ADB

Myanmar

Energy Sector Initial Assessment

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Acknowledgments

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Weights and Measures

bbl	–	barrel
BCF	–	billion cubic feet
BCM	–	billion cubic meter
BOPD	–	barrels of oil per day
ft^3	–	cubic feet
GWh	–	gigawatt-hour
ha	–	hectare
Hz	–	hertz
km	–	kilometer
km^2	–	square kilometer
kV	–	kilovolt
kVA	–	kilovolt ampere
kW	–	kilowatt
kWh	–	kilowatt-hour
MCF	–	thousand cubic feet
MMbbl	–	million barrel
MMCFD	–	million cubic feet per day
MTOE	–	million tons of oil equivalent
MW	–	megawatt
MWh	–	megawatt-hour
MVA	–	million volt-ampere
TCF	–	trillion cubic feet

Currency Equivalents

(as of 26 October 2012)

Currency Unit	=	kyat (MK)
MK1.00	=	$0.0012
$1.00	=	MK851.225

Abbreviations

ADB	–	Asian Development Bank
AFOC	–	ASEAN Forum on Coal
ASEAN	–	Association of Southeast Asian Nations
CNG	–	compressed natural gas
CNPC	–	China National Petroleum Corporation
DEP	–	Department of Electric Power
DHPI	–	Department of Hydropower Implementation
DHPP	–	Department of Hydropower Planning
ESE	–	Electricity Supply Enterprise
GDP	–	gross domestic product
GMS	–	Greater Mekong Subregion
HPGE	–	Hydropower Generation Enterprise
IEA	–	International Energy Agency
JVA	–	joint venture agreement
LPG	–	liquefied petroleum gas
MEPE	–	Myanmar Electric Power Enterprise
MES	–	Myanmar Engineering Society
MIC	–	Myanmar Investment Commission
MOAI	–	Ministry of Agriculture and Irrigation
MOE	–	Ministry of Energy
MOECAF	–	Ministry of Environmental Conservation and Forestry
MOEP	–	Ministry of Electric Power
MOF	–	Ministry of Forestry
MOGE	–	Myanma Oil and Gas Enterprise
MOI	–	Ministry of Industry
MOM	–	Ministry of Mines
MOST	–	Ministry of Science and Technology
MOU	–	memorandum of understanding
MPE	–	Myanmar Petrochemical Enterprise
MPPE	–	Myanmar Petroleum Products Enterprise
MTU	–	Mandalay Technological University
NCEA	–	National Commission for Environmental Affairs
NEDO	–	New Energy and Industrial Technology Development Organization
PRC	–	People's Republic of China
PSC	–	production sharing contract
PTTEP	–	PTT Exploration and Production Public Company
UNFCCC	–	United Nations Framework Convention on Climate Change
YESB	–	Yangon City Electricity Supply Board

I Energy Sector Initial Assessment: Context and Strategic Issues

A. Introduction

1. This initial assessment of Myanmar's energy sector highlights the government's plans for addressing priority energy needs, challenges and opportunities, and identifies—in a preliminary manner—possible areas of support by development partners. The assessment will be periodically revised based on new information and reflecting the evolving development partnership with Myanmar.

2. Like most other development partners, the Asian Development Bank (ADB) has not extended loan or technical assistance to Myanmar since the late 1980s. However, ADB has maintained limited involvement with the government through the Greater Mekong Subregion (GMS) Program of Economic Cooperation, the energy component of which has provided fragmented information on Myanmar's power supply system and its generation and transmission plans. Myanmar's energy sector, though, involves much more than regional cooperation in electricity generation and supply via hydropower. As described in this initial assessment of the energy sector, in addition to huge hydropower potential, Myanmar has important petroleum and coal reserves. Myanmar's extensive forest coverage is the primary source of energy for most households.

3. In order to have a better understanding of Myanmar's energy sector, an ADB mission[1] visited Myanmar from 20 through 30 September 2011. The information and findings gathered during the mission served in drafting an initial assessment of the sector. Subsequently, the assessment has been updated to reflect the findings of follow-up ADB missions and consultations with the government. To more fully determine the current status and needs of the energy sector, intensive analysis must be conducted concerning capacity building requirements, the institutional structure, the policy and regulatory framework, energy efficiency, renewable and "green" energy, and other issues.

B. The Country Context

4. Myanmar is a large country, with a land area of 676,577 square kilometers (km^2). Its strategic geographic location provides Myanmar the potential to become a land bridge between South and Southeast Asia, and linking the People's Republic of China (PRC) to these markets. Myanmar shares borders with Bangladesh, India, the PRC, the Lao People's Democratic Republic, and Thailand; it also has a 2,800-kilometer (km) coastline along the eastern side of the Bay of Bengal. Myanmar's population

[1] The mission comprised Jong-Inn Kim, Team Leader, Lead Energy Specialist, SEEN; Edward Baardsen, Principal Infrastructure Specialist, SEEN; Duy-Thanh Bui, Senior Energy Economist, SEEN; and K. Y. Nam, Senior Economist, EREA.

is approximately 60 million,[2] with more than 70% living in rural areas. Per capita gross domestic product (GDP) is one of the lowest in Southeast Asia, at about $715. Myanmar was ranked among the poorest countries (161 out of 180) by the International Monetary Fund and its ranking on the United Nations Human Development Index is also near the bottom of the list (149 of 187 countries). Some 26% of the population lives in poverty.

5. Despite economic sanctions since the late 1980s, Myanmar's economy has maintained relatively steady growth—by an estimated 5.5% in FY2011 (ended 31 March 2012) and by an average of 4.9% over the previous 3 years.[3] Prior to the devastation wrought by Cyclone Nargis in 2008, the economy had reportedly been growing at more than 10% annually. The economy is predominantly agriculturally based, with rice being the main crop and staple food. The agriculture sector accounts for about 36% of GDP, down from 57% in 2001. In contrast, the share of GDP accounted for by the industrial sector more than doubled, to 26%. Liberalization of the economy and opening up to foreign direct investment has prompted rapid growth of the industrial sector, notably exports of natural gas.

6. A parallel increase in employment generation in the industrial sector is unlikely, as the mineral and gas sectors are capital rather than labor intensive. Although employment data are unavailable, it appears that the agriculture sector still accounts for about 70% of total employment.

7. The imposition by many countries of deep economic sanctions in the late 1980s, in response to Myanmar's suspension of democratic liberties, clearly hampered development. During nearly 3 decades, Myanmar lost most access to international investment and assistance, including from the ADB and the World Bank. Consequently, development of Myanmar's energy sector has lagged greatly behind its potential.

8. The new government that took office in March 2011 has introduced sweeping reforms to both the political process and the economic system. Among the economic reforms, a new Land Law and Foreign Investment Law address issues fundamental to development, as does unification of the former multiple exchange rate system. The government is in the process of formulating a new national development plan. Investment in the energy sector is expected to be an important driver of the economy. In response to the reforms, especially those concerning democratic representation, the economic sanctions are now being lifted or at least eased. This opens the possibility of extensive international assistance for Myanmar's energy sector, including in partnership with the private sector.

C. Overview of the Energy Sector

9. Myanmar has abundant energy resources, particularly hydropower and natural gas. The hydropower potential of the country's rivers, which drain the four main basins of Ayeyarwaddy, Chindwin, Thanlwin, and Sittaung, is estimated to be more than 100,000 megawatts (MW). Myanmar has identified 92 potential large hydropower projects with a total installed capacity of 46,101 MW. Proven gas reserves total 11.8 trillion cubic feet (tcf) with huge potential for discovery. Offshore gas is the country's most important source of export revenues, currently supplying Thailand with a new gas pipeline planned to the PRC. A third of the country's $13.6 billion in foreign direct investment is in the oil and gas sector (as of September 2011). Myanmar is one of the five major energy exporters in the region, particularly of natural gas.

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[2] There has not been a census for the past 2 decades, hence the population estimate is only approximate.

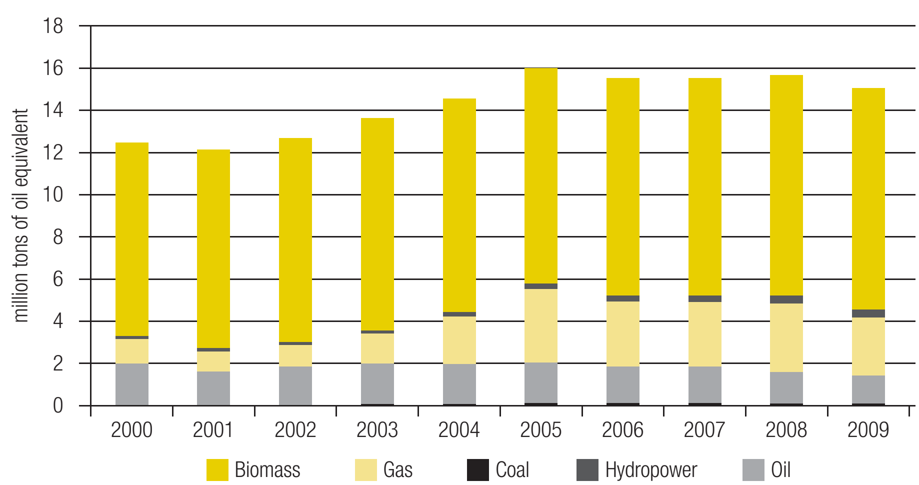
[3] ADB. 2012. *Asian Development Outlook 2012: Confronting Rising Inequality in Asia*. Manila.

10. **Primary energy supply.** Government energy-related data are limited, necessitating reliance on the International Energy Agency (IEA)[4] and other secondary sources. In 2009 (IEA's latest estimates for Myanmar) the country's total primary energy supply was about 15.1 million tons of oil equivalent (MTOE). The country's primary energy supply includes coal, oil, gas, hydropower, and biomass. Some two-thirds (69.9% or 10.5 MTOE) of Myanmar's energy supply was from biomass, followed by 18.2% (2.7 MTOE) from natural gas and 8.5% (1.3 MTOE) from oil. Coal and hydropower accounted for only small shares (0.9% and 2.4%, respectively) of total energy supply. These shares are changing, reflecting the rapid expansion of coal production (an 15.1% average annual increase from 2000 to 2009) and gas production (9.7% annually); hydropower production increased more slowly (9.2% annually). Investment in hydropower and coal-powered plants, gas fields, and oil and gas pipelines is gaining rapidly, evidence of a highly dynamic sector. Myanmar's energy exports in 2009 were the equivalent of 7.7 MTOE, or more than half of total energy supply. Figure 1 shows the total primary energy supply of Myanmar from 2000 to 2009.

