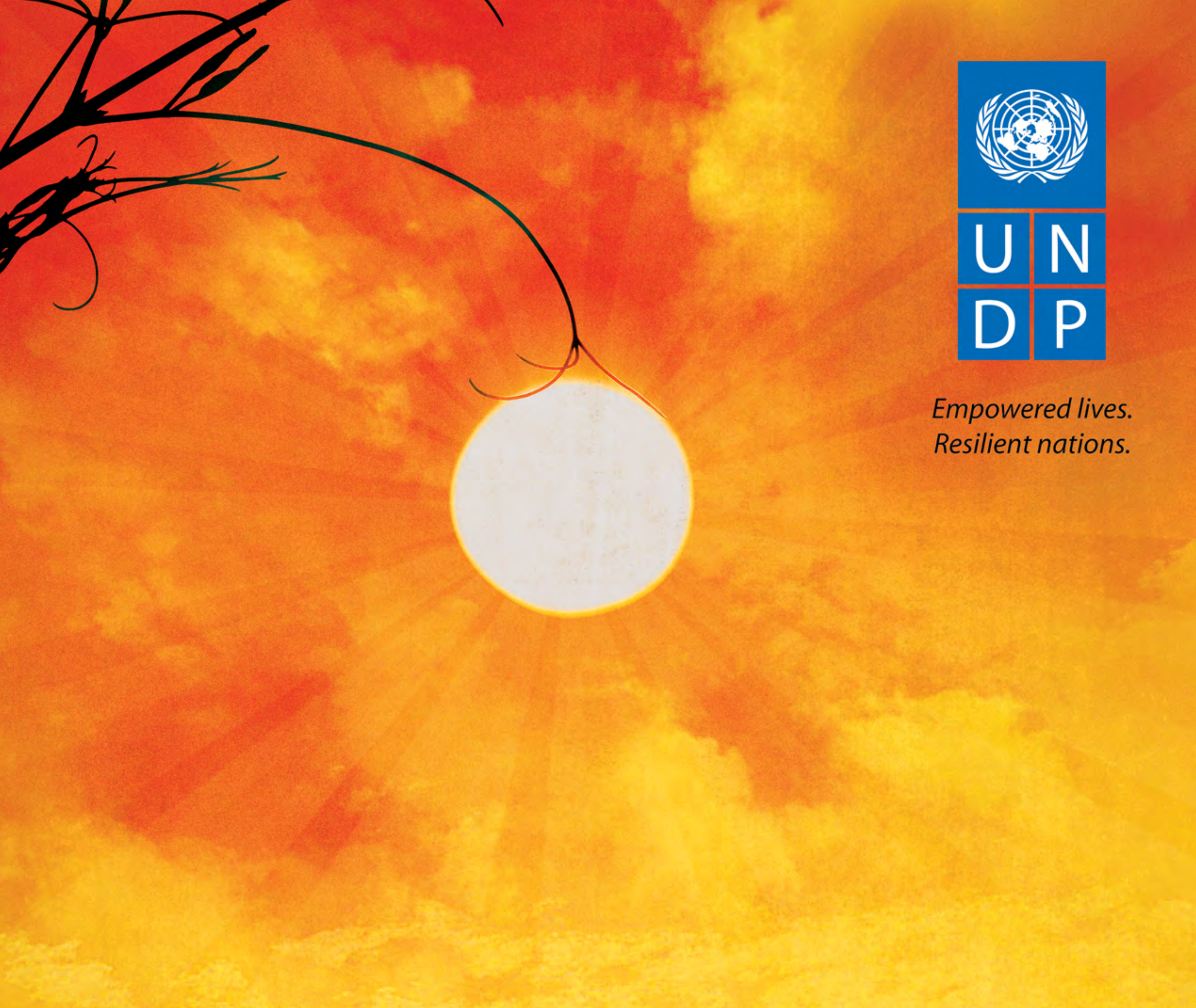

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ACCELERATING ENERGY ACCESS FOR ALL IN MYANMAR

United Nations Development Programme
MYANMAR

MAY 2013

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EXECUTIVE SUMMARY

In 2011, the secretary general of the United Nations launched an initiative to ensure universal access to energy by 2030. The initiative is called "Sustainable Energy for All" (SE4ALL), and has a threefold goal: Universal access to energy, double the rate of improvement in energy efficiency and double the share of renewables in the global energy mix by 2030.

Although the SE4ALL initiative encompasses three separate goals, improving access represents perhaps the most urgent one. Dependence on traditional fuels produces more significant and severe immediate impacts such as millions of premature deaths, mostly among women and children, throughout Asia. Meeting basic energy needs is an elemental first step for realizing other SE4ALL goals and, more so, the Millennium Development Goals such as higher incomes, longer lives, and gender equity. Electricity, renewable energy, and energy efficiency have an important role to play as well. When promoted under an "Energy Plus Approach" which emphasizes using energy for productive purposes, such technologies can modernize parts of Myanmar's economy, cut greenhouse gas emissions, and improve standards of living simultaneously.

This report examines energy access challenges in Myanmar, and what types of domestic mechanisms are well suited to address those very challenges. Hence, its primary purpose is to present basic reference data concerning the energy resources, challenges, and solutions for energy access in Myanmar, and to form a basis for a partnership consultation to design a National Rural and Renewable Energy Access Programme. To meet these tasks, the report begins by providing background information on energy poverty in Myanmar, including the most up-to-date data on primary energy consumption, electricity supply, rural energy, and energy resources. It notes, for example, that only 13 percent of the country's population have access to the national electricity grid, and that almost 95 percent depend on solid fuels such as wood and rice husks for cooking and heating.

National planners and development partners, however, can utilize a variety of mechanisms to overcome these challenges. To combat energy poverty, they can offer financing and micro-financing for renewable energy technologies and energy-efficient end-use equipment as well as woodlots for fuelwood management and nurseries for energy crops. . Tapping the country's extensive hydroelectric resource potential could also provide a much-needed source of electricity for the national grid. Furthermore, planners can create community development funds to promote women's and disadvantaged groups' empowerment as well as offer skills training. They can build the technical capacity of policy-makers to collect data about energy throughout the country, implement education and awareness campaigns for households and private sector entrepreneurs, and decentralize energy access programmes to communities themselves. The government can promote public private partnerships for larger, grid-connected wind farms, large-scale hydroelectric dams, geothermal power plants, biomass power plants, waste-to-energy facilities, and liquid biofuel manufacturing facilities. Planners can harmonize regulatory authority for energy access to a single agency, establish a rural renewable energy promotion center, create national technology standards to ensure technical quality, and construct maintenance and training centers to ensure communities care for energy equipment ensuring an effective local energy service delivery mechanism. They can lastly enhance community involvement in energy planning and integrate energy access efforts with other development goals.

Photo Credit

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CONTENTS

INTRODUCTION

In 2011, the Secretary-General of the United Nations launched an initiative to ensure universal access to energy by 2030. The initiative is called "Sustainable Energy for All" (SE4ALL), and has a threefold goal: Universal access to energy, double the rate of improvement in energy efficiency and double the share of renewables in the global energy mix by 2030. 2014-2024 is named the Decade of Sustainable Energy for All, and Myanmar has all the characteristics of a country that can benefit from the priorities of this initiative.

Myanmar, notwithstanding its plentiful hydroelectricity resources and incredibly rich cache of biodiversity, is the least developed economy in Southeast Asia.[1] In 2012, per capita Gross Domestic Product (GDP) was about $850, compared to $1,015 in Cambodia, almost $1,400 in Lao PDR, and more than $5,500 in Thailand. Table 1 illustrates some of the country's basic economic, social, and environmental indicators.[2] They reveal that Myanmar faces a unique, and daunting, set of energy access and security challenges, and it is in urgent need of energy systems that can build resilience and contribute to productivity and economic development.

In the realm of energy access and energy poverty, the official electrification rate is 13 percent, and a majority of households (95 percent) depend on solid fuels such as wood and rice husks for cooking and heating.[3] In the rural context, the national power grid network covers only 7 percent (4,550 villages) of the country's 65,000 villages, meaning millions of people are deprived of access to electricity services for enhancing their livelihood requirements.[4] Most rural villagers spend 233 hours a year (about 20 hours a month) collecting fuelwood that contributes to deforestation and also inhibiting household productivity; more than two-thirds (70 percent) of households depend on diesel lamps, batteries, or candles for lighting. Indeed, the International Energy Agency has calculated that Myanmar has the poorest

Table 1: Overview of Myanmar's Statistical Indicators, 2008-2012

Economic	2008	2009	2010	2011	2012
GDP ($ billion, current)	20.2	31.4	35.2	45.4	51.9
GDP per capita ($, current)	351	537.3	595.7	759.1	856.8
GDP growth (%, in constant prices)	5.5	3.6	5.1	5.3	5.5
Agriculture, livestock, fisheries, and forestry (%, in constant prices)	8	3.4	4.7	4.4	4.4
Industry (%, in constant prices)	21.8	3	5	6.3	6.5
Services (%, in constant prices)	12.9	4.2	5.8	6.1	6.3
Consumer price index (annual % change)	32.9	22.5	8.2	7.3	4.2
Liquidity (annual % change)	20.9	23.4	34.2	36.8	33.3
Overall deficit (% of GDP)	-3.8	-2.4	-4.8	-5.7	-5.5
Merchandise trade balance (% of GDP)	4.6	1.6	2	0.8	0.0
Current account balance (% of GDP)	0.6	-2.2	-1.3	-0.9	-2.7
External debt service (% of exports of goods and services)	4.6	5.1	4.3	3.1	3.9
External debt (% of GDP)	37.5	25.8	24.4	24.8	22.8

Poverty and Social	2000	Latest
Population (million)	50.1	60.6 (2011)
Population growth (annual % change)	2	1.3 (2009-2011)
Maternal mortality ratio (per 100,000 live births)	420 (1990)	240 (2008)
Infant mortality rate (below 1 year/per 1,000 live births)	79 (1990)	50 (2010)
Life expectancy at birth (years)	59.9	62.1 (2009)
Adult literacy (%)	89.9	92 (2009)
Primary school gross enrollment (%)	100 (1999)	126 (2010)
Child malnutrition (% below 5 years old)	34.3 (2005)	32 (2010)
Population below poverty line (%)	32.1 (2005)	25.6 (2010)

