power transactions that are possible currently and in the near future, with development of the first cross border connections. Stage 1 is designed to take advantage of the surplus capacity of cross border transmission facilities that were developed and linked to power purchasing agreements (PPAs). In this stage, transactions would be possible only between pairs of neighbouring countries.

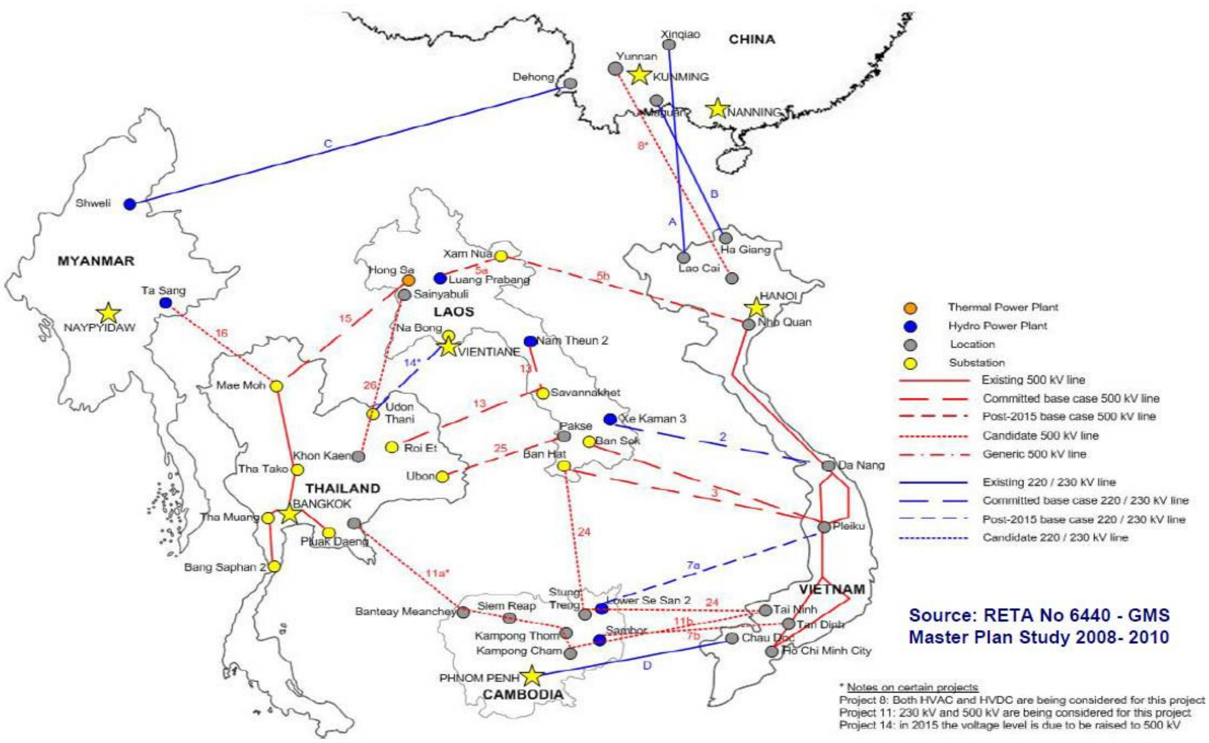
The major issue facing a future integrated GMS power market appears to be whether and when to move ahead to Stage 2, at which time the market would become "formalized" with permanent institutions in place alongside a formal Grid Code, transit tariffs, and rules for short-term cross-border power trading. Currently, under Stage 1, trade is almost wholly in the form of bilateral

[93] The four stages of the IGA are described in detail in **The Potential of Regional Power Integration: Greater Mekong Subregion (GMS) Transmission & Trading Case Study**

agreements between national utilities (or national utilities and independent power projects located in neighbouring countries). Hence, GMS member countries remain free to determine the conditions of trade and when trade will take place without any specific strategic coordination. Existing institutions do not have permanent offices or staff and largely act as a means of coordinating the activities of national utilities in developing mechanisms that can form the basis for a future regional market. While the GMS countries have committed to the "Road Map" described above, which includes activities to prepare for Stage 2, there is, as of yet, no formal agreement committing to the implementation of this stage by a given date. The Vientiane Plan of Action[94] refers only to projects related to Stage 1 of the regional power market, with dates for the commissioning of these projects extending out to 2016.

Figure A2 shows the planned connections in the GMS region projected out to the Year 2025 from the master plan developed for the GMS in 2010. These linkages are a part of the ASEAN Power Grid development

Figure A2. Planned Power Interconnections in the GMS by 2025



Source: Lefevre, 2012, Facilitating Regional Power Trading PowerPoint presentation

[94] Signed in 2008 but all GMS members, which includes a 5-year comprehensive plan of action for GMS Development, including transport and energy, and with prioritization given to establishing a sustainable and efficient energy supply market.

ANNEX III: TECHNICAL AND REGULATORY BARRIERS TO EXPANSION OF REGIONAL POWER TRADING

Regional institutions need to be set up and strengthened before the GMS countries can move on to the second stage of regional power trading. This will include the development and adoption of technical standards. Agreements are needed on (i) performance standards; (ii) regional communication, operational planning and coordination procedures, and protocols between system operators; (iii) metering arrangements for grid-to-grid interconnections and trading; (iv) regulation and regional trading rules; (v) periodic revision of a regional master plan for cross border investments; (vi) dispute resolution mechanisms; and (vii) a regional regulatory body. While the expectation is that this regulatory regime will apply to conventional sources of power (including large-scale hydropower), in principle, it would apply to any energy source supplying electricity to the grid whether those were GMS-wide, LMS-wide, or national and sub-national grids.