11. **Final energy consumption.** Per capita energy consumption of electricity in Myanmar is next to Nepal in being among the lowest in Asia, reflecting poverty-level per capita incomes and an electrification rate of only 26%—and much less than this in most rural areas. As documented by the IEA in its *World Energy Outlook 2012*, Myanmar is an extreme example of "energy poverty." Lacking electricity, households rely on burning firewood and animal dung in poorly ventilated dwellings, leading to acute respiratory diseases and high mortality/morbidity rates. Further, lacking electricity, economic development is stymied and achievement of the United Nations Millennium Development Goals severely hampered.

12. Overall final energy consumption in Myanmar increased between 2000 and 2009 by an average of 2.4% annually, from 11.1 MTOE to 13.8 MTOE. Energy consumption by the commercial sector is increased by 5.4% annually, followed by the industrial sector (4.8%) and transport, however, had a negative annual average growth (–1.9%). Residential consumption increased only by 1.3% annually but, nonetheless, this is the largest consumer of energy—mainly in the form of biomass (fuelwood and charcoal).

Figure 1 Myanmar's Total Primary Energy Supply, 2000–2009
(million tons of oil equivalent)



Source: International Energy Agency.

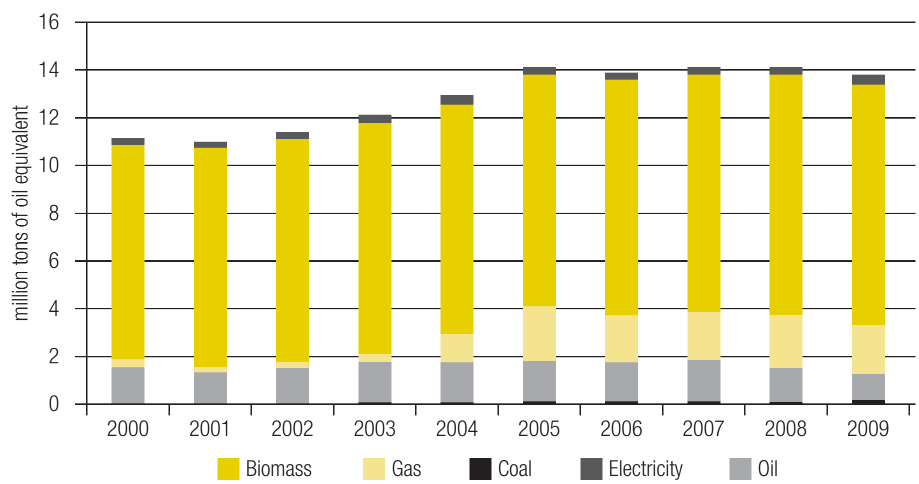
[4] All 2009 energy data are based on the International Energy Agency's *Energy Balances of Non-OECD Countries 2011*.

13. Energy consumption by fuel type is shifting in favor of natural gas, which increased on average by an estimated 15.1% annually during 2000–2009. This was followed by coal, energy consumption of which grew by almost 15% annually. Energy consumption from electricity and biomass sources increased by average annual rates of approximately 4% and 1.3%, respectively. Despite its slow increase, biomass continued to be the main source for energy consumption (accounting for almost 73% in 2009, compared to over 80% in 2000). Figures 2 and 3 show the final consumption by source and sector in 2000–2009.

14. **Energy resources.** According to the World Energy Council, in 2007, Myanmar had coal resources estimated at around 2 million tons, 447.7 TCF of natural gas (428 TCF onshore and 19.7 TCF offshore), and 206.9 million barrels (MMbbl) of oil (106 MMbbl onshore and 100.9 MMbbl offshore). The hydropower potential of Myanmar's four main rivers (Ayeyarwaddy, Chindwin, Thanlwin and Sittaung) is estimated at 100,000 megawatts (MW), less than 10% of which has been harnessed.[5] Myanmar is undertaking ventures to exploit these energy resources, both as a basis for accelerated overall economic development and for direct social benefit to residents—especially through greater electricity supply to rural areas. However, to more fully tap the huge potential of Myanmar's energy sector will require strategic approaches, including: (i) inviting foreign technical expertise and foreign investment for participation in its hydropower, oil, and gas subsectors; (ii) expanding the capacity of existing liquefied petroleum gas plants and implementing new liquefied natural and petroleum gas production projects; and (iii) substituting the use of liquid fuel in the transport sector with compressed natural gas.

15. **Policy framework and institutional structure.** Four main goals form the basis of Myanmar's energy policy framework: (i) maintaining energy independence; (ii) promoting the wider use of new and renewable sources of energy; (iii) promoting energy efficiency and conservation; and (iv) promoting household use of alternative fuels. Seven ministries in Myanmar are responsible for energy matters, with the Ministry of Energy (MOE) as the focal point for overall energy policy and coordination.

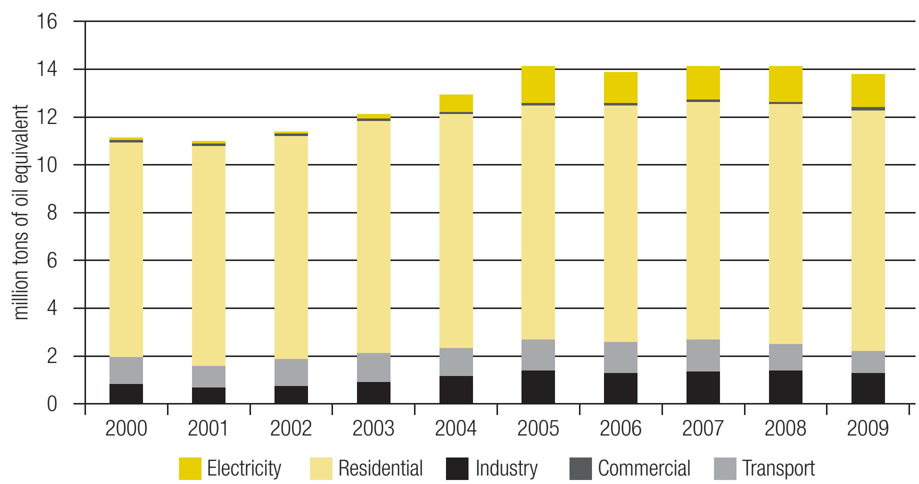
Figure 2 Myanmar's Total Final Consumption by Source, 2000–2009 (million tons of oil equivalent)



Source: International Energy Agency.

[5] The large Myitsone hydropower project has been suspended due to environmental concerns.

Figure 3 Myanmar's Total Consumption by Sector, 2000–2009
(million tons of oil equivalent)



Source: International Energy Agency.

The organizational chart of MOE is shown in Figure 4. The other six ministries together with their responsibilities are shown below:

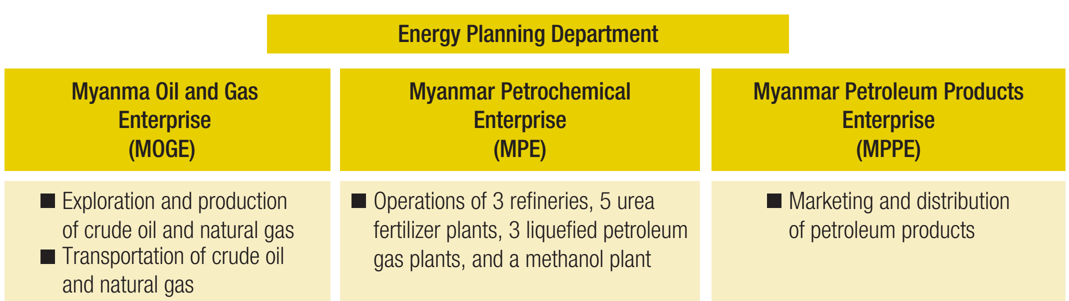
(i) Ministry of Electric Power;[6]

(ii) Ministry of Mines (MOM): coal;

(iii) Ministry of Agriculture and Irrigation (MOAI): biofuels and micro-hydro for irrigation purposes;

(iv) Ministry of Science and Technology (MOST): renewable energy;

Figure 4 Organizational Chart of the Ministry of Energy



Source: Ministry of Energy.

6 In September 2012, Ministry of Electric Power No. 1 (hydropower and coal power generation) and Ministry of Electric Power No. 2 (power transmission and distribution, gas-fired generation, mini-hydro) were merged.

(v) Ministry of Environmental Conservation and Forestry (MOECAF): fuelwood, climate change, environmental safeguard requirements; and

(vi) Ministry of Industry (MOI): energy efficiency.

16. Forecasts of long-term energy demand and supply by energy source are not available. Overall energy planning by MOE is limited. Problems, main cause, and deficient sector outputs in the energy sector are summarized in Appendix 1.

D. Coal Subsector

1. Coal Reserves

17. Some 400 coal occurrences have been identified in Myanmar, although many of them are of minor importance. The most notable occurrences appear to be in the Ayeyarwaddy and Chindwin river basins, as well as in the southern part of Myanmar and the intra-mountain basins, including in Shan State (Appendix 2, Figure A2). Systematic exploration for coal deposits has been carried out in various parts of the country since 1965, with the reserve potential estimated for some 200 of the deposits. The main discoveries to date have been in the Sagaing Division, Magwe Division, Tanintharyi Division, and Shan State. Most of Myanmar's coal resources were formed during the Tertiary period and are the most valuable type in terms of quality (lignite to sub-bituminous). Coal found in Shan State tends to be of lower quality (sub-bituminous).

18. The 33 major coal deposits (Appendix 2, Tables A2.1 and A2.2) have estimated reserves totaling some 488.7 million tons in various categories (Table 1). Only 1% of this estimated potential, however, has been confirmed.

Table 1 Reserve Estimates of Coal in 2011

Reserves	Estimate (in million tons)
Positive reserve	4.6
Probable reserve	228.4
Possible reserve	142.4
Potential reserve	113.3
Total	**488.7**

Source: Ministry of Mines.

2. Coal Production and Use

19. **Coal production.** From 1949 to 1988, during the period of the Parliamentary Democracy, 527 thousand tons of coal was produced. From 1988 up to January 2009, during the period of the State Peace and Development Council, 8,323 thousand tons of coal was produced (Appendix 2, Table A2.3).

20. While to date there has been no importation of coal, the government is considering a zero import tax in the event that imports are necessary. Over the past 2 decades there have been limited exports of coal, with approximately 4.5 million tons exported to Thailand from 1992 to 2009 and a smaller amount exported to the People's Republic of China (PRC) during this same period.

21. **Future plans for coal production**. Considering the vast untapped coal resources throughout Myanmar, the production and use of coal is expected to rise significantly. According to the 30-year plan

Box 1 Production Coordination through the Coal Mining Group

In May 2010, the Coal Mining Group of 13 companies was formed to integrate the development of coal mines in the Sagaing Region in a more efficient and profitable manner. Infrastructure in the region is poor and one of the objectives of the group is to construct an approach road on a cost-sharing basis. The Ministry of Mines issued integrated permits to the group based on the proven coal deposits, which stretched more than 50 miles. Coal production in the region will be used to supply: (i) cement manufacturing plants; (ii) thermal power plants; and (iii) the China Nonferrous Metal Mining for ferro nickel production.