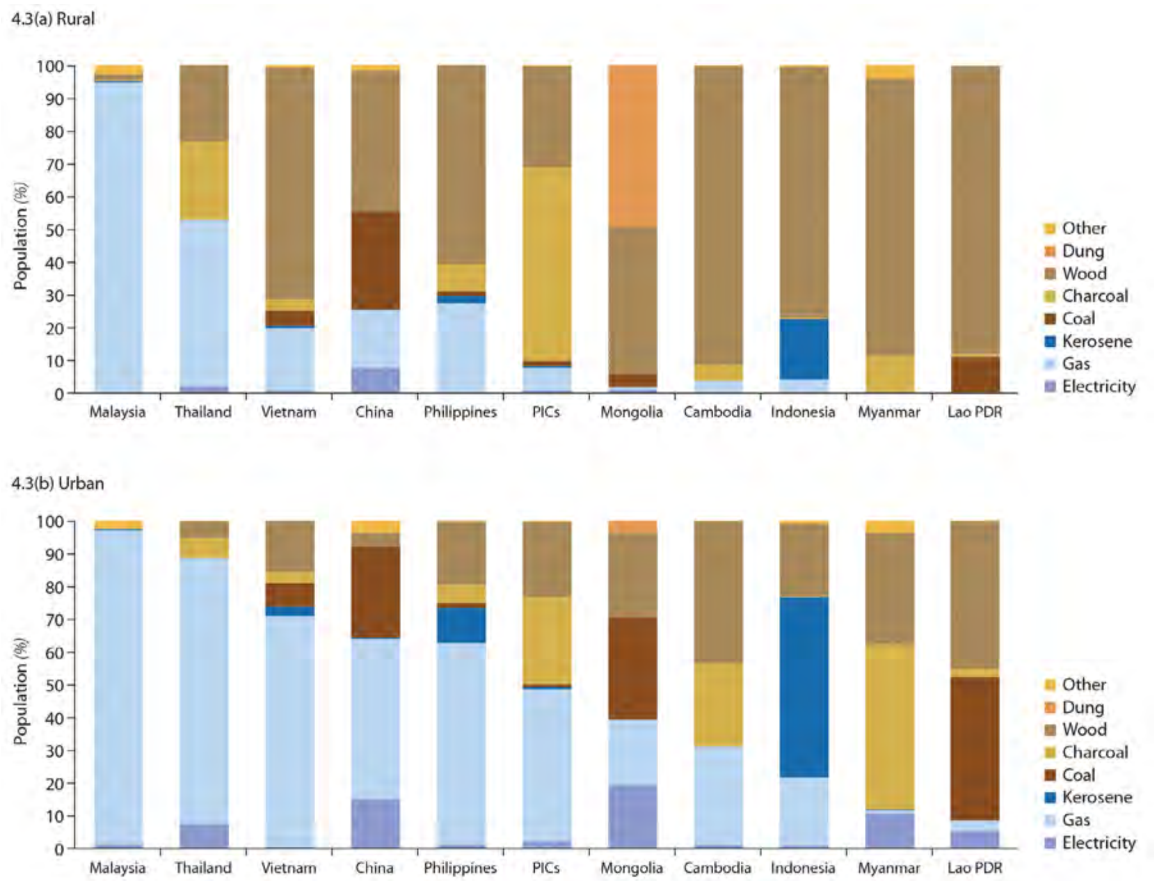
Source: Asian Development Bank 2012.

Table 1: Overview of Myanmar's Statistical Indicators, 2008-2012 (continued)

Population with access to safe water (%)	62.6 (2005)	69.4 (2010)
Population with access to sanitation (%)	67.3 (2005)	79 (2010)
Environment	**2000**	**Latest**
Carbon dioxide emissions (thousand metric tons)	4,276.00 (1990)	12,776.00 (2008)
Carbon dioxide emissions per capita (metric tons)	0.1 (1990)	0.3 (2008)
Forest area (million hectares)	34.9	31.8 (2010)
Urban population (% of total population)	28	33.9 (2010)

Source: Asian Development Bank 2012.

Figure 1: Cooking Fuel Profiles for Selected Asian Countries, 2009



Source: World Bank and Australian Government, *One Goal, Two Paths Achieving Universal Access to Modern Energy in East Asia and the Pacific* (Washington, DC: World Bank Group, 2011).

Table 2: Number and Share of Population Without Access to Modern Energy Services, 2009

	Without Access to Electricity		Dependence on traditional solid fuels for cooking	
	Population (million)	Share of population (%)	Population (million)	Share of population (%)
Africa	**587**	**58**	**657**	**65**
Nigeria	76	49	104	67
Ethiopia	69	83	77	93
Congo	59	89	62	94
Tanzania	38	86	41	94
Kenya	33	84	33	83
Other Sub-Saharan Africa	310	68	335	74
North Africa	2	1	4	3
Asia	**675**	**19**	**1,921**	**54**
India	289	25	836	72
Bangladesh	96	59	143	88
Indonesia	82	36	124	54
Pakistan	64	38	122	72
Myanmar	44	87	48	95
Rest of developing Asia	102	6	648	36
Latin America	**31**	**7**	**85**	**19**
Middle East	**21**	**11**	**0**	**0**
Developing Countries	**1,314**	**25**	**2,662**	**51**
World	**1,317**	**19**	**2,662**	**39**

Source: International Energy Agency, *Energy for All: Financing Access for the Poor* (Paris: OECD/IEA, October, 2011).

level of energy access in all of the Asia-Pacific, and percentages lower than a host of countries in Sub-Saharan Africa, figures shown in Table 2.[5]

The United Nations Development Programme[6] and the World Bank[7] have independently confirmed such low levels of access. Figure 1 illustrates that Myanmar was more dependent on solid traditional fuels for cooking than any other Asian country surveyed.[8] Indeed, the World Bank projected that Myanmar would need a staggering $444 million every year – almost ten percent of its GDP, the highest of any country in Asia – to achieve universal access to electricity by 2030; to put this number in perspective, the second highest country, Timor Leste, would need to invest only 2.7 percent of its GDP.[9]

This report draws from the academic literature, from recent reports, and in-depth assessments of field research and surveys conducted in Myanmar to analyze how policymakers within the country can best confront the challenge of energy poverty and energy access. It answers three questions:

- What is the current energy access situation in Myanmar?
- What are Myanmar's most pressing energy access concerns?
- What solutions are available to planners, within the public sector and the private sector, to expand access to modern energy in Myanmar?

COUNTRY BACKGROUND

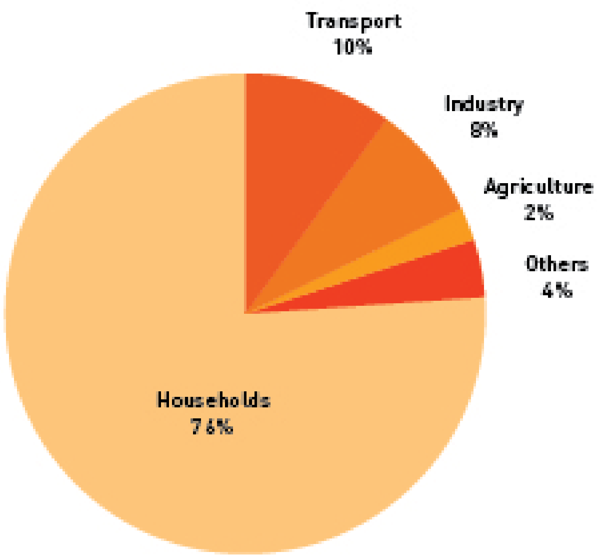
Modern energy services and electricity are crucial to meeting the primary development challenge of providing adequate food, shelter, clothing, water, sanitation, medical care, education, and access to information. Modern energy supports lighting, communication, transport, commerce, manufacturing, and industry. It can enable refrigerated vaccines and emergency and intensive health care, the pumping of clean groundwater for drinking and irrigation to increasing agricultural productivity. The lack of modern energy services is particularly damaging to women and children, who are usually responsible for food preparation and cooking. Without modern energy, they are typically forced to spend significant amounts of time searching for firewood for cooking and heating needs. Indeed, electricity makes so many things possible that some have even viewed its provision as a fundamental human right.[10] Therefore, the energy sector remains a central component of Myanmar's economy and, as such, needs to be understood prior to any assessment of challenges and approaches related to energy access and energy for all.

ENERGY AND ELECTRICITY

Myanmar remains a biomass-energy centered economy, with wood alone accounting for 70 percent of all primary energy supply in 2009—almost four *times* the second most significant source, natural gas, statistics displayed in Table 3. This dependence on solid fuels is largely due to the fact that 65 percent of country's population lives in rural areas. As Figure 2 shows, households consume about three quarters of national energy production (76 percent).[11] Despite such high reliance on biomass, the oil and gas, power, and mining sectors remain backbones of the national economy. Tables 4 and 5 show how oil, gas, and electricity alone account for more than 77 percent of annual foreign investment and more than 72 percent of annual domestic investment.

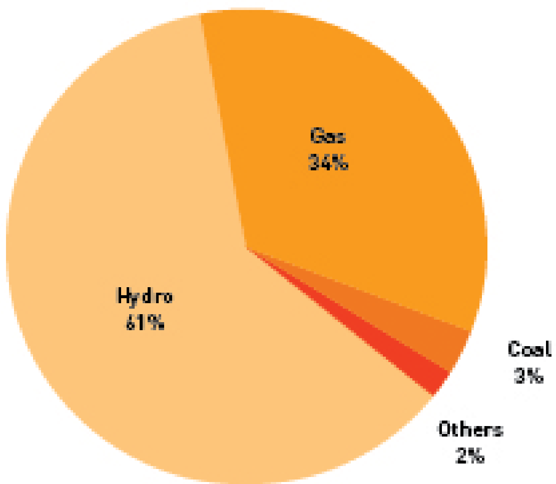
As Figure 3 illustrates, the electricity sector—which has slightly more than 1 GW of capacity, described in greater detail in Appendix I—remains dominated by hydroelectric power stations, which provided 61 percent of supply in 2010.[12] However, the national electricity grid reaches only a small percentage of the population and Myanmar's hydroelectric stations become

Figure 2: National Energy Consumption in Myanmar by Sector, 2010



Source: Wint Wint Kyaw et al. 2011

Figure 3: Electricity Fuel Mix for Myanmar, 2010



Source: Greacen and Greacen 2011

Table 3: Total Primary Energy Supply in Myanmar, 2001 to 2009 (kilotons of oil equivalent)

	2001	2002	2003	2004	2005	2006	2007	2008	2009	% (2009)
Crude Oil and Petroleum Products	1,983	1,991	1,924	1,924	1,957	1,756	1,904	1,789	1,280	8.5
Natural Gas	1,205	1,033	1,264	1,428	1,508	1,305	1,511	1,721	2,741	18.2
Coal and Lignite	83	71	76	123	196	85	501	558	135	0.9
Hydroelectricity	728	772	743	788	926	988	1,277	1,541	363	2.4
Biomass (Wood)	7,825	8,036	8,249	8,615	8,526	8,561	9,045	9,280	10,543	70.0
Total	11,824	11,903	12,256	12,878	13,113	12,695	14,238	14,889	15,062	100.0

Source: Ministry of Energy, "Developments in Myanmar Energy Sector," Presentation to the Subregional Energy Forum, Vietnam, November 22, 2008; and International Energy Agency, "Share of Total Primary Energy Supply in Myanmar," October, 2011.