The bilateral power trading that now exists (Stage 1) will gradually evolve into multiparty trading with transmission lines connecting several countries. However, this cannot take place until the need to develop capacity and technical skills in the utilities and government agencies that will be involved is addressed—which is a process that is expected to take several years. As such, the immediate priorities for technical assistance are (i) to define a road map for regional power trading that describes clearly the steps and milestones towards a regional power market, (ii) to define the activities to be undertaken and resources required to implement these activities, and (iii) to build the necessary institution(s) and address capacity-building needs. While these are recommendations that are applicable for the broader GMS, assistance for these steps is especially of need in LMS countries.

The three economically larger countries in the GMS—China (Yunnan), Thailand, and Vietnam—have all established national grids based on a 500 kV transmission voltage level, which is what would be required for a regional grid. However, the three economically smaller countries—Burma, Laos, and Cambodia—do not have a nationwide grid system, and they also do not have national load dispatch centers in operation yet. Though in Laos, such a national load dispatch center is currently under construction.

Laos, which commands the most central position in the GMS in terms of regional power trade because of its enormous hydropower export potential, has so far only 115 kV as its main transmission voltage, and still lacks a connection to the southernmost part of the country. The higher voltage level, 230 kV, is under implementation, but for effective regional power trade it would require the construction of a 500 kV grid for Laos. The situation is more or less the same in Cambodia. Burma would also need to develop a 500 kV transmission system, because of its large hydro export potential. This is a challenge, since there is currently no financial viability for the larger investments needed, but regional power exchange cannot take place without a proper transmission infrastructure.

The implications of this situation are that the large importers are securing their electricity needs in the way that best suits them. Thus, the independent power project/build-operate-transfer (IPP/BOT) model, with dedicated transmission lines to the purchasing country, appears to be the most popular model. This results in imported power being "tied up" under PPAs of 25 years and more.

So far, private investors are looking much more to invest in generation projects rather than transmission projects. There are substantial costs to developing "backbone" grids with 500 kV transmission lines in Laos, Cambodia and Burma, and it may be that only public sector financiers, like the World Bank or the ADB would be interested in supporting these investments. Even in Vietnam it is estimated that the investments required for transmission lines would be on the order of USD 700 million to one billion per year for the next five years.[95]

The institutional and regulatory frameworks in the GMS are in vastly different stages from one another. Perhaps the most important challenge is that two of the six GMS countries do not even have energy regulators at all (Laos and Burma), while the regulators are not necessarily in a strong position in the other countries, since they may lack adequate staff, capacities and the required regulatory independence to carry out their mandates effectively. Thus, a whole host of factors required for regional power trade to take place at all cannot exist in the absence of regulators and regulatory frameworks. Expanding outwardly in scope to examine the long-standing barriers to regional power integration across ASEAN countries, the following are identified:

- Cross-border licensing;
- Expropriation of assets;
- Contractual confidentiality, if justified;
- Consumer protection and safety standards, including grid codes;
- Anti-competitive practices;
- Third party access to transmission systems;
- Investment recovery;
- Information access;
- Double taxation agreements;
- Import and export restrictions on electricity;

This long list of regulatory barriers to ASEAN interconnection applies directly to the GMS as well. These barriers will have to be tackled at both national and regional levels if a regional power market is to be established in the GMS. While some work has already been done on grid codes, a top priority for bilateral trade from the list above will be arranging for third party access to transmission systems. [96]

[95] Review of the GMS Regional Power Trade and RETA 6440 (2011), p.29
[96] Ibid., pp. 29-30

ANNEX IV. ROLE OF THE PRIVATE SECTOR IN REGIONAL POWER INTEGRATION

Challenges to regional power integration related to private sector investment patterns mainly have to do with independent power projects. The main issue here is that private investors, generally in consortiums, are starting to create an "energy landscape" in Laos, Cambodia and Burma that is based on IPPs with dedicated transmission lines to export power based on long term PPAs to neighbouring countries, as noted. Such arrangements then become part of the list of barriers described above, since there winds up being no third party access to the transmission system (not even by the host country's utility).

As mentioned in Annex II, with the IPP – BOT model of investment, unless the exporting country is able to negotiate well, the PPAs will likely tie up electricity for approximately 25 years. If this situation continues as it has so far, especially in Laos, then the opportunities for broader regional power trading (as opposed to bilateral trades) will remain minimal. In Laos, the national electricity authority does not even have access, let alone control of the "export" transmission lines that have been constructed by the power developers.

If national utilities are not able to access these transmission lines, or buy them back, this has implications not only for future development of regional power trading, but also for potentially serious social and environmental aspects, especially if multiple transmission lines have to be constructed from projects to the national power authority's grid in Thailand.[97]

ANNEX V. SOURCES OF FINANCE FOR PRIVATE POWER GENERATION PROJECTS IN THE LMS

Several patterns have emerged in the financing of power generation in the LMS. First, private sector finance has been much more interested in power generation projects than in power transmission/distribution projects, with the exception of the PPAs described above with their dedicated transmission lines. Second, financing of these projects is generally through syndicated loans consisting of groups of regional banks, both public and private, and sometimes with the participation of large regional construction engineering firms. However, China is increasingly participating in the financing and construction of large hydroelectric dams beyond its borders. This is notably the case in Africa, but China also was financing the giant Myitsone Dam in Burma before the government stopped the project due to its large social and environmental impacts.[98] Chinese international hydropower project finance is dominated by state-owned hydro-engineering companies, such as Sino Hydro, but also the Chinese ExIm Bank, China Export and Credit Insurance Corporation and the China Development Bank.[99]

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[97] Ibid., pp. 30-31
[98] Chinafolio, 2013, **http://www.chinafolio.com/hydro-power-and-hydro-hegemony/#building-dams-abroad**
[99] Ibid.

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