Five mining companies (Htun Thwin Mining, Geo Asia Industry and Mining, Myanmar Economics Corporation, Yangon City Development Committee, and the Max Myanmar Group) are in production while the remaining eight companies are still at the development stage. It is expected that the production of coal will significantly increase after all development work is completed. Output is targeted at 5 million tons of coal by 2030, fully owned and operated by the private sector.

Source: Ministry of Mines.

prepared in FY2007, coal production is scheduled to increase by 16% annually, reaching 2,761 thousand tons by FY2016 and 5,654 thousand tons by FY2031. The Myanmar Mines Rules, adopted at the end of 1996, sets out the compliance measures for coal mine safety and the prevention of accidents.

22. **Domestic use of coal.** In FY2011, a total of 693 thousand tons of coal was used domestically: 290 thousand tons (42%) for electric power generation, 362 thousand tons (52%) for cement and other industrial uses, and 41 thousand tons (4%) for household (cooking and heating) and other uses.

23. The large coal-fired power plant in Tigyit, Southern Shan State, operated by the Ministry of Electric Power (MOEP), has a capacity of 120 megawatts (MW). Japan has provided new technology to the plant, enabling it to use lignite coal more efficiently. To help meet the growing demand for electricity, Myanmar is planning to construct and operate the following coal-fired power plants: (i) a 270 MW plant in Yangon; (ii) a 600 MW plant in Kalewa; and (iii) a 6 MW plant in Tanintharyi Division.

24. Domestic coal prices are set by the market and vary from about 7,000 to 25,000 kyats per ton in Shan State and about 40,000 kyats in Kalewa Region, depending on the calorific value.

3. Institutional Arrangements

25. The Ministry of Mines is responsible for overall mining policy and development. The ministry has two main departments and six state enterprises. The Department of Geological Survey and Mineral Exploration is responsible for mapping, prospecting, and exploration of minerals, including coal. The Department of Mines is responsible for formulating mining policy, granting exploration permits, and coordinating the mining sector. The exploration permits are issued to private companies in accordance with the Myanmar Mines Law, 1994.

26. The state-owned No. 3 Mining Enterprise is responsible for the production of coal.[7] It relies on a production sharing contract (PSC) system with private companies, by which 100% of investment is borne privately and profits are shared between the two parties.[8] Following privatization of the Kalewa mine in Sagaing Division and Namma mine in Northern Shan State, state enterprises no longer are involved in

[7] Besides coal, No. 3 Mining Enterprise is responsible for the production of iron and steel, industrial materials, and dimension stones from granite and marble deposits as well.

[8] The average PSC provides 30% of profits for the government and 70% for the private contractor. Besides the PSC, there is a 3% royalty levy, a 5% commercial tax, and a 2% income tax.

coal production. As of late 2011, 43 coal production licenses had been issued to 32 locally based private companies.

27. MOM has a number of policy objectives, including: (i) improved data on the production and use of coal; (ii) increased coal production and consumption and share of total energy output; (iii) control of pollution caused by coal, in accordance with the Environmental Law; (iv) lead responsibility for international cooperation on coal; and (v) implementing Myanmar's role under the Association of Southeast Asian Nations (ASEAN) Plan of Action for Energy Cooperation and the ASEAN Forum on Coal (AFOC). In turn, these objectives call for the following actions: (i) replacing firewood with coal briquettes to prevent deforestation; (ii) cooperation with other ASEAN member states for the efficient use of coal; and (iii) promoting coal-based industries and coal trade within ASEAN. The government is playing a lead role in obtaining clean coal technologies and transferring these to private companies.

28. **Regional cooperation.** In 2000, Myanmar formed the National Committee for AFOC,[9] chaired by the Deputy Minister for Mines and with the Director General of the Department of Mines as the secretary. Other members are the Director General of the Department of Geological Survey and Mineral Exploration, the Managing Director of the No. 3 Mining Enterprise, and the directors general from other relevant ministries. The committee's role includes: (i) cooperating with ASEAN member states for the development of coal resources; (ii) facilitating the exchange of technology for making coal briquettes, to replace wood-based charcoal so as to mitigate deforestation; and (iii) cooperating with ASEAN member states on using clean coal technology for power generation. The Ninth AFOC Council Meeting was held in August 2011 in Nay Pyi Taw, Myanmar.

E. Oil and Gas Subsector

1. Historical Development

29. Myanmar's hydrocarbon reserves are predominately in the form of natural gas, reserves of which are estimated to be 11.8 trillion cubic feet.[10] While this ranks Myanmar in 34th position globally, its position is much more significant regionally. Myanmar exported 8.81 billion cubic meters (BCM) of natural gas in 2010, significantly more than Malaysia (1.45 BCM) and second only to Indonesia (9.89 BCM). Myanmar, however, is a net importer of oil.

30. The oil and gas industry was nationalized in January 1963 and referred to as the People's Oil Industry. Myanma Oil Corporation was created in March 1970 under MOM and renamed in 1985 as Myanma Oil and Gas Enterprise (MOGE). Until 1989, MOGE had exclusive rights to explore, develop, and produce petroleum, both onshore and offshore. Subsequently, two additional entities of MOM were established: the Myanmar Petrochemical Enterprise (MPE), which operates refineries and processing plants; and the Myanmar Petroleum Products Enterprise (MPPE), which handles the distribution of petroleum products.

31. During the 1960s and 1970s, oil production remained modest, increasing from 3.8 million barrels in 1965 to 9.6 million barrels in 1978. In the early 1980s, however, oil production declined, owing to technical limitations and the government's reluctance to accept the participation of foreign firms.[11]

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[9] The objectives of AFOC are to (i) effectively use and maintain coal-fired power plants; (ii) cooperate with ASEAN member states for the development of coal-based industry and downstream technology; (iii) to standardize chemical analysis and quality control; and (iv) to undertake environmental impact assessments of coal projects.

[10] 2011. *BP Statistical Review of World Energy*. London.

[11] A. Kolas. 2007. Burma in the Balance: The Geopolitics of Gas. *Strategic Analysis*. 31(4).

32. With the promulgation of the Foreign Investment Law of November 1988, joint ventures and production sharing in the oil and gas subsector began. In the early 1990s, the State Law and Order Restoration Council invited foreign bids for offshore exploration rights in 18 concession blocks—13 in the Gulf of Martaban and 5 off the coast of Arakan State. Starting in 1990, the first foreign companies to buy offshore natural gas concessions were Premier Oil (UK) and Total (France). Since 1990, Total, Petronas Carigali, Daewoo, PTT Exploration and Production Public Company (PTTEP), and China National Offshore Oil Corporation have signed 20 offshore production sharing contracts and are currently exploring and/or developing 21 blocks.

33. Offshore gas discoveries have been significant. Two major offshore gas fields, Yadana (5.7 TCF) and Yetagun (3.16 TCF), were discovered in the 1990s in the Gulf of Moattama. The two fields have been supplying natural gas to Thailand since 2000, at a rate of about 755 million cubic feet per day (MMCFD) from the Yadana field and 424 MMCFD from the Yetagun field. In 2004, Daewoo International Corporation announced the discovery of the Shwe field, off the coast of Sittwe, with estimated gas reserves of about 5 TCF. Recent estimates indicate approximately 10 TCF of recoverable gas if the nearby gas fields of Mya and Shwe Phyu. Production from the Shwe field is expected to commence in 2013, for export to the PRC, through an overland pipeline from Myanmar to Kunming, Yunnan Province, PRC. The pipeline will have capacity of about 500 MMCFD, with a possible expansion to 1,200 MMCFD.

34. PTTEP, the national oil company of Thailand, has made a number of significant discoveries in blocks M-9 and M-7 in the Gulf of Martaban (near the Yetagun gas field). These include the Zawtika, Gawthika, Shweypyihtay, Kokona, and Zatila discoveries, with estimated cumulative reserves as much as 8 TCF (but possibly significantly less than this). PTTEP plans to build a pipeline to Thailand that would carry natural gas at the rate of 250 MMCFD. The pipeline could parallel the gas pipeline from the Yetagun and Yadana fields. Onshore gas discoveries have also been significant. In 2012, seven companies, Myanmar Petroleum Resources, Goldpetrol, China National Offshore Oil Corporation, Sinopec International Petroleum, Nobel Oil, Essar, and North Petro-Chem, were operating or developing nine onshore blocks.

35. Natural gas is Myanmar's most important source of export earnings and the oil and gas subsector accounts for a third of total foreign direct investment in Myanmar. According to the Myanmar Investment Commission (MIC), as of September 2011, a total of 60 investment projects had been approved for the oil and gas subsector, totaling $13.2 billion. The Myanmar Oil, Gas and Power Summits held in March and September 2012 provided the forum for another round of bidding for deep and shallow water blocks and onshore blocks. More than 150 companies from some 30 countries attended the summits, testifying to the highly appealing investment opportunities in Myanmar.

2. Oil and Gas Reserves

36. Seventeen geological sedimentary offshore basins have been identified (Appendix 3, Figure A3), only three of which have been thoroughly explored, all offshore: Rakhine, Mottama, and Tanintharyi basins. Likewise, fourteen onshore basins have been identified, only three of which have been thoroughly explored: Central Myanmar, Pyay Embayment, and Ayeyarwaddy Delta basins. Six of the other onshore basins have been explored to some extent while five have yet to be explored at all.[12]

37. The future recoverable oil and gas reserves are shown in Tables 2 and 3.

[12] Chindwin and Rakhine coastal basins have been explored to some extent. Hukaung, Shwebo-Monywa, and Bago Yoma basins have been lightly explored. Five basins have yet to be explored, namely, Hsipaw-Lashio, Namyau, Kalaw, Sittaung Valley, and Mawlamyine/Mepale.

Table 2 Future Recoverable Oil Reserves by Region (as of September 2011)

Region	Proven	Probable	Possible	Total
Onshore	102	355	4,160	4,617
Offshore	57	–	–	57
Total	**160**	**355**	**4,160**	**4,674**

– = unknown.
Source: Ministry of Energy.

Table 3 Future Recoverable Gas Reserves by Region (as of September 2011)

Region	Proven	Probable	Possible	Total
Onshore	394	530	4,682	5,606
Offshore	11,400	16,182	13,867	41,449
Total	**11,794**	**16,712**	**18,549**	**47,055**

Source: Ministry of Energy.

3. Oil and Gas Field Exploration

38. In Myanmar, concessions include (i) Exploration and Production and PSCs, (ii) Improved Oil Recovery and Performance Compensation Contracts, and (iii) Reactivation of Suspended Fields. Concessions set the terms for exploration and development activity within geographic blocks determined by the MOE. As of August 2011, 105 blocks were demarcated. A concession may apply across a number of blocks. For example, the PSC for the Yadana Project sets terms for the extraction and sale of natural gas from blocks M-5 and M-6. As of August 2011, 41 separate concessions were active, covering exploration and production activity in 75 blocks. A profile of these concessions is shown in Table 4.