Table 4: Foreign Investment in Myanmar by Sector (as of October 2010)

SN	Particular	Approved No	Approved Amount (Million US $)	Percentage (%)
1	Oil and Gas	99	13,447.975	42.08
2	Power	4	11,341.632	35.49
3	Mining	62	2,395.386	7.50
4	Manufacturing	155	1,663.126	5.20
5	Hotel and Tourism	45	1,064.811	3.33
6	Real Estate	19	1,056.453	3.31
7	Livestock & Fisheries	25	324.358	1.01
8	Transport & Communication	16	313.272	0.98
9	Industrial Estate	3	193.113	0.60
10	Agriculture	5	96.351	0.30
11	Construction	2	37.767	0.12
12	Other Services	6	23.08	0.07
Total		**441**	**31,957.324**	**100.0**

Source: Directorate of Investment and Company Administration.
1,000 Myanmar Kyat equals roughly US$1.

significantly constrained, operating at partial capacity for only a few hours a day, during the dry season.[13] Off-grid energy needs, which are vast, are only partly met by a network of 175 diesel generators supplying energy to 121 villages.[14] Non-hydroelectric sources of renewable energy represent negligible sources of supply, with only 116 kW of solar energy, 519 kW of wind energy, 19 MW of biomass, and 1.6 MW of biogas capacity installed and operating in 2009. Indeed, Myanmar has the highest transmission and distribution losses in Southeast Asia; and Myanmar has small rates of renewable energy penetration compared to its neighbors, low levels of energy consumption per capita, and low levels of investment in the energy sector.[15]

In terms of its greenhouse gas emissions associated with energy production and use, these are dwarfed by those from the agricultural and forestry sectors. Nonetheless, in 2000 energy-related emissions amounted to about 7.86 million metric tons of carbon dioxide equivalent, excluding biomass fuel combustion.[16]

Table 5: Domestic Investment in Myanmar by Sector (as of October 2010)

#	Particular	Approved No	Approved Amount (Million Kyats)	Percentage (%)
1	Construction	39	55,3575.15	52.72
2	Power	4	217,017.58	20.76
3	Manufacturing	533	88,332.98	8.41
4	Other Services	14	61,545.98	5.86
5	Real Estate Development	30	30,081.96	2.86
6	Transport	13	64,446.17	6.14
7	Livestock & Fisheries	55	14,402.35	1.37
8	Mining	49	12,187.92	1.16
9	Hotel and Tourism	20	6,960.11	0.66
10	Industrial Estate	1	10,12.79	0.10
11	Agriculture	5	547.9	0.05
Total		**763**	**1,050,110.89**	**100.00**

Source: Directorate of Investment and Company Administration

Myanmar has the stated energy policy goal of encouraging energy independence, improving hydroelectric sources of supply, expanding the grid to rural areas, and promoting energy efficiency and renewable energy,[17] though it appears accomplishing these tasks is proving more difficult than expected. Blackouts and brownouts (lower voltage) remain frequent in urban areas, and difficulty earning foreign exchange and lack of parts and labor has complicated attempts to repair and maintain existing power plants and the transmission network.[18] Planners have tried to respond to such obstacles by relaxing rules and allowing cooperatives to supply power, and by launching an "Energy Thrift" campaign in 2002 following the establishment of a Supervisory Committee for Utilization of Power and Fuel. The official national target is to grow the electricity grid at 8.5 percent per year, reaching 15,000 MW of capacity by 2020, efforts to be coordinated by the Work Committee for National Electricity Development under the supervision of the Leading Committee for National Electricity.[19]

In reality, however, its energy strategy for the past few decades has consisted largely of exploiting oil and gas reserves for export, rather than domestic use—a challenge elaborated upon further below.[20] In 2005, however, the government did start to allow private enterprises to supply electricity. Under the Yangon City Electricity Supply Board Law, small businesses can generate and distribute power directly to consumers, though "arduous" government standards and higher retail costs have impeded this programme.[21]

Moreover, in terms of greenhouse gas emissions related to changes in land use and deforestation, Myanmar ranks *third* in the world, coming only after Indonesia and Brazil. In 2000, its emissions within this sector amounted to 116 million metric tons of CO_2e.[22] Myanmar is one of the highest countries in the world for the percentage of overall greenhouse gas emissions coming from the land use and agricultural sector, at 83.7 percent.[23] Despite its relatively undeveloped economy, as of 2000, the last year reliable data was available, Myanmar was sixteenth in the world for overall carbon equivalent emissions.

INSTITUTIONAL AND POLICY STRUCTURE

Myanmar's institutional and policy structure for the energy sector is complex. The Cabinet and National Energy Management Committee represent the primary decision-making bodies on energy and environmental affairs, and their responsibility is supplemented with the roles that numerous other ministries play. The Energy Management Committee, for instance, is tasked with, among other priorities:

- Coordinating public-private partnerships in the energy sector and devising ways to modernize energy infrastructure;
- Systematically linking the goals of the Energy Plan and Industrial Development Plan;
- Formulating laws to "regulate energy projects" and "minimize environmental and social impacts,"

Table 6: Major Energy Policies, Targets, and Plans in Myanmar

Name	Year	Description
Petroleum Act	1934 (Amended 1937 and 1946)	To consolidate regulations concerning the importation, transport, storage, production, refining, and blending of petroleum and petroleum products
Electricity Act	1948 (Amended 1967)	To declare the statutory powers and functions of the state's electricity boards and generating companies with the goal of providing the rational use of the production and supply of electricity
Territorial Sea and Maritime Zone Law	1977	To implement the United Nations Law of the Sea treaty defining maritime and contiguous zones (essentially setting the boundaries for Myanmar's offshore oil and gas reserves)
Myanmar Electricity Law	1984	To maximize the rational generation, production, transmission, distribution, and usage of electricity
Private Industrial Enterprise Law	1990	To avoid environmental pollution in the face of rural development and industrialization, and to promote the use of energy in the most economical matter
Forestry Law	1992	To prevent dangers of destruction to forests and biodiversity and to conserve and establish forest plantations (partially for fuelwood supply)
National Environmental Policy	1994	To establish sound environmental policies in the utilization of water, land, forests, mineral resources, and other natural resources to preserve the natural environment and prevent its degradation
Atomic Energy Law	1998	Set the legal foundations for cooperation with Russia over building a nuclear research reactor
Conservation of Water Resources and Rivers Law	2006	To conserve and protect the water resources and rivers for beneficial utilization by the public, and to prevent serious environmental contamination
National Sustainable Development Strategies	2009	To promote social, economic, and environmental growth and achieve sustainable development

- Setting prices for the purchase and sale of energy products;
- Educating staff from the private sector and media about energy technology;
- Gathering information to enable the effective use of energy and the efficient coordination of energy projects;
- Seeking ways to implement the country's civil nuclear energy programme so that it meets international standards.[24]

In addition to the Energy Management Committee, the Ministry of Energy is the coordinating body for all types of energy in Myanmar, and its Energy Planning Department (EPD) has overall authority for formulating national energy policies. The electric utility sector is divided into the Gas and Hydro Power sector and the Power Distribution sector, and controlled by the Ministry of Electric Power 1 and Ministry of Electric Power 2, respectively (recently combined into a single Ministry of Electric Power). Responsibility for the coal sector falls to the Ministry of Mines. The Ministries of Industries, Science and Technology, and Agriculture are jointly entrusted with promoting renewable energy, and the Ministries of Environmental Conservation and Forestry and Ministry of Agriculture and Irrigation deal with all biomass related energy needs. The Ministry of Construction manages energy use in buildings. Other actors involved in various aspects of energy planning include the Yangon City Electricity Supply Board, Ministry of Education, and the Ministry of Cooperatives. Table 6 lists some of the most important energy policies, targets, and plans in Myanmar over the past eight decades.

Myanmar has plenty of other important institutional stakeholders. At the top of the list would certainly be the government linked energy companies, the Myanma Oil and Gas Enterprise (MOGE), the Myanma Petroleum Products Enterprise (MPPE), and the Myanma Petrochemical Enterprise (MPE), which are all stated owned. The MOGE and MPPE both explore, produce, transport, and refine crude oil and natural gas. The MPPE markets and distributes petroleum products. Established as a nongovernmental organization (NGO) in 1999, the mission of the Renewable Energy Association of Myanmar (REAM) is to increase the living standards of rural people in Myanmar and to protect the environment through the promotion of renewable energy applications. The Myanmar Engineering Society (MES) also plays a key role in promoting technical assistance related to renewable energy activities across the country.

The policy environment has been further complicated by a large number of energy access programmes in recent years. Taking just one technology, fuel-efficient stoves, sixteen different projects have been implemented from 1997 to 2011 involving a variety of different actors summarized in Appendix II.[25] These actors include EcoDev, United Nations Development Programme, Groupe de Recherche et de Travail, Forest Resource Environmental Development Association, Ever Green Group, Metta Foundation, Mangrove Service Network, and Malteser.

ENERGY RESOURCES

Contrary to Myanmar's relatively low levels of energy access, the country does possess significant energy resources. This section categorizes those resources according to four types: conventional fuels (including nuclear power), grid-connected or commercial-scale renewable sources of energy, off-grid or household- and community-scale sources of energy, and energy efficiency. In Myanmar, modern forms of energy are expensive: a connection to the grid costs $595, a significant sum given that per capita GDP is less than $1,000 per year and where one quarter of the population live below the national poverty line.[26] This does, however, make alternative sources of energy from renewables, household-scale systems, and energy efficiency practices even more financially attractive and competitive.

CONVENTIONAL FUELS

Oil and Gas

The oil and gas sector in Myanmar is composed of 105 demarcated blocks for exploration and development, 53 of them onshore and 52 offshore. Estimates suggest that Myanmar has proven gas reserves of 11.8 trillion cubic feet and gas production in 2011 was 1.2 billion cubic feet per day. Myanmar's oil production onshore reached 7,600 barrels per day in 2011, in addition to offshore gas fields that produced 11,600 barrels per day of condensates. That year, the country was home to three refineries with a total capacity of 51,000 barrels per day of petroleum products. A vast majority of natural gas production—about 95 percent—came from two offshore fields at Yadana and Yetagun, which export their gas almost entirely to Thailand. The country has about 2,100 miles of gas pipelines onshore and 431 miles of offshore pipelines.[27]

Coal

Myanmar has roughly 490 million tons of coal reserves, and in 2011 produced 692,000 tons of coal. Cement and steel companies use most of this coal (52 percent), the remainder going for power generation and "other" uses. Since 2010, all coal production has involved private companies with prices set by the global market.[28]

Nuclear Energy

In 2007, Myanmar and the Russian Federation signed an agreement to construct a nuclear research reactor near Yangon. The research center will include a 10 MWe light water reactor to be reportedly used for research on nuclear power and medical isotopes, though arms control advocates warn that such technology could have the primary goal of manufacturing nuclear weapons rather than nuclear electricity.[29]