39. Bidding on 18 onshore blocks was announced in July 2011. Proposals from interested investors were submitted in November 2011 and subsequently evaluated. As noted earlier, bidding on additional offshore and onshore blocks occurred following the Myanmar Oil, Gas, and Power Summits in March and September 2012.

Table 4 Reported Profile of Myanmar Petroleum Block Concession as of August 2011

Item	Number of Blocks
Petroleum block	53 (onshore)
	26 (offshore—shallow water)
	26 (offshore—deep water)
Total	**105**
Concession Type	
Production Sharing Contract and Exploration & Production	30 (onshore)
Production Sharing Contract	28 (offshore)
Improved Oil Recovery/Production Compensated Contract	7 (onshore)
Reactivation of Suspended Fields	10 (onshore)
Total	**75**

Source: Ministry of Energy.

4. Oil and Gas Production

40. **Natural gas production.** Gas production in FY2011 averaged about 1,232 MMCFD. Of total gas production, more than 90% was from the offshore Yadana (57%) and Yetagun (34%) fields; the remainder was from the MOGE-operated onshore fields. In September 2011, domestic gas delivery from the Yadana field was 174 MMCFD. In terms of annual output, in FY2011 gas production from the Yadana field reached 282 billion cubic feet (BCF) while that for the Yetagun field reached 164 BCF.

41. **Crude oil production.** Myanmar's onshore oil production is estimated to have reached 7,562 barrels per day (bbl/day) in September 2011. Most oil production is from fields located in the Salin sub-basin, led by MPRL's Mann field, which produced about 1,700 bbl/day. Myanmar is hoping to increase oil production to 10,000 bbl/day, in order to meet the country's growing demand for oil. There is no offshore oil production.

42. **Condensate production.** The Yetagun field, the only offshore condensate source, accounts for about 90% of Myanmar's total condensate production. In September 2011, the field produced 11,573 bbl/day. The MOGE-operated onshore fields of Nyaungdon and Shwepyitha accounted for the residual condensate production.

43. **Key offshore gas field production: Yadana.** The Yadana field has estimated gas reserves of more than 5.7 TCF, or 162 BCM, with an expected field life of 30 years. The Yadana project was developed by a consortium composed of Total (31%), Unocal (28%), PTTEP of Thailand (26%), and MOGE (15%). It is operated by Total and started production in 1998. Gas from Yadana is transported via a 346-kilometer subsea pipeline and a 63-km onshore pipeline to the border with Thailand at Ban I Thong. At the border, the Yadana pipeline connects with a pipeline built by Thailand, which carries the gas to its destination near Bangkok, providing fuel to the Ratchaburi and Wang Noi power plants. Gas from the Yadana field covers an estimated 15%–20% of Thailand's demand for natural gas. The Sein field, located south of the Yadana field, is estimated to have recoverable reserves of 200 BCF.

44. **Key offshore gas field production: Yetagun.** The Yetagun field has estimated reserves of 3.16 TCF. Production from Yetagun started in 2000, and was initially developed by a joint venture of Texaco (50%), the British oil company Premier Oil (30%), and Nippon Oil (20%). Following the withdrawal of Texaco in 1997 and Premier Oil in 2002, Yetagun has been operated by Petronas, in partnership with MOGE (20%), Nippon Oil (19%), and PTTEP (19%). The gas is transported via a 210-km subsea pipeline and a 67-km onshore pipeline to Thailand.

45. **Key offshore gas field production: A-1 and A-3 Shwe.** In August 2000, Daewoo International partnered with MOGE to explore and develop offshore natural gas deposits in the Bay of Bengal off the coast of Arakan. In 2004, Daewoo International announced the discovery of the Shwe field, off the coast of Sittwe, the capital of Arakan State. Test drilling in blocks A-1 and A-3 has indicated gas reserves of 3.56 TCF or more. Partners in the project are Daewoo International (60%), Korean Gas Corporation (10%), India's Oil and Natural Gas Corporation (20%), and Gas Authority of India, Limited (GAIL) (10%). Gas production from the field will be exported to the PRC, as described in Box 2.

5. Export of Gas

46. In 2011, a total of 365.7 BCF of gas was exported from the Yadana and Yetagun fields, of which 59% was from the Yanada field and 41% from the Yetagun field. The trend of gas export from both fields is in Table 5 and the amount of royalty is in Table 6.

Box 2 Myanmar–People's Republic of China Gas Pipeline Project

In June 2008, the China National Petroleum Corporation (CNPC) signed a memorandum of understanding (MOU) with the Government of Myanmar and a Daewoo-led consortium on the sale and transport of natural gas from the offshore blocks A-1 and A-3. Following signing of the MOU, Daewoo commenced development of the gas fields, targeting 2013 for the start of on-stream production. An Export Gas Sale and Purchase Agreement was signed in December 2008, and includes a provision whereby the gas price will be reviewed quarterly to reflect global trends.

Daewoo, CNPC, and Myanmar Oil and Gas Enterprise (MOGE) have agreed on a gas price for Daewoo's Shwe, Shwe Phyu, and Mya fields on Block A-1 and Block A-3 in the Rakhine Basin, offshore of northern Myanmar. Gas from the fields will be sold to the People's Republic of China (PRC) at a rate of about $7.73 per million British thermal units (MMBtu), inclusive of a tariff of $1.02 per million British thermal units. The contract is valid for a 30-year period and is indexed to the inflation rate in the United States. Concurrently, another consortium of block partners, consisting of Oil and Natural Gas Corporation Videsh, GAIL India, Daewoo, and the Korean Gas Corporation, were reportedly planning to invest approximately $2.8 billion to develop the fields, with first gas production also scheduled for 2013. The consortium planned to spend a further $936 million to lay an undersea pipeline to transport the gas to shore.

Upon landfall, the gas will be transported from Myanmar to the PRC's southwest province via an 870-kilometer 40-inch pipeline, to be constructed by Daewoo, CNPC, and MOGE, with a capacity of up to 1,200 million cubic feet per day (MMCFD.)

In combination, it is expected that the above fields will produce a total of 500 MMCFD; 400 MMCFD will be transported to the PRC and 100 MMCFD kept for domestic use.

Source: Ministry of Energy.

Table 5 Natural Gas Export (billion cubic feet)

Year	Yadana	Yetagun	Total
2002	192	756	268
2003	192	92	284
2004	190	92	283
2005	193	109	302
2006	191	142	333
2007	237	153	390
2008	242	158	400
2009	198	130	328
2010	223	151	374
2011	215	151	366

Source: Ministry of Energy.

Table 6 Amount of Royalty from Both Gas Fields

Year	Yadana	Yetagon	**Total** ($ million)
2006	47	76	123
2007	64	87	152
2008	75	103	178
2009	94	109	203
2010	83	97	180

Source: Ministry of Energy.

6. Domestic Use of Gas

47. Domestic gas demand in 2011 was about 60 BCF. Currently, domestic gas consumption is primarily for 10 gas-fired power plants (60%), fertilizer production (12%), and compressed natural gas (10%). Table 7 shows domestic use of gas from FY2002 through FY2011.

Table 7 Domestic Use of Natural Gas
(million cubic feet)

Fiscal Year	Power Generation	Industry (fertilizer)	Domestic	Transport	Others	Total
2002	30,183	3,296	2,517	68	3,383	39,446
2003	33,689	4,588	2,882	60	4,156	45,375
2004	38,695	6,462	2,832	70	3,746	51,805
2005	43,957	4,335	3,027	137	3,590	55,045
2006	38,547	4,837	2,574	1,440	6,572	53,970
2007	35,057	5,139	3,124	3,356	8,231	54,907
2008	41,086	5,617	2,570	4,813	7,188	61,274
2009	39,747	5,332	2,617	6,006	9,699	63,400
2010	25,872	2,796	2,149	6,664	6,676	44,157
2011	41,226	2,818	2,570	7,040	6,770	60,424

Source: Ministry of Energy.

48. About 2,775 miles of gas pipeline were constructed onshore and 431 miles offshore. It is planned to extend the natural gas pipeline network and to replace small diameter pipelines with larger diameter pipes.

49. **New Yadana–Yangon pipeline.** In June 2010, MOGE completed a new gas pipeline connecting the Total-operated Yadana gas field, in Blocks M-5/M-6, Moattama Basin, to Yangon. It delivers gas to the gas distribution station of Ywama, in Yangon's Insein Township, and will help ease power shortages in Yangon due to leakage from an old gas pipeline. Construction of the new pipeline was fast-tracked, as the government had pledged to deliver 200 MMCFD by 2010 to supply Myanmar's power plants. However, as noted earlier, most of the gas produced from Yadana is exported to Thailand.

50. **Compressed natural gas and natural gas vehicle program.** In 1986, the government initiated the compressed natural gas (CNG) and natural gas vehicle program, so as to expand the use of domestically-produced natural gas and respond to climate change concerns. Between 1986 and 2011, 50 CNG refueling stations were established (42 in Yangon, 2 in Mandalay, 4 in Yenangyaung field, and 2 in Chauk field). Further, more than 27,000 buses and cars were converted to natural gas. The use of natural gas in vehicles is in compliance with the Gas Control Safety Law (based on Japanese Industrial Standards).

7. Petroleum Products

51. In FY2011, total domestic demand for petroleum products was 8.1 MMbbl: 3.7 MMbbl of gasoline; 3.4 MMbbl of diesel; 11 MMbbl of kerosene; 598 MMbbl of auto turbine fuel; and 454 MMbbl of furnace oil.

52. In order to meet the demand for petroleum products, the Myanmar Petroleum Enterprise is currently operating three refineries (Table 8) with a total processing capacity of 51,000 barrels of oil per day (BOPD). The refineries use a blend of domestic crude oil from onshore fields (heavy sweet crude oil) and condensates from the Yetagun offshore gas field. A new refinery will be built near Mandalay,

Table 8 Refineries in Myanmar, 2011

Serial No.	Refinery	Design Capacity (BOPD)	Refine Capacity	% of Design Capacity	Year of Commissioning
1	Thanlyin Refinery[a]	20,000	400,000 gallons (11,429 BOPD)	57	1963[b] 1980[c]
2	Chauk Refinery	6,000	70,000 gallons (2,000 BOPD)	33	1954
3	Thanbayakan Refinery	25,000	300,000 gallons (8,571 BOPD)	34	1982

BOPD = barrel of oil per stream day.
[a] a coker plant of 5,300 BOPD was added in 1986.
[b] unit 1.
[c] unit 2.
Source: Ministry of Energy.

scheduled for completion in 2014, with a capacity of 20,000 BOPD to process crude oil from the Myanmar–PRC oil pipeline.

53. The refineries are old and the operation percentage is low, ranging from 33% to 57%. To upgrade the Thanlyin refinery, a supply contract was signed by the Myanmar Petrochemical Enterprise (MPE) and Angelique of India, with financial assistance of $20 million from the Indian government. Most of the renovation works have been completed, with the exception of a 4.5 MW new power plant. Also, a contract has been signed between MPE and Novatech Process Equipment for upgrading the Mann-Thanbayakan Refinery, again with financial assistance from the Indian government. Commissioning of the renovated refinery is scheduled for August 2013.

54. There are five urea fertilizer factories in Myanmar with a total capacity of over 2,000 metric tons per day, depending on the availability of natural gas. There are three liquefied petroleum gas (LPG) plants with a total capacity of 42–50 MMCFD. Currently, the price of LPG is 5,764 kyats/25-kilogram bottle, equivalent to 131 kyats/liter. LPG is used for cooking purposes.

55. Gashol is a blend of gasoline (95%) and bioethanol (5%) made from sugarcane. Biodiesel is also blended with diesel, again on a 95% to 5% basis. Highly refined petroleum products (e.g., aviation fuel) are imported, mainly from Singapore.

56. **Price of petroleum products.** Official retail prices of major petroleum products are shown in Table 9. In response to the upsurge of global oil prices and to contain demand, in August 2007, the government sharply increased some petroleum retail prices; the price for motor gasoline and jet fuel was increased from 330 kyats/liter to 549.9 kyats/liter, while the price for diesel was increased from 330 kyats/liter to 659.9 kyats/liter. The retail price of furnace oil and kerosene was unchanged, at 2.6 kyats/liter and 3.3 kyats/liter, respectively; both are highly subsidized.

Table 9 Official Retail Prices of Major Petroleum Products, 2004–2011 (in kyats/liter)

Item	2004	2005–2006	2007–2010	2011
Gasoline	39.6	330.0	549.9	549.9
Diesel Fuel	35.2	330.0	659.9	659.9
Furnace Oil	2.6	2.6	2.6	2.6
Kerosene	3.3	3.3	3.3	3.3

Source: Ministry of Energy.

57. For the government sector, the price of motor gasoline and high speed diesel is also heavily subsidized. In a step towards a more market-based economy, most petrol stations formally run by the Myanmar Petroleum Products Enterprise (MPPE) (261 out of 273 as of 2010) have been privatized. The government now allows private companies to import petroleum products, using foreign exchange earnings from their businesses. The government continues to be an active participant in the distribution of gasoline and diesel—including through ownership of 12 fueling stations.

58. The price of gasoline and diesel has been liberalized in 2012.[13] MOE is in the process of implementing further liberalization measures, including regulations concerning the import and distribution of gasoline and diesel.

59. The government allows the importation and construction of storage tanks by the private sector and 19 companies are doing so.[14] For example, E-lite will build a 2-million-metric-ton tank for diesel fuel and a 2-million-metric-ton of tank for gasoline. Max Myanmar will also build a 5.2-million-metric-ton tank for diesel fuel and 1.3-million-metric-ton tank for gasoline.

60. **Clean fuel program.** The Environmental Conservation Committee was re-formed in 2011, in part to intensify the effort to reduce carbon dioxide emissions. Initiatives have included the promotion of increased use of natural gas in power generation and in the industrial sector, and by converting (as described earlier) gasoline, diesel, and LPG vehicles to CNG vehicles.

61. **Myanmar–PRC crude oil pipeline.** The PRC has interest in constructing a crude oil pipeline through Sittwe, given the reduced cost and time of importing oil from Myanmar in this manner rather than by oil tanker through the Strait of Malacca. Accordingly, in 2007, MOE and CNPC signed an MOU on joint development of a crude oil pipeline, under which CNPC will finance almost the entire cost of the project. CNPC has also signed an agreement with Yunnan Province to cooperate in oil refining, a complementary step in building the oil pipeline to Myanmar.

62. In 2010, CNPC began constructing the Myanmar section of the pipeline. CNPC's subsidiary, Southeast Asia Crude Oil Pipeline, is in charge of the design, construction, operation, and maintenance of the pipeline.[15] The expected capacity of the oil pipeline will be about 161 million bbl/year (or about 440,000 bbl/day).[16]

63. The government guarantees the safety of the pipeline and ensures the ownership of CNPC, which holds a 50.9% stake in the Myanmar section of the project with the remaining stake held by MOGE.

F. Renewable Energy

64. Myanmar has abundant renewable energy resources, notably hydropower and biomass, but also potential for wind, solar, and other types of renewable energy. Among these resources, hydropower is

[13] In October 2012, the price of gasoline was 922.2 kyats/liter and the price of diesel was 877.8 kyats/liter, respectively.

[14] Licenses for the construction of petroleum storage are still issued by the Ministry of Mines.

[15] CNPC has also commenced construction of the Chinese sections of the two oil and natural gas pipelines that will link Southwestern China to Myanmar. The company has also begun construction of a refinery near Kunming, Yunnan Province. The 200,000 bbl/day refinery will process crude imported from Myanmar; the refinery is expected to be fully operational in 2013.

[16] The oil pipeline will have a total length of 2,402 km, including a 771-km section in Myanmar. The planned 244,000 bbl/day (up to 400,000 bbl/day capacity) crude oil pipeline will run from Kyaukphyu township in Myanmar's Rakhine State to PRC's Kunming via the border city of Ruili in Yunnan Province. It will also be extended by 1,700 km to the Guizhou and Chongqing provinces in the PRC. The construction of the Kyaukphyu deep-sea port started in late 2009 was the first step of the project.

being developed and utilized on a commercial scale. The other renewable energy resources remain under research and in development or pilot stages.

65. As stated earlier, MOE's policy guidelines include promoting wider use of new and renewable sources of energy. The Ministry of Science and Technology (MOST) is responsible for related research and development, and ensuring that the deployment of renewable energy technologies addresses the basic energy requirements of rural households and the agriculture sector. The Ministry of Electric Power (MOEP) supports general rural electrification programs in the country.

1. Hydropower

66. As introduced in Section C, Myanmar's four main river basins (Ayeyarwaddy, Chindwin, Thanlwin and Sittaung) are the source of huge hydropower potential, estimated to be more than 100,000 MW. As of the end of 2011, only 753 MW of hydropower power had been commissioned. Myanmar Electric Power Enterprise (MEPE), under the MOEP, has so far identified more than 200 locations suitable for hydropower development, with a combined potential capacity of about 40,000 MW. Thirty-six projects have been formed to tap these resources and 14 are under construction.

67. **Small hydropower projects for border area development.** Over the past 5 years, some 26 micro- and 9 mini-hydropower power projects have been developed by MEPE, with installed capacity ranging from 24 kilowatts (kW) to 5,000 kW (Appendix 4, Figure A4). These projects have included border areas, aimed at improving the social and economic conditions of poor rural households and remote communities. These mini-hydropower projects also facilitate cottage industries and enhance agricultural productivity through improved irrigation. Table 10 provides the list of the planned micro-hydropower power projects in border areas.

68. Village-scale hydropower projects range from primitive wooden wheel types to a variety of small modern turbine systems. Research on micro-hydropower plants, led by MOST, includes the design and construction of different types of turbines and synchronous generators for micro-hydropower plants.[17]

Table 10 Planned Micro-Hydropower Projects in Border Areas

Project	Installed Capacity (kilowatt)	Location	Objective
1. Mepan Chaung	1,200 (600 x 2)	Eastern Shan State	To supply electric power to Mong Hsat and Mong Ton towns
2. Tumpang Hka Chaung	6,000 (2,000 x 3)	Kachin State	To supply electric power to Myitkyina and Waing-Maw towns
3. Kang Hkawng	1,200 (400 x 3)	Eastern Shan State	To supply electric power to Mong Hkak and Mong Yang townships
4. Kyu Hkak Chanung	320 (160 x 2)	North Eastern Shan State	To supply electric power to Kyu Hkok town and nearby villages in Muse townships
5. Nam Mae Sai	6,000 (2,000 x 3)	Eastern Shan State	To supply electric power to Tachileik town and also to export excess power to Thailand

Source: ASEAN Energy. http://www.aseanenergy.org/energy_sector/electricity/myanmar/future_hydro_projects.htm

[17] In 2009, MOST's micro-hydropower project group designed and constructed 3 kW and 7 kW low head propeller turbines for village hydropower. The 3 kW low head propeller turbine was constructed at the Central Workshop (Kyaukse) and tested at the Dan Taing Village hydropower site near Kyaukse. The 7 kW low head propeller turbine was also designed and constructed at the Central Workshop (Kyaukse), and tested at the Kulla Village hydropower site near Kyaukse.

2. Biomass and Biogas

69. As noted earlier, approximately two-thirds of primary energy in Myanmar is supplied by biomass (fuelwood, charcoal, agriculture residue, and animal waste). Fuelwood accounts for more than 90% of biomass-sourced energy, most of which is harvested from natural forests;[18] it is used in both urban and rural areas. Charcoal, which accounts for 4%–6% of total fuelwood consumption, is mainly used in urban areas. The annual consumption of fuelwood per household is estimated to be about 2.5 cubic tons (4.5 m^3) for rural households and 1.4 cubic tons (2.5 m^3) for urban residents.

70. Myanmar's forest policy is designed to promote forest conservation and efficient use and management of forestry resources. The policy is based on six principles: protection, sustainability, basic needs, efficiency, public awareness, and participation. In 2002, the Ministry of Forestry (MOF) announced its long-term (to 2030) National Forestry Master Plan, including for bio-energy. Despite an increasing population, fuelwood use is forecast to decrease, reflecting greater reliance on energy efficient stoves and alternative energy sources, such as hydropower and natural gas. By 2030, fuelwood is projected to account for less than half of total primary energy, compared to almost two-thirds currently. The department's predictions of fuelwood supply in 2030 are shown in the Table 11.

Table 11 Predicted Supply of Fuelwood as Indicated in the National Forestry Master Plan

	2002		2030	
Source	(million cubic meter)	(%)	(million cubic meter)	(%)
Plantations	1.06	3.36	1.26	4.23
Non-forest land	7.89	25.01	7.44	25.00
Community forests	0.06	0.19	7.44	25.00
Natural forests	22.54	71.44	13.63	45.77
Total	**31.55**	**100.00**	**29.37**	**100.00**

Source: Ministry of Forestry.

71. **Programs implemented by MOF for the supply, efficient use, and substitution of fuelwood.** To assist in meeting the demand for bio-energy, the Forest Department has helped establish fuelwood plantations and community forests. It has also encouraged fuelwood conservation by promoting the use of efficient cooking and heating stoves and the use of alternative energy sources, such as agricultural waste and coal briquettes.

72. **Establishment of fuelwood plantations.** The Forest Department established a total of 0.84 million hectares (ha) of forest plantations between 1981 and 2010, some 20% of which were for fuelwood. The plantations expanded at an average annual rate of about 4,300 ha during 2000–2005, but this slowed to about 1,900 ha annually during 2006–2010.