ENERGY EFFICIENCY

In line with the energy targets espoused by the Association of Southeast Asian Nations (ASEAN), the government in Myanmar has set the target of cutting primary energy consumption by 5 percent from 2005 to 2020 and a further 8 percent by 2030. However, while the Ministry of Industry is responsible for energy efficiency activities, the Asian Development Bank warns that "Myanmar does not have a legal and regulatory framework for energy efficiency, or a central and dedicated organization for those activities."[30] Thus, energy efficiency savings potential are quite high. One recent assessment calculated that the inefficient natural gas turbines in use at most of the country's thermoelectric power plants use "about twice as much gas as modern single-cycle gas turbines and three times as much as modern combined cycle gas generators." With gas costs of $10 per thousand cubic feet, such inefficiency means that the fuel cost of natural gas-fired power is *twice* as much as it needs to be, and also that upgrading to more efficient turbines would pay for itself in roughly one year.[31]

COMMERCIAL-SCALE RENEWABLE ENERGY

Hydroelectricity

Myanmar has immense hydroelectricity potential, given that it serves as the home to the drainage basins of four large rivers: the Ayeyarwaddy, Chindwin, Thanlwin, and Sittaung. Table 7 shows that Myanmar has 34,568 MW of achievable large-scale hydroelectric capacity spread across hundreds of potential sites, with less than 1 percent of this potential realized so far.[32] Admittedly, harnessing all of this hydropower will present challenges—one involving the seasonal variation in output during the dry and wet seasons, one involving historically low tariffs for electricity sold in the local market.[33]

Table 7: Microhydro, Small Hydro, and Large Hydro Potential in Myanmar

State and Division	Microhydro Capacity (1 kW to 1 MW)		Small Hydro Capacity (1 to 10 MW)		Large Hydro Capacity (>10 MW)		Total	
	Number of Projects	Capacity (MW)	Number of Projects	Capacity (MW)	Number of Projects	Capacity (MW)	Number of Projects	Capacity (MW)
Kachin State	17	5.33	14	48.180	6	1852.000	37	1,905.020
Chin State	11	3.48	2	2.800	1	200.000	14	206.280
Shan State	35	10.64	24	63.900	11	4161.000	70	4,235.603
Sagaing State	5	0.806	3	13.300	6	2889.000	14	2,903.106
Mandalay Division	3	0.650	2	6.250	9	3475.000	14	3,481.900
Magway Division	1	0.100	2	11.000	2	93.000	5	104.100
Rakhine State	6	1.915	-	-	4	804.500	10	806.415
Kayah State	2	0.158	-	-	4	3740.000	6	3,740.158
Bago Division	4	1.890	-	-	7	391.000	11	392.890
Kayin State	3	0.864	1	3.000	4	16268.000	8	16,271.864
Mon State	5	1.248	-	-	2	254.500	7	255.748
Taninthayi Division	9	1.706	2	19.500	2	440.000	13	461.206
Total	**101**	**28.787**	**50**	**167.930**	**58**	**34,568.000**	**209**	**34,764.290**

Source: Ministry of Electric Power, *Hydropower Potentials of Myanmar (State and Division Wise)* (Yangon: Ministry of Electric Power, 2006).

At present, the Electricity Supply Enterprise has 32 small and medium hydropower stations—generally ranging between 1 MW and 10 MW in capacity—all of which have been built by the government outside the Grid system supplying electricity to the rural areas. All these mini hydropower stations have been running for several years serving the remote areas which are very far from the Grid system with electricity enhancing the economic growth and living standard of the rural population.[34] As Table 8 reflects, the hydropower sector is a magnet for foreign direct investment in the country, with $8.2 billion being funneled into it in 2010 and 2011, an amount only slightly less than the $10.2 billion invested into the oil and gas sector.[35]

Table 8: Foreign Investment in Myanmar by Country and Sector, 2010-2011 [billion US $]

By Country	
China	14.1
Thailand	2.9
Korea	2.7
Other	0.3
Total	**20**
By Sector	
Oil and Gas	10.2
Power (Hydropower)	8.2
Mining	1.4
Other (Agriculture & Manufacturing)	0.2
Total	**20**

Source: Mekong Energy and Ecology Network, 2012.

Wind Energy

Myanmar has significant resources of wind energy, with an estimated 365 terrawatt-hours (TWh) of technical potential per year, a resource especially abundant in the Chin and Shan states, more highly elevated parts of the Central Region, and along the coast.[36]

Bioelectricity

Because Myanmar is a "rice economy,"[37] that is rice dominates the agricultural sector, 21.6 million tons of rice husks from milling each year could create 4 million metric tons of fuel, or could be converted in biomass power plants, along with plentiful bagasse from sugarcane production and sugar processing.[38] The Myanmar Engineering Society has calculated considerable resource potential for lumber waste, bagasse, molasses, and livestock waste as well, numbers shown in Table 9.[39]

Table 9: Biomass Energy Resources in Myanmar

Type	Quantity per year
Rice Husks	4,392 x 10^3 ton/yr.
Lumber Waste	1.5 million ton/yr.
Bagasse	2,126 x 10^3 ton/yr.
Molasses	240 x 10^3 ton/yr.
Livestock Waste	34,421 x 10^3 ton/yr.

Source: Myanmar Engineering Society, 2012.

Geothermal Energy

According to government estimates, Myanmar also possesses scores of exploitable sites for geothermal power plants.[40] The Asian Development Bank noted in December 2012, for example, that at least 93 locations across the country had sufficient heat to produce electricity, with investors such as Japan's Electric Power Development Company and Caithness Resources in the United States already submitting letters of interest. As that report concluded, "Geothermal energy is abundant, with considerable potential for commercial development."[41]

Waste-to-Energy

Waste-to-energy facilities such as those in Singapore and Malaysia could be promoted as well, including refuse-derived fuel waste incineration and methane capture from landfills.[42] Yangon alone, for example, is comprised of 33 townships which produce more than 1,500 tons of trash each day, 800 tons of which are dumped into the Htain Pin Waste Pit.[43] The Myanmar Engineering Society estimates that the country has at least 20 MW of waste-to-energy capacity.[44]

Biofuels

Myanmar has already cultivated about 3 million hectares of jatropha and also grows maize, cassava, sweet sorghum, and sugarcane—each of which could be feedstocks for liquid biofuels.[45] The government already has an ambitious plan to plant a further 500,000 acres of jatropha plants in every state within 3 years (7 million acres in all), producing 700 million gallons by 2015.[46] The Asian Development Bank reports that as of 2011, 65 percent of this targeted production has been achieved, but that because of low yield from Jatropha seeds, biodiesel production is low.[47]

HOUSEHOLD-SCALE ENERGY SYSTEMS

Woodlots and Nurseries

As mentioned earlier, Myanmar is a biomass-centered energy economy. Therefore, one of the most effective ways to improve access to household energy is through the more sustainable or efficient harvesting of fuelwood. Community Based Organizations have successfully managed nurseries to supply reforestation projects and "encouraging wood-fuel collectors to become wood-fuel producers can also be a key strategy to reduce illegal deforestation."[48] In the past, the Forest Department has distributed as many as 11 million seedlings per year to be planted as part of a "country-wide, re-greening programme," and the Forest Law makes provision for private entrepreneurs to establish plantations and community woodlots on government-owned land. These efforts could be further bolstered and extended, and possibly integrated with a "School Nursery Programme" where fulltime, salaried staff could travel to strategically located schools to enroll principals and students in various sivicultural aspects of nursery management—educating children and providing a source of income for the schools.[49]

Improved Cookstoves

Since the 1990s, the government has been attempting to disseminate improved cookstoves 40 percent more efficient than traditional designs through a Ministry of Environmental Conservation and Forestry programme. More than one million were reportedly distributed, saving the need to cull 150,000 acres of fuelwood,[50] but the programme seems to have stopped as of 2002. One 2011 assessment of household willingness to pay for improved cookstoves in Myanmar noted that 100 percent "would use them if they were available and affordable" but that only 13 percent could afford to purchase them.[51] The study also documented that 80 percent of homes could afford only $1 to $2 to expend on a new cookstove—implying that most households could afford stoves that currently cost $1 to $3.

However, new cookstove programmes will face barriers. Household surveys by the European Union Energy Initiative scoping mission conducted in 2012 noted that many households in Myanmar believed that they did not need an ICS as their fuel supply situation was still "favorable" or "cheap," in some cases free, mitigating the incentive to adopt a more efficient cookstove.[52] The surveys found that other households had negative experiences with low quality improved cookstoves that had difficulties in terms of their efficiency and durability, and that still others wanted an improved cookstove, but couldn't find one available or couldn't afford those that they could find.

Biogas Digesters

A June 2012 feasibility study from the SNV Netherlands Development Organization estimated that in aggregate about 1,200 biogas units existed across the country, but that 80 percent of them were no longer in operation.[53] It calculated the technical potential for at least 600,000 household-scale biogas units in addition to 5,500 community-scale units. These units would have favorable returns on investment, with a typical unit resulting in a financial rate of return of 17 to 18 percent (presuming that households were entirely dependent on fuelwood or diesel, and that the government sponsored the systems with a 40 percent subsidy).

Additionally, the government managed a biogas generation from animal waste programme in Central Myanmar, distributing 867 "floating type" biogas plants between 1980 and 1983 across 134 townships and 14 states, and from 2001 to 2005 it started promoting 50 cubic meter size biogas plants with two domes constructed from local materials made in partnership with the Yangon Technological University. According to the

Ministry of Energy, 35 of these community-scale plants, which cost about $2,000 but can support 300 houses in a village, have been installed so far in the Mandalay, Sagaing and Magway Divisions.[54]

Off-grid Microhydro

In addition to the 32 "small" and "medium" size hydropower stations discussed above, Myanmar has at least 17 mini hydro facilities with about 5.23 MW of capacity, 29 microhydro facilities constituting 378.5 kW of installed capacity, and 6 picohydro facilities with 35 kW of combined capacity.[55] Significant microhydro potential, however, remains, with the government estimating at least 60 sites with 170 MW in total output could be suitably developed.[56] Rather than power the national grid, these types of sites could be utilized to generate electricity for microgrids consisting of 50 to 200 homes, or (in cases of picohydro facilities) a few interconnected homes. In the rugged Shan state, for example, microhydro units ranging from 2 kW to 5 kW sell for $70 to $450 and provide enough electricity to energize light bulbs, fans, televisions, and radios.[57]

Solar Energy

Myanmar is well suited for solar energy, as it receives ample amounts of sunlight due to its near equatorial location, especially in the central dry zone. Existing uses include, among others, household electricity supply in rural areas, water pumping and irrigation and commercial supply to hospitals.[58] One 220 kW hybrid solar-wind-diesel-battery system even provides reliable energy to 100 households in Chaungthar Village.[59]

Many government agencies have been involved in studying the specific application of solar home systems to rural areas, but actual promotion and dissemination has been limited primarily to health centers, water supply systems, and a select few of the "remotest" villages.[60] The Renewable Energy Association of Myanmar (REAM) and UNDP are working to create a "Revolving Fund" project termed "Substitution of Candle Light with Solar Lighting System with LED lights (CSSLS)" in 30 other villages in 3 townships.[61] Currently, the Ministry of Industry operates a small thin-film solar PV factory, and four solar equipment providers operate in Myanmar: Earth Renewable Energy Solutions, Myanmar Eco Solutions, Myanmar Solar Energy Systems, and Earth Computer Systems, but these firms remain dependent on foreign suppliers and


Photo Credit: UN/Thandar Soe

imported technology from China, Japan, Singapore, and Thailand, and solar home systems have not significantly penetrated rural markets.