73. **Establishment of community forests.** Community Forestry Instructions were issued in 1995, stressing the importance of local community participation in sustainable forest management. According

[18] About 47% of the country's total area (31.77 million hectares) is covered by different types of forest (Forest Resource Assessment 2010): (i) permanent forest estates—which are reserved forest and protected public forest—cover about 24% (162,523 km^2) of the total land area; and (ii) protected area systems cover almost 6% (37,895 km^2) of the total land area, primarily serving as havens for the country's rich biodiversity and for protection of the environment. An additional 7,213 km^2 (1.07%) has been proposed under the protected area systems.

to the instructions, local communities are granted 30-year land leases for the establishment of community forests. By the end of 2010, community forests occupied about 41,840 ha and it is expected that their continued expansion to 2030 will result in their fulfilling 25% of the projected demand for wood fuel.

74. **Distribution of fuel efficient stoves and promotion of wood fuel substitutes.** The distribution of efficient stoves was initiated in the 1990s by MOF and implemented in cooperation with the United Nations Development Programme and the Food and Agriculture Organization. Since 2004, MOF has been implementing the Bago Yoma Greening Project, which includes dissemination of efficient stoves and utilization of wood fuel substitutes, such as coal briquettes and agricultural waste. By March 2011, 232,000 fuel efficient stoves, including A1 and rice-husk stoves, had been distributed free of charge or at an affordable price. Research has indicated that A1 stoves can reduce wood fuel use by up to 40%.

75. **Biomass biological energy.** Millions of tons of crop residues, such as rice husks, are produced year round in Myanmar due to the continuous cultivation of various crops. Further, many millions of tons of animal waste (particularly cattle excreta) are produced every year. In light of this extensive biomass energy potential, the government has started to actively promote its use.

76. Over the past 10 years, about 152 community-based biogas digesters (plants) have been built, mostly in the central region (Mandalay, Sagaing, and Magway divisions) and in the Northern Shan State. The digesters vary in capacity (from 25 to 100 cubic meters)[19] and electricity output ranges from 5–25 kW. While the combined output of these digesters is modest, it is enough to serve 172 villages with four hours of electricity per day. Table 12 summarizes the biogas energy projects in Myanmar until 2011.

77. In 2009, MOST developed 23 family-sized, fixed-dome type biogas digesters and deployed them in Nay Pyi Taw, Mandalay, Ayeyarwaddy Region, and Eastern Shan State. From one family-sized biogas digester, about 30 to 50 gallons per day of organic fertilizer is produced, which can be used for soaking seeds for germination, organic farming, or as feed for pigs and fish.

78. **Biomass thermo-chemical energy.** Biomass thermo-chemical energy for power generation has relied mainly on paddy husk and bagasse. For cottage industry sector applications, some private sector rice mills have been using rice husk as permanent fuel in driving steam turbines. Rice husk gasifiers have been improved and more than 1,000 kW can be generated. MOST is also undertaking research and development for woodchip and other forms of small-scale gasifiers, capable of producing 30–50 kW of electricity for villages in rural areas.

3. Biofuels

79. Based on the government's energy plan, gasoline will be gradually substituted by bioethanol (95% ethanol) to meet energy demand at the community level, and by gasohol (15% anhydrous ethanol in gasoline) at the national level. Diesel will be substituted by a diesel-blend (5% to 20% Jatropha oil) at the community level and biodiesel at the national level.

80. **Bioethanol.** Produced from sugarcane, molasses, and starchy materials, such as broken rice corn, bioethanol is used as a transportation fuel to substitute for gasoline or to mix with gasoline. Several private companies engaged in sugar production have diverted surplus sugar output to bioethanol production.

[19] In 2008, a 25-cubic-meter, fixed-dome type biogas plant using human wastes was constructed at the Sinmin cement factory. Biogas from that plant is utilized for cooking and the effluent from the biogas plant is used as organic fertilizer for plants. A 100-cubic-meter, fixed-dome type biogas plant was constructed in 2008 at a dairy cow breeding farm in Mandalay Division. It can produce biogas for cooking, chop the forage for cows, and produce electricity to provide light to the whole farm.

Table 12 Biogas Energy Projects in Myanmar

Digester Size (cubic meters)	Location	Type	Date Started	Purpose	Cost ($ per plant)	No. of Biogas Plants
50	Nay Pyi Taw Division	Fixed-Dome Type	2003	Electricity	5,000	6
10			2009	Electricity, cooking, and lighting	900	4
8			2008	Cooking and lighting	600	8
100	Mandalay Division		2008	Electricity	9,000	1
50			2002		5,000	102
35			2009		4,000	3
25			2009		3,000	2
8			2009	Cooking and lighting	600	3
50	Sagaing		2004	Electricity	5,000	23
15			2010		2,500	1
10			2009	Cooking and lighting	700	1
50	Magway		2004	Electricity	5,000	8
25			2009		3,000	1
50	Shan State (North)		2005		5,000	1
25	Shan State (East)		2009		3,000	1
10			2009		900	1
60	Shan State (South)		2010	Cooking	5,000	1
25			2009	Electricity	3,000	1
50	Kayah		2009		5,000	1
15	Kachin		2010		2,500	2
5			2010	Cooking and lighting	500	1
10	Ayeyarwaddy		2009	Electricity	900	2
Total						**174**

Source: Ministry of Science and Technology.

81. In 2000, the Myanmar Sugarcane Enterprise (now the Sugarcane Development Department) established the first gasohol plant in the country, with a capacity of 500 gallons of 99.5% ethanol per day. It was uneconomic at the time, as the cost of production (3,000 kyats/gallon) was twice the government-controlled price of gasoline (1,500 kyats/gallon) and there was no market for the factory's output. When the price of gasoline was sharply increased in August 2007 (from 330 kyats/liter to 549.9 kyats/liter), there was renewed interest in the factory, which was transferred to private ownership.

82. Since 2002, the Myanmar Chemical Engineers Group has constructed four plants producing 99.5% ethanol: the Pyinmana plant in Mandalay, with 500 gallon/day capacity; the Kantbalu plant in Sagaing and Taungsinaye plant in Bago, both with a capacity of 3,000 gallons/day; and the Kathar plant in Sagaing with capacity of 15,000 gallons/day. Their total annual production capacity is 1.95 million gallons.

83. The Myanmar Economic Cooperation has built two large bioethanol plants, with a combined capacity of 1.8 million gallons/year. Commercial production of the two plants commenced in 2008. In addition to public sector leadership, Great Wall, a private company, has built an ethanol plant capable of producing 3,700 gallons of anhydrous alcohol per day, based on sugarcane. Another factory, based on

cassava, will be constructed by an associated company of Great Wall. Regulations concerning bioethanol production would appear needed so as to avoid potential conflict with food security.

84. **Biodiesel.** Biodiesel as a substitute for petrol diesel can be produced from a number of raw materials found in Myanmar, including crude palm oil and *Jatropha curcas* oil. MOST has initiated research and development on biodiesel, including production in pilot plants using *Jatropha curcas* oil.[20]

85. In 2005, the government launched the Jatropha Plantation Project (Box 3).

Box 3 Jatropha Plantation Project for Biodiesel Production

Jatropha biodiesel holds promise as a fuel alternative. Research has shown that Jatropha biodiesel provides engine performance that is very similar to diesel fuel. It is expected that biodiesel would be widely accepted by the world automobile industry, consistent with the need to reduce carbon emissions and to protect the environment. Moreover, Myanmar imports more than 200 million gallons of diesel annually and biodiesel could be a substitute, with important foreign exchange savings.

The Jatropha Plantation Project for Biodiesel Production was first launched in 2005, with the initial target of 3.23 million ha (8 million acres) of plantation. The *Jatropha curcas* seed has high oil content (more than 26%) and 50–60 gallons of oil per acre are projected. By September 2011, about 2 million ha (5.2 million acres) had been planted with Jatropha. The government encourages entrepreneurs and local farmers to grow Jatropha and different types of Jatropha cultivation can be found in large-scale plantations, community forests, and roadsides.

Despite the ambitious start, numerous constraints have impeded Jatropha biodiesel production:

(i) difficulty in the dissemination of technology;
(ii) lack of capacity;
(iii) lack of a promising variety, as existing variety has low yields;
(iv) presence of pest and diseases, leaf miner, red mite, mealy bug;
(v) problems during post harvest;
(vi) ownership issues; and
(vii) marketing and processing concerns.

The government believes that the following steps must be implemented to enhance Jatropha biodiesel production:

(i) increase productivity through new improved varieties;
(ii) expand cultivation in highly fertile areas of the country;
(iii) improve management practices;
(iv) improve post-harvest technology and processing techniques;
(v) develop marketing systems and credit facilities;
(vi) create better linkages between research and extension;
(vii) motivate smaller holder producers;
(viii) facilitate technology exchange with international organizations; and
(ix) enhance the information network.

[a] *Jatropha curcas* is a new crop and the cultivated area has expanded very rapidly. Much of the cultivated area for Jatropha was along roadsides and under shade. Low nutrient value, lack of fertilizer, narrow spacing, and lack of systematic pruning resulted in marginal yields.

Source: Ministry of Agriculture and Irrigation.

[20] Other biodiesel research by MOST includes: (i) preparation of biodiesel by a non-catalytic superheated methanol vapor bubble method; (ii) acid/base catalyzed esterification reaction for preparation of biodiesel from high free fatty acid oil; (iii) exploration of liquid rich microalgae for biodiesel production; (iv) purification and esterification of waste lipids from rice bran oil industry; (v) direct trans-esterification of biomass for biodiesel preparation; and (vi) liquid organic fertilizer from *Jatropha curcas* press cake.

4. Wind

86. Due to the initial high cost of wind energy, its development is at the experimental and research phase in Myanmar. The evaluation of wind energy resources using modern systems has been conducted since 1998, led by the Myanmar Scientific and Technological Research Department and the Department of Meteorology and Hydrology. Judging from existing data, the western part of the country appears to have the best potential for harnessing wind power.[21] However, available data on wind energy sources are not sufficient to evaluate suitable sites for the construction of wind turbines.

87. Other institutions have also conducted research and development on wind energy, including the Department of Physics at Yangon University and the Department of Electric Power (DEP) and MEPE at the MOEP. This research was in cooperation with the New Energy and Industrial Technology Development Organization (NEDO) of Japan, which has constructed meteorological observation stations in Central and Lower Myanmar. Further, NEDO has assisted in installing wind and solar measuring equipment at several sites, to collect data and to conduct feasibility studies for wind-solar power hybrid systems.