Nonetheless, one 2011 survey of Myanmar attitudes and willingness to pay for lighting noted that the average weekly cost of household fuel consumed for light ranged from $1.10 for batteries and $1.79 for candles to $2.17 for grid electricity—implying that households could contribute between roughly $4 and $8 per month for solar home system payments (though the survey also found average monthly income was a paltry $44).[62] A second 2012 survey from the European Union Energy Initiative estimated that rural households spend upwards of $10 per month on candles and disposable batteries for flashlights.[63] This means investments in solar lanterns and torches—which can sell for as little as $10—can pay for themselves in one *month*.

ENERGY ACCESS CHALLENGES

Realizing the full energy resource potential for Myanmar will not occur effortlessly. As Table 10 summarizes, barriers to expanding energy access in Myanmar fall into four similar, interconnected categories: poverty and subsistence needs, conflicting priorities, lack of resources, and policy fragmentation. This section discusses each in turn.

POVERTY AND SUBSISTENCE NEEDS

Myanmar is an agrarian and predominately poor country. The Central Statistical Organization, for example, collected household data on food and non-food expenditures among more than 25,000 Myanmar households in the late 1990s and estimated that the collective poverty rate (the percentage of both urban and rural households living on less than $1 per day) was 22.9 percent.[64] The United Nations Development Programme (UNDP) conducted a "household living conditions" survey in 2004 and 2005 and estimated that 32 percent of the population lived in poverty with 10 percent in "extreme poverty," unable to cover basic needs.[65] Another academic household survey published in 2006 confirmed a rural and gender dimension to poverty in Myanmar. It estimated that about one-quarter of total rural households were landless and another one-third owned less than 3 acres (1.2 hectares) of land, making poverty "a major problem … because the majority of rural households engage in the primary sector with inadequate holdings;" it also noted that the poorest households are headed by women, with such households representing only 9 percent of the population but 46 percent of those in poverty.[66] A 2009 and 2010 survey from the UNDP of 18,660 households estimated that this poverty rate had reduced by 6 percentage points, but it also concluded that the amount spent on food as a share of household income had increased and that landlessness among rural households had worsened as well.[67]

Table 10: Summary of Challenges to Expanding Energy Access and Protecting the Environment

Challenge	Description(s)
Poverty and subsistence needs	Fuelwood collection and charcoal production for cooking and heating place stress on Myanmar's rainforests and mangrove habitats
Conflicting priorities	The government remains focused on producing crude oil and natural gas for export to meet regional energy demands
	The government is committed to upgrading the national grid and building centralized hydroelectric, fossil-fuel, and even nuclear plants to power industrial and agricultural facilities instead of addressing off-grid energy access issues
Lack of resources	The country's state-controlled economy makes it difficult to procure international financing and investment in the energy sector
	A growing deficit and rising inflation constrain government budgets for electricity and energy
	Declining natural gas prices have further reduced state revenue available for energy projects
	Poor access to credit and limited rural banking networks compound efforts to give loans to energy-deprived households
Policy fragmentation	More than a dozen government agencies vie for control and jurisdiction over energy and electricity planning
	Scores of actors in the private sector and civil society further complicate the regulatory landscape

Essentially, these high rates of rural poverty place severe stress on Myanmar forests and mangroves for fuelwood collection and charcoal production—homes cannot afford modern energy services, so they cut down trees or scavenge for free wood. As an independent United Nations assessment summated:

> *The demand for fuelwood and charcoal for cooking is rising with the growth in population, resulting in indiscriminate cutting of trees for fuelwood in forest areas adjacent to villages and towns. In addition, illegal logging of valuable trees in some areas is worsening deforestation and environmental degradation … It is highly probable that unless alternative sources of fuel are provided the rate of depletion of unclassified forests will be aggravated, particularly in the dry zone.*[68]

Myanmar does formally practice "sustainable forest management," but these practices simply do not produce enough wood. Estimates predicated on standing stocks of forests give an annual sustainable yield of about 13 to 15 million cubic tons per year, yet demand for wood far exceeds 20 million cubic tons per year—a shortfall of 5 million cubic tons, or approximately 275,000 acres (111,288 hectares) of natural forest destroyed each year.[69]

Dependence on fuelwood and charcoal not only results in scarcity and deforestation; it also culminates in rising prices. The average price for firewood in Yangon, for example, increased by a factor of *eight* between 1988 and 1997, and it further *quadrupled* from 1998 to 2004. Analogously, the price of charcoal increased by a factor of *six* between 1998 and 1997 and increased further by *tripling* in price from 1998 to 2004. Government efforts to rapidly introduce alternatives such as briquettes and fuel sticks (made from paddy husk, sawdust, charcoal dust or petroleum coke with a suitable binding agent) have so far been insufficient to meaningfully reduce demand for fuelwood and charcoal. [70]

CONFLICTING PRIORITIES

Though it has stated a commitment to expanding energy access and encouraging electrification, current government priorities miss rural and off-grid options. All indications point to a strong national strategy towards exports of oil, gas, and electricity rather than domestic use. As one study explained:

> *Although Myanmar is basically an agrarian nation with rice as its largest export earner, the government's long-term plan is to increase foreign exchange earnings through the export of onshore and offshore oil and gas resources as well as of mineral deposits-primarily gold, silver, copper, and lead … Many of the mineral and energy resource extraction projects are quite large by world standards and can be expected to have a major impact both on the overall economy and the future development of the nation.*[71]

At present, more than two dozen firms from Australia, Canada, China, France, India, Indonesia, Japan, Malaysia, Singapore, Thailand, the United Kingdom, and United States are involved in oil and gas extraction within Myanmar. In the electricity sector, national planners are embarking upon a Myanmar-Thai "cooperative project" to dam the Thanlwin (Salween) river along the border to construct a series of hydroelectric dams to export power to Thailand. The first of these is supposed to generate more than 7,000 MW, and is currently at the stage of surveying and soliciting finance.[72]

A second indication that rural energy access programmes do not appear to have a strong priority among the government comes from the government's December 2012 Framework for Economic and Social Reforms. That framework states national development goals across multiple sectors of the economy, including telecommunications, agriculture, and industry. Yet only two relate to energy at all—improving power provision through the grid, and extending public transport in Yangon—and nothing about rural energy needs, or rural households, is mentioned.[73]

A final sign that Myanmar prioritizes centralized electricity supply and grid extension rather than the expansion of off-grid access is its recent focus on industrialization and its potential shift to embrace nuclear power. Though about 70 percent of its population, 64 percent of its labor force, and 40 percent of its export earnings are connected with the agricultural sector, Myanmar is seeking to industrialize—a path that would require investments in centralized electricity supply.[74]

LACK OF RESOURCES

A number of factors limit the resources available to the Myanmar government to facilitate energy access. Myanmar's developing economy makes it hard to procure international financing and investment. A burgeoning deficit and rising inflation rates constrain government budgets. Falling prices for natural gas further reduce state revenues and limited rural banking networks and access to credit blunt efforts to procure financing for rural households. Moreover, falling prices for natural gas worldwide have created unexpected shortfalls in government revenue. In 2009, for example, natural gas prices fell by a global average of 25 percent, creating a shortfall of 30 to 40 percent of Myanmar's gas revenues (though the full impact of these price surges would have been obviated by bilateral, fixed-price contracts).[75]

One of the macroeconomic implications of lack of investment and declining government revenue, however, is a growing deficit that already reached about 5 percent of GDP in 2009, particularly high that year due to the devastation caused by Cyclone Nargis. The Central Bank of Myanmar reported the same year

that inflation exceeded 50 percent. The country also lacks a functioning stock and bond market, has a limited rural banking sector with little to no microfinance institutions, and it has the lowest domestic savings rate (12.7 percent of GDP) compared to all Southeast Asian countries.[76]

POLICY FRAGMENTATION

As mentioned above in the section of the report on "Country Background," more than a dozen government agencies are involved in energy and electricity planning, and even greater numbers of actors in the private sector and civil society complicate the energy policy landscape. This complex policy environment creates overlapping and at times confusing mandates and poorly coordinated efforts at promoting energy access. For example, if a microhydro plant wanted to power a mini-grid (at the village scale) but also export excess electricity to the national grid, it would require the involvement of the Ministry of Electric Power (responsible for planning permits and maintenance for hydroelectricity, and for transmission and distribution), and the Yangon City Electricity Supply Board (responsible for electricity sales). Similarly, a hybrid solar-biomass facility would need the involvement of the Ministry of Environmental Conservation and Forestry (responsible for biomass and fuelwood), Ministry of Education (responsible for basic and applied research), the Ministry of Science and Technology (responsible for development of renewable power sources), and, if using direct combustion of biomass, the Ministry of Agriculture & Irrigation.[77]

The labyrinthine policy landscape can also lead to conflicting or competing goals. For example, in 2006 the partial withdrawal of kerosene subsidies in Myanmar by the MOE provoked some rural villagers to consume more fuelwood, competing with management plans from the Ministry of Environmental Conservation and Forestry. Similarly, in an understandable effort to reduce government deficits, the Myanmar government removed state subsidies on natural gas and diesel in 2007, leading to a doubling of domestic prices for bus fares and automobile fuel and spilling over into an increase in the price of basic commodities such as rice, beef, fish, milk, and eggs—hitting rural and poor households the hardest.[78]

ENERGY ACCESS SOLUTIONS

Though the challenges facing Myanmar are daunting—cutting across poverty and subsistence needs, conflicting priorities, lack of resources, and policy fragmentation—various distinct mechanisms exist to address them. Table 11 matches such challenges with the particular mechanisms best situated to remediate them, each of them discussed in turn in this section of the report.

Table 11: Summary of Challenges and Domestic and International Mechanisms in Myanmar

Challenge(s)	Domestic Mechanism(s)
Poverty and subsistence needs	Financing and micro-financing from the Central Bank of Myanmar, Myanmar Agricultural Development Bank, and/or private banks for improved cookstoves, biogas digesters, solar PV, microhydro dams, and woodlots and nurseries
	Community development funds to emphasize productive energy, the "Energy Plus" approach, and income generating activities
	Community ownership and involvement in energy projects
Conflicting priorities	Education and awareness campaigns (including demonstrations) concerning renewable energy
	Transparent village energy committee models
Lack of resources	Public private partnerships for grid-connected wind farms, hydroelectric dams, geothermal facilities, rice-husk power plants, and biofuel plantations
	Capacity building for both government and energy end-users
Policy fragmentation	Creating a coordinating body to set development strategies and create enabling policy environment
	Setting national technical standards for all renewable energy equipment
	Establishing rural technology centers or relying on an ESCO model to ensure proper maintenance

CAPACITY BUILDING

The number one priority to increase energy access is for the government to express clear political will in their policies and strategies to promote energy access, rural electrification, energy efficiency and renewable energy. When Myanmar develops a national energy strategy, these priorities should be clearly articulated.

Once this occurs, capacity building efforts could be aimed at both government institutions and households. Such capacity building could perhaps begin by bolstering the government's ability to conduct research and collect basic data about household energy use. Myanmar stopped publishing national-accounts data in 1998.[79] Energy data for planning and decision making are only "partly available" and "inconsistent" and the government has "weak capacities for policy and strategy formulation."[80] This particular problem is not confined to the energy sector, with the Asian Development Bank recently cautioning that:

> *Effective policymaking, planning, implementation, and monitoring will require reliable, timely, and relevant information on the country's social, economic, and environmental conditions. Most government ministries are endowed with some statistical abilities to meet the data requirements in their sector; however, the absence of adequate institutional arrangements [in Myanmar] poses profound challenges in coordinating statistical activities and maintaining uniform statistical standards across ministries.*[81]

Thus, government planners and institutions need to be trained on internationally accepted standards and methodologies for collecting energy data and using that data in national energy strategizing. One high priority item would be conducting a comprehensive assessment of rural energy resources and needs undertaken with a focus on energy demand for households, small and medium enterprises, and community and public services. Another would be compiling inventories of best practices, quality services and affordable technologies that the government should commit to developing. Based on the findings of such a household assessment and an inventory, rural energy initiatives could therefore be developed and implemented by the local community-based organizations and groups in collaboration with NGOs and in partnership with technology suppliers.[82]

Moving away from the government, capacity building efforts could also focus on energy users. Households, village leaders, and even local entrepreneurs are to a large extent unaware about both the technical aspects of renewable energy technologies and associated business opportunities. As one example, the fact that households have expressed a willingness to pay $1 to $2 for improved cookstoves that currently cost $1 to $3 in Laputta Township[83]—but have not purchased them—implies the existence of a significant awareness gap. This awareness gap could be addressed in a variety of ways, including the:

- Distribution of sales catalogs for renewable energy technologies;
- Display of sample systems;
- Transmission of reliable information to potential customers through targeted television; radio, and newspaper marketing campaigns;
- Hosting of workshops and conferences;
- Empowering community organizations and women's groups with knowledge and skills;
- Sponsoring door-to-door promotional efforts, demonstrations, and road shows.

Part of this approach involves not only disseminating information to consumers and customers, but receiving feedback about what they want—through feasibility studies, surveys, and an appreciation for the particular energy services they desire. A previously successful solar home system programme for health clinics, for instance, relied on specially designed systems that could be carried by foot, that could operate laptops and computers along with lights, that was simple to install and "plug and play," that could be moved when the security situation demanded it, and that could withstand rough terrain with strain-relief terminal strips protected within a rugged cabinet, built to be more durable.[84] The programme succeeded, in part, because it asked the health clinics what they wanted rather than presuming an "ordinary" solar design would perform well.

FINANCING AND MICRO-FINANCING

As mentioned earlier in the section on household-scale energy systems, a team from the European Union Energy Initiative scoping study reported households in central Myanmar spending $9.26 per month on candles and torches. Down in the Irrawaddy Delta, mean monthly household spending on candles and large batteries amounts to $12 against mean monthly incomes of $40-80. At these budgets, solar lanterns and solar-LED lighting systems are already cost competitive at $10-86. If credit were charged at 15 percent per year – a common, even low, rate for microcredit – systems could be paid off after five years, assuming income was not affected by bad harvests or disasters.[85] A flexible repayment scheme or guarantee mechanism could deal with such uncertainties.

National banks, notably the Myanmar Agricultural Development Bank (MADB), could therefore enable households and communities to purchase renewable energy equipment through loans and other financing packages. Admittedly, the banking sector in Myanmar is struggling. The MADB is the sole provider of rural credit with 216 branches, and it is meant to cover 30 percent of a farmer's cultivation costs, but in practice it falls short. One critical evaluation noted that "staff are poorly skilled in credit assessment techniques" based on land, rather than assets or productive use of that land, and that it had an "extraordinarily small" amount of capital and slightly less than $183 million[86]—which works out to about $4.60 per rural citizen. Since 1991, the bank has been forbidden from writing off any bad loans (so it tends not to reach the poorest households) and borrowers reliant on MADB loans frequently cannot afford seeds and fertilizer, let alone solar panels or microhydro units.[87] A separate assessment from Harvard University noted that rural credit is "scarce or nonexistent" and that "every group of farmers that the team spoke with identified a lack of credit as one of the principle problems they faced … farmers reported that credit was scarce at any price," even when they could agree to high interest rates (in excess of 15 percent per month) and had "strong personal connections" with banking staff.[88]

Six interconnected approaches could address some of these problems. First, the MADB needs more credit, an injection of funds from either the government or international development partners and banks. Second, MADB officers need to be trained beyond giving loans for crops to those involving energy technology, which they have little familiarity with. Third, the Central Bank of Myanmar, which sets monetary policy, could establish lower interest rates for loans related to energy access (though these rates would need to be set to also ensure the commercial viability of lending institutions).[89] Fourth, the MADB could partner with a collection of private banks and cooperatives to give loans for energy access, potential financiers shown in Table 12. [90] Fifth, the government could reduce tax on imported parts for solar panels, wind turbines and other renewable energy technologies to encourage the private sector to use these renewable energy sources to enhance rural electrification and promote economic development.[91] Sixth, the government could cross-subsidize energy access programmes with some of its revenues from the oil and gas sector, with that sector producing $13.6 billion in annual foreign direct investment in 2011.[92]

COMMUNITY MOBILIZATION FUNDS AND PRODUCTIVE ENERGY

The productive use of modern energy can improve income generation and contribute to poverty reduction in many ways. These include:

- Using energy to improve efficiency or productivity of existing economic activities, e.g. increasing agricultural productivity via mechanized irrigation;
- Expanding operation of existing enterprises beyond daylight hours or into new services;
- Establishing new energy-based enterprises and creating employment opportunities.
- Improving operation of schools, health facilities and other public services;
- Employing local people in the delivery of energy services (e.g. local masons building biogas digesters, local technicians servicing solar home systems (SHSs)) and other productive activities.

One innovative way of using energy for productive uses—to raise incomes and strengthen enterprise/commercial establishments—is to couple energy access programmes with community development funds (CDFs). CDFs create revenue to promote disadvantaged groups and women's empowerment, skills enhancement, better management of technology, and income generation. In Nepal, for example, a CDF attached to microhydro diffusion has offered $400,000 in total for the promotion of non-lighting uses of electricity such as agro-processing, poultry farming, carpentry workshops, bakeries, ice making, lift irrigation, and water supply. The CDF also gave grants for power connections from microhydro schemes to schools, health posts, clinics and hospitals, and promoted afforestation to offset any trees felled for the construction of distribution poles. CDF funds were also utilized for community training and to educate the operators of microhydro plants and other end-use machinery.

Table 12: Private Financial Institutions in Myanmar

#	Name	Credit Line / Estimated Capital (in millions of Kyat)
1	Myanmar Universal Bank	3,997
2	Kanbawza Bank	11,000
3	Myanma Livestock and Fisheries Development Bank	5,779
4	Cooperative Promoters Bank	500
5	Cooperative Bank	2,500
6	Cooperative Farmers Bank	500
7	Myanma Industrial Development Bank	500
8	Myanmar Oriental Bank	2,000
9	Myanmar May Flower Bank	3,000
10	Asia Wealth Bank	15,000
11	Tun Foundation Bank	410
12	Yoma Bank	5,000
13	Sibin Tharyaryay Bank	50

Source: May Toe Win. "Liquidity Measurement and Management in Myanmar," *Liquidity Measurement and Management in the SEACEN Economies* (Kuala Lumpur: South East Asian Central Banks Research and Training Center, 2010), pp. 147-171. 1,000 Myanmar Kyat equals roughly US$1.

COMMUNITY INVOLVEMENT

Experiences in other countries such as Nepal suggests that renewable energy access programmes show better results and success when implementation is decentralized to the villages themselves. For example, the Rural Energy Development Project in Nepal was specially designed to improve accountability and hedge against corruption. It was formally institutionalized in Village Development Committees, the lowest level of governance in Nepal, and also Microhydro Functional Groups, working committees that must meet at least once a month to maintain and manage each plant. Similarly, in Myanmar the solar health clinic programme alluded to the above, operated by nongovernmental actors such as Green Empowerment, Palang Thai, Karen Health and Welfare Department (not part of the government), the Open Society Institute, and Knightsbridge International, worked so effectively because actors were empowered and showed motivation to lead when distributing solar equipment.[93]

PUBLIC PRIVATE PARTNERSHIPS FOR RENEWABLE ENERGY

Private sector participation through partnerships with the government have proven an effective vehicle for facilitating investment in Myanmar's oil and gas sector, and to some degree its large-scale hydroelectricity infrastructure.[94] The same models could be applied to the promotion of grid-connected wind, mini and microhydro, geothermal, and biomass electricity plants as well as the cultivation of biofuels.[95] Indeed, the government in Myanmar has attempted to solicit foreign direct investment with a variety of recent reforms, including the creation of the Foreign Investment Law and protections on property rights for overseas firms. [96]

One particularly innovative model relates to pro-poor public-private partnerships, usually indicated by the abbreviation "5P." The 5P model views the poor not only as consumers that receive benefits, but also as partners in business ventures. It expands beyond the private sector to include partners from development banks, equipment manufacturers, rural energy service companies, philanthropic organizations, CBOs, cooperatives, and households themselves. Each of these groups plays a different role in the 5P: private sector participants can meet their corporate social responsibility obligations, utilities and energy companies can fulfill their obligation to deliver basic services, communities and members of civil society can expand access to basic services. Or, as the UNDP defines it, a 5P is one that "increases access of the poor to basic services by promoting inclusive partnerships between local government, business, community groups, NGOs, Faith Based Organizations and others."[97]

In other words, three things make 5Ps unique from ordinary PPPs:

- They are participatory, involving a broad number of institutions, contrary to having only one or two (government or government plus donor);
- Their priority is helping the poor, not necessarily profits but social and economic development, contrary to how most corporations and electric utilities operate;
- They are inherently cooperative rather than competitive, attempting to get partners to work together rather than at the expense of others

Figure 4 summarizes some of the key innovations and benefits to the 5P structure.[98]