88. There are some wind turbines operational in Myanmar, including at the Technological University (Kyaukse), Shwetharlyoug Mountain in Kyaukse Township, the Government Technical High School (Ahmar) in Ayeyarwaddy region, and Dattaw Mountain in Kyaukse Township. It was perfectly utilized for lighting purpose in the township's monastery. Up to September 2011, 15-foot wind turbine (3 kW) of axial-type permanent magnet generator has been constructed and tested at the Shwetharlyoug Mountain (Table 13).

Table 13 Wind Energy Projects in Myanmar

Name	Location	Type	Date Started	Cost ($)
1.2 kW wind turbine	Monastery, Dattaw Mountain, Kyaukse Township, Mandalay Region	Radial-flux, permanent magnet generator, three-blade system	7 July 2008	2,000
1.2 kW wind turbine	Government Technical High School (Ahmar), Ayeyarwaddy Region	Direct-driven, horizontal type and three-blade system using axial-flux permanent magnet generator	16 April 2010	2,300
3 kW wind turbine	Wind energy project group (Kyaukse) Ministry of Science and Technology	Direct-driven, horizontal type and three-blade system of wind turbine using axial-flux permanent magnet generator	10 January 2009	3,000

kW = kilowatt.

Source: Ministry of Science and Technology.

89. Two foreign companies, Gunkul Engineering Public Company Limited and China Three Gorges Company, signed MOU with MOEP in 2011 and has undertaken the feasibility study for potential development of 4,032 MW of wind energy.

[21] The results from investigative studies indicate that feasible areas to harness wind energy are in locations with an average wind speed of 5.6 to 7.4 meters per second, which would yield outputs ranging from 55 kW to 225 kW. Myanmar has a 2,832-km coastal strip facing the Bay of Bengal and the Andaman Sea. Potential available wind energy along this coastal strip, with its southwesterly wind for 9 months and northeasterly wind for 3 months, is around 365.1 terawatt-hours per year.

5. Solar

90. Similar to wind energy, solar energy in Myanmar is in the research and development stage, due to its initial high cost. Solar energy potential in Myanmar is perhaps highest in the Central Dry Zone Area of Myanmar.[22]

91. Solar energy is being introduced in a limited manner in some rural areas, through photovoltaic cells to generate electricity for charging batteries and to pump water for irrigation. As an initial step to demonstrate photovoltaic power systems for remote villages, some equipment has been installed under a technical cooperation program with other developing countries.

92. Pilot projects have included the following:

i. "Solar Photovoltaic Battery Charging Community Enterprise," financed by the Energy Services and Income Generating Opportunities for the Poor (Project "ENSIGN"), in collaboration with Yoma Bank and Energy Planning Department of the Ministry of Energy (MOE);

ii. "Demonstrative Research on a Photovoltaic Power Generation System in Myanmar," in cooperation with NEDO of Japan and the Department of Electric Power of MOEP; and

iii. "Solar Power Village Electrification Scheme," with research and development of solar equipment prototypes, supported by the Myanmar Scientific and Technological Research Department and the Department of Physics of the Yangon Technological University.

93. Research continues on the use of solar power for household purposes (lighting and cooking), for irrigation pumps, and for solar driers for grain and fish. Research has successfully demonstrated the use of solar energy for making salt from seawater.

94. MOST has begun providing electricity to schools and institutes by using solar energy. To help demonstrate the practicality of this initiative, Mandalay Technological University (MTU)[23] has installed 3 kW photovoltaic (PV) power systems in several MOST technical schools and institutes located in remote areas and without access to the national grid system. For each school, there is enough power to supply 10 computers, one overhead projector, IPSTAR internet equipment, and 10 fluorescent lamps. The solar system used can be applied at minimum cost.[24] MOST plans to install the system throughout the country in technical schools lacking electricity.

6. Geothermal

95. Geothermal energy is abundant in Myanmar, with considerable potential for commercial development. Ninety-three geothermal locations have been identified throughout the country. Forty-three of these sites are being tested by the Myanma Oil and Gas Enterprise (MOGE) and MEPE,[25] in cooperation with the Electric Power Development of Japan and Union Oil Company of California and Caithness Resources of the United States.

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22 Experimental measurement indicates that radiation intensity of more than 5 kilowatt-hours per square meter per day was observed during the dry season.

23 Specifically, the Department of Engineering Physics and the Electrical and Electronic Research Center, MTU.

24 Most materials were designed and constructed by MTU and all of the materials are in compliance with international codes of practice. Both poly-crystalline and amorphous solar panels were used in order to evaluate actual performance and application. As a result, two sets of 3 kW solar energy systems were installed in the Government Technical High School in Putao and Kamtee (both are located at the northernmost part of the country with harsh weather conditions). The sunshine availability in both townships is approximately four hours per day, enabling students to access the internet during this period.

25 Testing includes chemical and X-ray diffraction analysis.

7. Tidal Energy

96. The first tidal power plant in Myanmar was installed in 2007 in Kanbalar village. It is a barrage style power plant with a single basin. Its 3-kW turbine was locally designed and built and provides electricity to 220 households (about 1,200 persons). A similar project with a 5-kW turbine was implemented at a salt production site.

97. **Future development of renewable energy resources.** While Myanmar has abundant renewable energy resources, harnessing them is hampered by several factors: (i) lack of a fully transparent institutional and legal framework to support exploration, development, and deployment; (ii) limited financial capital to support research and development, market-based investment programs, and development of physical infrastructures; (iii) lack of human resource capacity; and (iv) subsidized power and petroleum prices, which make it difficult for wind and solar energy alternatives to compete. Establishment of a more supportive environment for development of Myanmar's renewable energy resources should include the following: (i) more information on the resource potential; (ii) improved inter-ministerial cooperation and coordination; (iii) promotion of private sector participation; (iv) clarification of government policy regarding renewable energy; and (v) technology dissemination regarding family-size biogas digesters, mini-hydropower plants, and other options for rural use.

G. Power Subsector

1. Overview

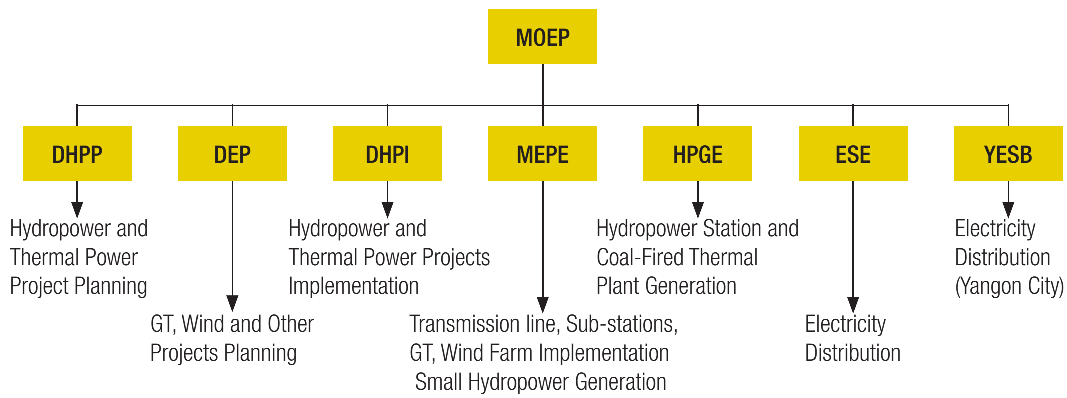
98. Even though electricity consumption in Myanmar has doubled during the last 10 years, in 2011, total electricity consumption was 6,312 GWh. With a population of about 60 million, Myanmar's per capita electricity consumption was only 100 kWh per year, which was the lowest among ASEAN 10 countries. The low national average per capita electricity consumption is due to the low electrification rate, low industrial development and lack of investment. The country's average electrification[26] grew from about 16% in 2006 to 26% in 2011. Yangon City has the highest electrification ratio (67%), followed by Nay Pyi Taw (54%), Kayar (37%), and Mandalay (31%). The remaining rural areas are still poorly electrified averaging at about 16%. Total system installed capacity in 2011 was 3,361 megawatts (MW) consisting of 2,520 MW (76%) hydropower capacity, 715 MW (21%) gas-fired capacity, and 120 MW (4%) coal-fired capacity. Although the installed capacity exceeds the 2011 peak load of 1.58 MW, the availability capacity of the gas and coal power plants were low due to poor maintenance. Particularly, during the dry season, the hydropower plants cannot generate at full capacity due to lack of water. Hence, Myanmar's power grid is experiencing significant load shedding during the dry season of up to 400–500 MW. MEPE is responsible for the development and implementation of transmission network, covering the voltage levels of 66 kV, 132 kV, and 230 kV. Distribution systems consist of lower voltage levels—33 kV, 11 kV, 6.6 kV, and 0.4 kV. Two distribution enterprises operate the distribution systems in the country. The Yangon City Electricity Supply Board (YESB) is responsible for the supply of electricity to consumers in Yangon City. The Electricity Supply Enterprise (ESE) covers the rest of the country comprising 13 states and regions, including off-grid generation and distribution. It was reported that technical and non-technical losses of the transmission and distribution system were as high as 30% in 2003 and reduced to 27% in 2011. These high losses and low electrification ratio will require improvement of transmission and distribution network in Myanmar.

[26] It is defined as the number of electrified households connected to the grid over the total number of households.

2. Organization

99. The regulatory framework for the power sector in Myanmar includes the Electricity Act of 1948 (as amended in 1967), the Myanmar Electricity Law (1984), and the Electricity Rules (1985). The power sector in Myanmar was the responsibility of two ministries: MOEP1 and MOEP2 until a merger in September 2012. The organization and function of MOEP is provided in Figure 5.

Figure 5 Organization and Function of Ministry of Electric Power



DEP = Department of Electric Power, DHPI = Department of Hydropower Implementation, DHPP = Department of Hydropower Planning, ESE = Electricity Supply Enterprise, GT = gas turbine, HPGE = Hydropower Generation Enterprise, MEPE = Myanmar Electric Power Enterprise, MOEP = Ministry of Electric Power, YESB = Yangon City Electricity Supply Board.
Source: Ministry of Electric Power.