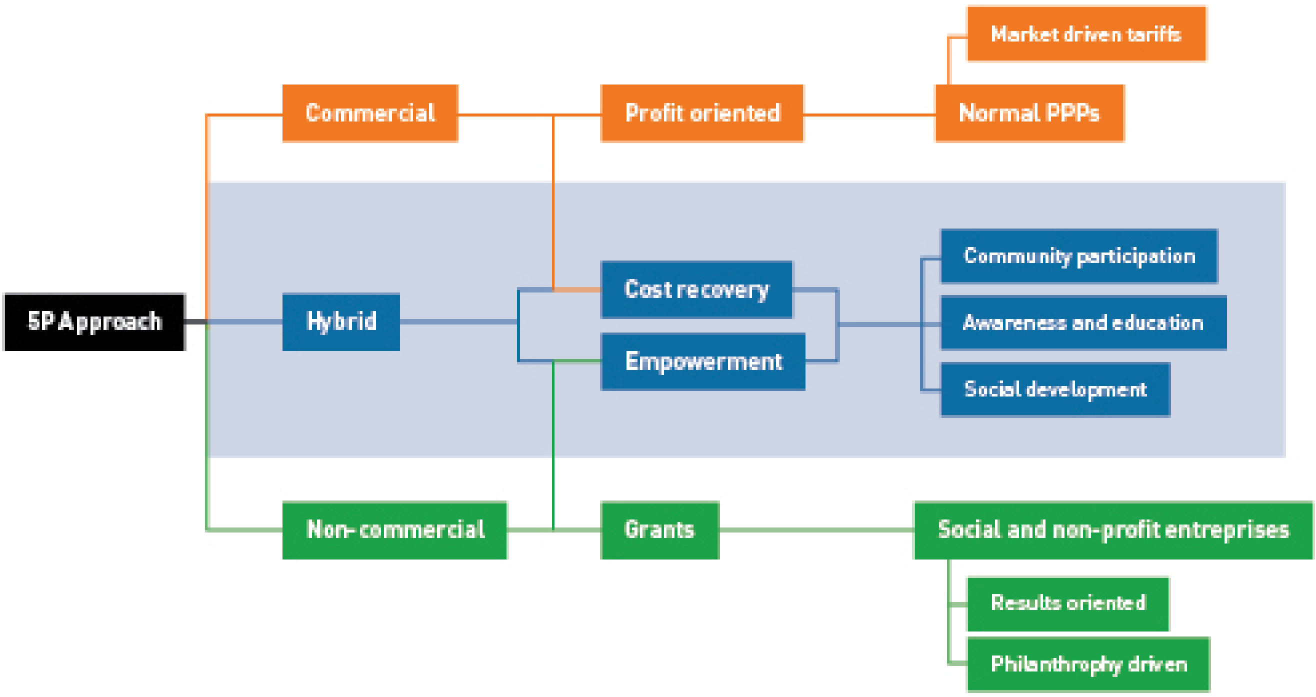
The 5P approach, of course, is not the only partnership model that Myanmar could utilize to promote energy access. Appendix III lists eight such partnership models that have effectively promoted renewable energy in developing countries. These models could conceivably be applied to Myanmar to encourage wind energy, grid-connected hydroelectricity, geothermal power plants, biomass rice-husk facilities, waste-to-energy facilities, and the cultivation of biofuels. If carried out efficiently, the 5P approach can result in building commercially viable markets, enhancing existing supply chains, and replicating domestic good practices.

HARMONIZATION OF REGULATORY AUTHORITY

Planners in Myanmar might want to consider consolidating and coordinating regulatory authority over energy access within a single organization. The Alternative Energy Promotion Center (AEPC) in Nepal is one structure the country could replicate; the AEPC, within the Ministry of Environment, is responsible for the promotion of all alternative energy systems and mechanisms in rural areas. Its jurisdiction covers all coordination and monitoring of renewable energy programmes throughout the entire country. Similarly, Sri Lanka established their Sustainable Energy Authority in 2007 to guide the nation in all of its efforts related to the exploration, facilitating, research, development, and knowledge management of alternative energy technologies.

Myanmar's new government seems to recognize this need in part, and it has formed the Central Committee for Rural Development and Poverty Alleviation to monitor tasks for rural development and poverty alleviation. The committee has laid down eight tasks to achieve the goals. Development of rural energy and environment conservation has been listed as goal 6

Figure 4: Key Institutional Innovations of the 5P Approach



and 8 respectively. An inter-ministerial coordination committee is reportedly formed under the chairmanship of Minister of Industry and this committee is supposed to address issues of rural energy access as one of the Government's eight development priorities for poverty reduction.

It does set importance on the development of rural energy and its application for poverty reduction and livelihood enhancement. However, a clear policy on rural energy and regulatory framework is absent at present.[99]

CREATION OF NATIONAL TECHNOLOGY STANDARDS

The government should set and enforce national renewable energy technology standards. There is already some evidence that such standards would protect consumers and improve the quality of cookstoves and solar equipment within Myanmar. Improved cookstoves, for example, have been critiqued for "irregular quality" due to "community-led production systems" which have negatively impacted consumer satisfaction in some areas.[100] Analogously, the government's earlier biogas programme from the 1980s has had a "negligible" impact on the energy balance of Myanmar because of "technical constraints" and poor quality installations.[101]

Efforts to certify and improve technical quality could emulate the "Technology Improvement" component of China's Renewable Energy Development Programme. This component included:

- Competitive grants, on a cost-sharing basis, to investments in technology improvement from component and system manufacturers;
- The creation of a Standards Committee which modified existing standards, developed new ones, and certified testing laboratories;
- The establishment of an "Approved Components" list based on quality tests carried out by the selected testing laboratories as well as a "Testing Team" which travelled throughout China randomly testing components;
- The organization of a Component Testing seminar for companies whose products did not meet quality standards as well as the publication of quarterly newsletters and bulletins to raise awareness;
- Sponsored visits to trade fairs, testing institutions, and conferences to build recognition about the programme;

- Sponsored upgrades to PV testing laboratories;
- The creation of a "Golden Sun" label to signify that a particular component or system met prevailing standards.

ESTABLISHMENT OF SERVICE AND TRAINING CENTERS

Once technologies start to be diffused and commercialized, policymakers must ensure that proper after-sales service is provided through service and training centers. For example, Grameen Shakti in Bangladesh operates a collection of "Grameen Technology Centers" throughout the country which teach users how to properly maintain and conduct minor repairs, and train hundreds of technicians each year in renewable energy maintenance and the manufacturing of selected components. The REAP in Mongolia gave financial support for the creation of more than 60 after-sales service call centers and the establishment of warranties. It created new centers to help nomadic herders maintain their solar home systems, provide advice on battery charging, distribute spare parts, and honor warranties.

Or planners could rely on an energy services company (ESCO) model where maintenance is automatically provided by companies (for an extra fee or bundled with the price of a system) rather than consumers, a model that has proven successful in disseminating solar equipment in Zambia[102] and India.[103]

Photo Credit: Renewable Energy Association of Myanmar

CONCLUSION

Four conclusions arise from the analysis presented in this report.

First, notwithstanding some of the best natural gas, hydroelectricity, and solar resources in the Asia-Pacific, Myanmar has an energy access crisis. The country has some of the lowest reported levels of access across the entire region, as well as the highest energy investment needs as a share of the country's GDP. The country's electricity systems serves less than 10 percent of the population and by some accounts, less than 1 percent have reliable, consistent access to electricity. Almost 90 percent of households depend on woody biomass and charcoal to meet their household cooking energy needs, yet such activities are becoming more expensive due to rising fuel prices, and contribute to accelerated rates of national deforestation of mangroves.

Second, however, is that positive synergies exist between expanding energy access and accomplishing other sustainable development goals. Solar energy or microhydro systems that provide electricity and mechanical energy for pumping or irrigation come to mind; they simultaneously improve energy security, and enhance agricultural productivity. Similarly, deforestation related to fuelwood collection continues to ravage Myanmar's forests and mangrove species but improved cookstoves and biogas potential both expand access to cleaner and more efficient sources of heating and reduce those very rates of deforestation. Also, properly managed community woodlots would both protect biodiversity and enhance livelihoods, and community owned plantations could integrate reforestation and afforestation projects with growing Jatropha carcus trees for biodiesel. These types of interrelationships create opportunities to rapidly address energy and environmental problems simultaneously, and they also align with the UNSG's SE4ALL Initiative.

Third, distinct opportunities exist—for both the government, and for development partners to overcome Myanmar's challenges and exploit the positive synergies. For instance, the government can:

- Develop a National Policy on Rural and Renewable Energy, especially one that includes energy access for poverty reduction as a key goal;
- Establish and strengthen Lead National Institutions for Energy Access

- Develop policy and guidance for Independent Power Producers (IPPs)
- Provide financing or re-financing facilities for banks and micro-financial institutions
- Ensure that the energy efficicnt/renewable energy technology products and installations meet approved quality standards and code
- Develop renewable energy Pilot Projects and Rural Renewable Energy Access Programmes
- Provide sector-wide capacity development support for the public sector, civil society, and private companies
- Mobilize funding and provide financing, co-financing and re-financing to renewable energy projects
- Provide a supporting pro-poor gender friendly policy environment with incentives for expansion of energy access in the rural and remote areas, with empowered governance structures at the local level
- Promote productive uses of energy services with focus on poverty reduction and improvement of livelihoods of rural communities
- Build technical capacity in statistics, data collection, and energy planning.[104]

Development partners can supplement these activities and:

- Promote commercially viable energy technology products, services, markets and models
- Strengthen project planning and implementation capacity with renewable energy specialists
- Support sector-wide capacity development among key stakeholders and programme implementing agencies
- Advocate and promote mainstreaming gender in rural energy and renewable initiatives
- Support and strengthen establishment of renewable energy database
- Facilitate and support network building with national, regional and international organizations.[105]

Fourth, the ability of the poor to utilize energy for productive purposes is a crucial aspect of the energy access goal. Productive uses of energy for agriculture, enterprise, education, health and public services does not only bring income to the poor that allows them to pay for and maintain energy services; it also leads to wider human development impacts that enable the poor to move out of poverty. The importance of productive use of energy is embodied in UNDP's "Energy Plus" approach, which recognizes that many barriers can exist that prevent communities from using energy for productive purposes and aims to overcome these through improving the capacity for government leadership and support, reliable access to finance and commercial markets and better access to skills, equipment and technology.[106]

In closing, the promotion of off-grid and grid-connected renewable sources of energy, energy efficiency, and household energy options can enable Myanmar to rapidly increase its standards of living and improve community welfare. As the Asian Development Bank has noted, "Myanmar could become one of the next rising stars in Asia if it can successfully leverage its rich endowments—such as its natural resources, labor force, and geographic advantage—for economic development and growth."[107] This finding serves as an enduring reminder that modern energy offers a useful vehicle for which other development goals, such as those relating to health, education and gender, can be achieved.

APPENDIX I: MYANMAR ELECTRICITY STATISTICS

Table AI: Power demand and supply situation from 2000-01 to 2008-09

Fiscal Year	Firm Power(MW) (Power available all year round)	Demand (MW)	Power Surplus (+)/ Shortage (-) (MW)
2000-01	724.0	785.0	- 61.0
2001-02	724.0	860.0	- 136.0
2002-03	744.0	860.0	- 116.0
2003-04	744.0	880.0	- 136.0
2004-05	895.0	900.0	- 5.0
2005-06	962.0	1050.0	- 88.0
2006-07	996.0	1150.0	- 154.0
2007-08	1050.0	1275.0	- 225.0
2008-09	1060.9	1300.0	- 240.0

Source: MEPE

Table A2: Existing Hydropower Stations in the Myanmar Grid System

#	Name of Station	Location	Installed Capacity (MW)	Annual Energy (GWh)	Type of Turbine	Year Commissioned
1	Baluchaung.1	Loikaw, Kayah State	(14MW×2Nos) 28MW	200	Francis	9-8-92
2	Baluchaung.2	Loikaw, Kayah State	(28MW×6Nos) 168MW	1,190	Pelton	April/1960 2-3-74
3	Kinda	Myittha, Mandalay Division	(28MW×2Nos) 56MW	165	Francis	4-12-85
4	Sedawgyi	Madayar, Mandalay Division	(12.5MW×2Nos) 25MW	134	Kaplan	6-6-89
5	Zawgyi.1	Yatsauk, Shan (S) State	(6MW×3Nos) 18MW	35	Francis	28-7-95
6	Zawgyi.2	Yatsauk, Shan (S) State	(6MW×2Nos) 12MW	30	Francis	16-3-2000

Source: Ministry of Electric Power

Table A2: Existing Hydropower Stations in the Myanmar Grid System

#	Name of Station	Location	Installed Capacity (MW)	Annual Energy (GWh)	Type of Turbine	Year Commissioned
7	Thaphanzeik	Kyunhla, Sagaing Division	(10MW×3Nos) 30MW	117.2	Kaplan	18-6-02
8	Zaungtu	N-W of Bago Division	(10MW×2Nos) 20MW	76.3	Kaplan	22-3-00
9	Mone	Sidoktaya Magwe Division	(25MW×3Nos) 75MW	330	Francis	27-11-04
10	Paunglaung	N-E of Pyinmana	(70MW×4Nos) 280MW	911	Francis	25-3-05
11	Yenwe	Kyauktaka Bago Division	(12.5MW×2Nos) 25MW	123	Francis	10-2-07
12	Kabaung	Oaktwin, Bago Division	(15MW×2Nos) 30MW	120	Francis	23-3-08
13	Kengtawng	Moene, Shan (S) State	(18MW×3Nos) 54MW	377.6	Francis	21-3-09
14	Shweli.1	Namkham, Shan (N) State	(100MW×6Nos) 600MW	4,022	Francis	16-5-09
15	Yeywa	Mandalay	(197.5MW×4Nos) 790MW	3,550	Francis	15-12-10

Source: Ministry of Electric Power

Table A3: Existing Coal Fired Thermal Power Stations in the Myanmar Grid System

#	Name of Station	Location	Installed Capacity (MW)	Annual Energy (GWh)	Annual Required Amount of Coal (Tons)	Year Commissioned
1	Tigyit (Coal Fired)	Pinlaung, Shan (S) State	(60MW×2Nos) 120MW	600	640,000	25-12-04

Source: Ministry of Electric Power

Table A4: Existing Gas Turbine, Combined Cycle and Thermal Power Stations in the Myanmar Grid System

#	Name of Station	Installed Capacity (MW)	Annual Energy (GWh)	Commissioned Year	Gas Requirement Per Day Onshore	(MMCF) Offshore
1	Kyunchaung	(18.1MW×3Nos) 54.3MW	300	1974	18	27
2	Mann	(18.45MW×2Nos) 36.9MW	238	1980	12	18
3	Shwedaung	(18.45MW×3Nos) 55.35MW	300	1984	18	27
4	Myanaung	(18.45MW×1No) 18.45MW (16.25MWx2Nos) 16.25MW	200	1984 1975	6 5	9 8
5	Thahtone	(18.45MW×1No) 18.45MW (16.25MWx2Nos) 32.5MW	300	1985 2001	6 10	9 16
6	Mawlamyaing	(6MW×2Nos) 12MW	60	1980	0	8
7	Hlawga	(33.3MW×3Nos) 99.9MW (54.3MWx1No) 54.3MW	640 350	1996 1999	33	48
8	Ywama	(18.45MW×2Nos) 36.9MW (24MWx1No) 24MW (9.4MWx1No) 9.4MW	238 140 60	1980 2004 2004	12 8	18 12
9	Ahlone	(33.3MW×3Nos) 99.9MW (54.3MWx1No) 54.3MW	640 350	1995 1999	33	48
10	Thaketa	(19MW×3Nos) 57MW (35MWx1No) 35MW	368 200	1990 1997	18	27

Source: Ministry of Electric Power

APPENDIX II: KEY STAKEHOLDERS INVOLVED IN FUEL-EFFICIENT STOVE PROGRAMMES IN MYANMAR

Actor	Location	Duration	Description
EcoDev	Kachin State	2008 to present	A joint World Food Programme "Food for Work" scheme that establishes community-based forestry plantations
EcoDev	Sagaing Division	1997 to 2001	Fuel-efficient stove programme focusing on income generation for women, community forestry, and soil conservation
EcoDev	Magwe Division	1997 to 2002	Fuel-efficient stove dissemination and reforestation project
Ever Green Group	Shan State	2007 to 2009	Fuel-efficient stove dissemination
Ever Green Group	Ayeyarwady Division	2008 to 2009	Fuel-efficient stove dissemination
Forest Resource Environmental Development Association	Sagaing Division	2000 to present	Wildlife conservation, natural forest conservation, and stove distribution
Forest Resource Environmental Development Association	Shan State	2004 to present	Fuel-efficient stove dissemination and reforestation project
Forest Resource Environmental Development Association	Ayeyarwady Division	2004 to present	Fuel-efficient stove dissemination and reforestation project
Groupe de Recherche et de Travail and Mangrove Service Network	Rakhine State	2007	Fuel-efficient stove dissemination and reforestation project
Malteser and Mangrove Service Network	Rakhine State	2009	Fuel-efficient stove dissemination and reforestation project
Metta Foundation	Kachin State	2008 to present	Fuel-efficient stove dissemination and reforestation project
Metta Foundation	Shan State	2008 to present	Fuel-efficient stove dissemination and reforestation project
Metta Foundation	Shan State	2008 to present	Fuel-efficient stove dissemination and reforestation project
Metta Foundation	Kayah State	2008 to present	Fuel-efficient stove dissemination and reforestation project
Metta Foundation	Ayeyarwady Division	2008 to present	Reforestation project
Metta Foundation	Mon State	2008 to present	Fuel-efficient stove dissemination and reforestation project
Mangrove Service Network	Kachin State	2005 to 2006	Fuel-efficient stove construction and manufacturing training
Mangrove Service Network	Chin State	2006 to 2007	Fuel-efficient stove construction and manufacturing training
Mangrove Service Network	Mon State	2006 to 2007	Fuel-efficient stove construction and manufacturing training
United Nations Development Programme	Ayeyarwady Division	2000 to present	Fuel-efficient stove dissemination and reforestation project

Source: MercyCorps, *Myanmar Energy Poverty Survey* (Yangon: January, 2011).

APPENDIX III: EIGHT PUBLIC PRIVATE PARTNERSHIP MODELS FOR ENERGY ACCESS FROM ASIA

Model	Description	Example	Primary Partners
Technology improvement and market development	A sort of "supply push" structure where the PPP develops a renewable energy technology to reduce costs	China's Renewable Energy Development Programme	World Bank, Global Environment Facility, National Development and Reform Commission, local solar manufacturers
End-user microfinance	A sort of "demand pull" which gives loans to energy users to that they can purchase renewable energy equipment	Grameen Shakti in Bangladesh	International Finance Corporation, Infrastructure Development Company Limited, Grameen Bank
Project finance	Where small- and medium-scale projects are supported with loans and financial assistance from commercial banks	Energy Services Delivery Project in Sri Lanka	World Bank, GEF, Ceylon Electricity Board, and national banks
Cooperative	Where communities own renewable energy systems themselves	Cinta Mekar Microhydro Project in Indonesia	Yayasan Ibeka, Hidropiranti Inti Bakti Swadaya, Directorate General of Energy Electricity Utilization, PLN, UNESCAP, Cinta Mekar Cooperative
Community mobilization fund	Where revenues from renewable electricity or energy production are invested back into local communities	Microhydro Village Electrification Scheme in Nepal	World Bank, , Government of Nepal, United Nations Development Programme, Nepal Alternative Energy Promotion Center, District Development Communities, Village Development Communities, Microhydro Functional Groups
Energy services company (ESCO) "fee-for-service"	Where private sector enterprises purchase technology and then charge consumers only for the renewable energy "service" that results	Zambia's PV-ESCO Project	Ministry of Energy, Stockholm Environmental Institute, Swedish International Development Authority
Cross subsidization	Where tariffs on one type of electricity are then funneled into a fund to support renewable energy	The Rural Electrification Project in Lao PDR	Electricité du Lao PDR, Ministry of Energy and Mines, World Bank, Global Environment Facility, Provincial Electrification Service Companies
Hybrid (end-user microfinance and ESCO "fee-for-service")	Where private sector enterprises purchase technology and then charge consumers only for the renewable energy "service" that results	India's Solar Lantern Project	Small-Scale Sustainable Infrastructure Fund, Solar Electric Light Company, local banks and entrepreneurs

Source: Source: BK Sovacool, "Expanding Renewable Energy Access with Pro-Poor Public Private Partnerships in the Developing World," Energy Strategy Reviews 1(3) (March, 2013), pp. 181-192.

Application	Technology	Dates	Cost (US$)	Accomplishments
Off-grid (nomadic herders)	Solar home systems	2002 to 2007	$316 million	Distributed more than 400,000 units in 5 years
Off-grid (rural households)	Solar home systems, biogas digesters, and improved cookstoves	1996 to 2010	-	Installed almost half a million solar home systems, 132,000 cookstoves, and 13,300 biogas plants among 3.1 million beneficiaries.
On-grid and off-grid	Solar home systems, grid-connected hydro, off-grid village hydro	1997 to 2002	$55.3 million	Installed 21,000 solar home systems and 350 kilowatts of installed village hydro capacity in rural Sri Lanka, in addition to 31 megawatts of grid-connected mini-hydro capacity
On-grid	Microhydro	2004 to present	$225,000	Constructed a 120 kW microhydro scheme that has electrified homes and creates thousands of dollars of monthly revenue funnelled back to the village
Off-grid	Microhydro	2004 to 2011	$5.5 million (original proposal)	Distributed 250 units benefitting 50,000 households in less than 10 years
Off-grid	Solar home systems	1999 to 2009	-	Three ESCOs currently lease the services of 400 solar panels and have hundreds of clients waitlisted
On-grid and off-grid	Solar home systems and grid-connected hydroelectricity	2006 to 2009	$13.75 million	Electrified 36,700 previously off-grid homes and disbursed more than 9,000 solar home systems
Off-grid	Solar lanterns	2005 to present	-	Distributed 80,000 units across 25 separate cities

Source: Source: BK Sovacool, “Expanding Renewable Energy Access with Pro-Poor Public Private Partnerships in the Developing World,” Energy Strategy Reviews 1(3) (March, 2013), pp. 181-192.

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