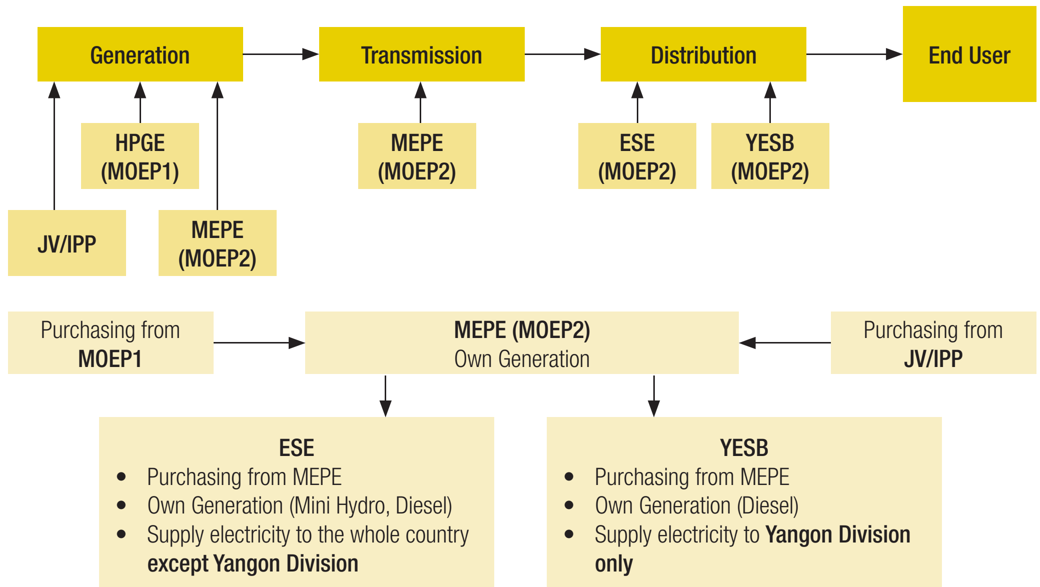
100. Before the merger, MOEP1 was responsible for developing, implementing, operating, and maintaining all large hydropower and coal-fired thermal power plants. MOEP2 was responsible for: (i) developing, operating, and maintaining the transmission network and distribution systems throughout the country; (ii) operating and maintaining gas-fired thermal power generation plants; and (iii) planning, implementing, and operating mini-hydropower plants. These two ministries were merged as one ministry—Ministry of Electric Power—in September 2012. An overview of the entire power sector before the merge is provided in Figure 6.

101. MOEP1 has three departments: Department of Hydropower Planning (DHPP), Department of Hydropower Implementation (DHPI), and Hydropower Generation Enterprise (HPGE). DHPP plans hydropower projects to be implemented by MOEP1 itself, by local provincial enterprises, or by joint ventures with foreign investors. DHPI has four institutes responsible for design, investigation, and mechanical works, and seven engineering construction companies capable of undertaking large hydropower projects. HPGE operates and maintains all of MOEP1's hydropower stations, and participates in the operation and maintenance of power plants under joint ventures. HPGE also operates a coal-fired power plant. The organizational chart of MOEP1 is shown in Figure 7.

102. MOEP2 has four departmental level organizations: the Department of Electric Power (DEP), MEPE, YESB, and ESE. DEP's main function involves power system strategic planning. MEPE is responsible for the development, operation, and maintenance of the transmission network,[27] and the

[27] The transmission network under MEPE's responsibility covers the following voltage levels: existing 66 kV, 132 kV, and 230 kV; and future 500 kV. Distribution systems consist of lower voltage level, namely: 33 kV, 11 kV, 6.6 kV, and 0.4 kV. Two distribution enterprises operate the distribution systems.

Figure 6 Organizational Overview of the Whole Power Sector



ESE = Electricity Supply Enterprise, HPGE = Hydropower Generation Enterprise, IPP = independent power producer, JV = joint venture, MEPE = Myanmar Electric Power Enterprise, MOEP = Ministry of Electric Power, YESB = Yangon City Electricity Supply Board.
Source: Ministry of Electric Power.

Figure 7 Organizational Chart of the Ministry of Electric Power No. 1

Department of Hydropower Planning (DHPP)	Department of Hydropower Implementation (DHPI)	Hydropower Generation Enterprise (HPGE)
■ Projects and generation planning	■ Investigation and design (4 institutes) ■ Implementation of hydropower project (7 construction companies)	■ Generation of hydropower and coal-fired plants ■ Operation and maintenance of power stations

Source: Ministry of Electric Power.

operation and maintenance of gas-fired power plants, including gas turbines. YESB is responsible for the supply of electricity to consumers in Yangon City. ESE covers all 13 states and divisions in the rest of the country, including off-grid generation and distribution; it is also responsible for planning, implementing, and operating off-grid mini-hydropower and diesel stations.[28] Correspondingly, YESB and ESE also implement system improvement and expansion of distribution systems. The organizational chart of MOEP2 is shown in Figure 8.

[28] This organizational structure is similar to that of Thailand, where the Metropolitan Electric Authority is responsible for the Bangkok metropolitan area, and the Provincial Electric Authority is responsible for the rest of the country.

Figure 8 Organizational Chart of the Ministry of Electric Power No. 2

Department of Electric Power (DEP)	Myanmar Electric Power Enterprise (MEPE)	Electric Supply Enterprise (ESE)	Yangon City Electricity Supply Board (YESB)
■ Project and power system strategic planning	■ Power system operation and maintenance ■ Generation from gas turbine ■ Operation and maintenance of gas turbine and combined cycle ■ Implementation of transmission line and substation projects	■ Distribution to the whole country (except Yangon City) ■ Small off-grid systems (hydropower and diesel) planning, implementation and operation	■ Distribution in Yangon City

Source: Ministry of Electric Power.

3. Generation System

103. Before 1960, the generation system consisted mainly of isolated grids supplied by diesel generators and mini-hydropower. The first stage of the first medium-scale hydropower plant, Baluchaung-2 in central-east Myanmar about 420 km north of Yangon, was commissioned in 1960 with an installed capacity of 84 MW. The plant was designed for an annual generation of 595 gigawatt-hours (GWh) to supply Yangon and, in 1963, Mandalay. The second stage was commissioned in 1974, also with 84 MW capacity and providing an additional 595 GWh. During the subsequent 30 years, another eight hydropower plants were built, ranging from 12 MW to 75 MW and totaling 264 MW. In 2005, the 280 MW Paunglaung Hydropower Plant, about 20 km east of the new capital, Nay Pyi Taw, was commissioned. From 2005 to 2011, eight power plants, totaling 1,934 MW, were built. Two large-scale hydropower plants, one partly for export to the PRC (Shewli-1, 600 MW) and the other for domestic supply (Yeywa,[29] 790 MW), were commissioned in 2008 and 2010, respectively.

Sedawgyi Hydropower Station

104. With regards to the Shewli-1 hydropower plant, the agreement with the PRC investor is that three of its six generating units will provide power to the Myanmar grid. Of the

[29] The 790 MW Yeywa hydropower plant on the Myitnge River, 50 km southeast of Mandalay, cost $600 million to build. Commissioned in 2010, it has four 197.5 MW generating units and a 134-m high roller compacted concrete dam, with a volume of 2.5 million cubic meters. It is one of the largest roller compacted concrete dams in the world. MOEP used the services of the Swiss consulting firm Colenco for detailed design and construction supervision of the plant, and engaged Chinese contractors for the construction. The power plant is estimated to generate 3,550 GWh per year.

total generated electricity, 50% will be provided at no cost to Myanmar and an additional 15%, if required, will be provided at cost. MOEP records indicate that 49% of the electricity generated by the power plant since 2008, operating at about 75% of its potential capacity, has been transmitted to the Myanmar grid. For the Dapein-1 hydropower plant (240 MW), also being developed by Chinese investors, 10% of the generated electricity will be made available to the Myanmar central grid. In combination, the two plants will augment domestic supply by 324 MW.

105. The 120 MW Tigyit power plant in central Myanmar was completed in 2002 in central Myanmar and was the first coal-fired power plant. It generates between 217 GWh/year and 389 GWh/year, corresponding to an average capacity factor of 31%; to be efficient, it should operate at 75%–80% capacity.

106. Off-grid power supply is provided for by ESE, local communities, and district authorities. There are 32 mini-hydropower plants with a combined generating capacity of 33.1 MW. A sub-department of ESE plans, builds, and operates the mini-hydropower plants. An exception is the 10.5 MW Buga hydropower plant at Myitkyina, Kachin State, which is a private sector arrangement. The company pays a royalty to ESE and is contracted to generate and distribute the power to villages and small industries in the surrounding project area. However, off-grid power supply is intermittent and electricity is only provided up to two hours a day in remote areas.

107. The first gas-fired power plant, Kyunchaung in central-western Myanmar, was commissioned in 1974 with an installed capacity of 54.3 MW. During the following 30 years up to 2004, another nine gas-fired power plants were commissioned with a total capacity of 714.9 MW. Ywama, the first gas-fired power plant close to Yangon, was commissioned in 1980 with an installed capacity of 36.9 MW. In 2004, two units of 33.4 MW capacity were added. Subsequently, another three gas-fired steam turbine power plants were built in stages surrounding Yangon: Hwlaga (154.2 MW), Thaketa (92 MW), and Ahlone (154.2 MW). The total installed capacity is now 470.7 MW. Output has not been as high as expected due to the low calorific value of Myanmar gas[30] and low pressure without gas compression. According to MOEP, the energy potential of these power plants is 4,384 GWh/year, representing an average capacity factor of 70%.

Ahlone Combined-Cycle Gas Turbine

108. The existing generation comprises 30 power stations with a combined installed capacity of 3,495 MW as of August 2012 (Appendix 5, Table A5.1). Due to scheduled maintenance and various operational limitations at a number of the stations, the actual firm capacity as of August 2012 is 1,957 MW. During the wet season (June to September), the hydropower stations are able to generate at optimum capacity. However, during the dry season, their capacity drops off due to insufficient water storage.

109. In 1995, 49% of electricity generation to the national grid was provided by thermal units, primarily gas-fired turbines, with the remainder provided by hydropower sources. Since then, there has been less dependency on gas-fired generating plant with hydropower providing 74% of the annual production in

[30] Gas produced in Thailand has a calorific value of 902 BTU per cubic foot (BTU/ft^3), while Myanmar gas has a much lower calorific value due to its high nitrogen content (about 25%): 615 BTU/ft^3 for gas from the Kanapauk offshore field; 651 BTU/ft^3 from the Dawnyein offshore field; and 850 BTU/ft^3 for onshore gas (negligible nitrogen content).

2012. In 1989, there were severe shortages in gas supplies, but by 1994 this had stabilized following the development of off-shore gas fields. Nevertheless, with generation being unable to sustain demand, the gas-fired plants are supplying base load and running almost continuously at 100% of available capacity. The installed and available capacity of generation plant is summarized in Tables 14 and 15.

Table 14 Installed and Available Generation, 2012

	Installed Capacity		Firm Capacity		Annual Production	
Power Plant	(MW)	(%)	(MW)	(%)	(MW)	(%)
Hydro	2,660	76	1,504	77	13,268	75
Coal-fired	120	3	27	1	600	3
Gas turbine	715	21	427	22	3,946	22
Total	3,495	100	1,958	100	17,814	100

MW = megawatt.
Source: Ministry of Electric Power.

Table 15 Annual Total Generation and Maximum Demand

Year	Annual Production (GWh)	Maximum Demand (MW)
2012 (year to date)	–	1,640
2011	10,033	1,588
2010	7,811	1,371
2009	6,830	1,129

– = unknown, GWh = gigawatt-hour, MW = megawatt.
Source: Ministry of Electric Power.

110. Overall, there is currently a shortfall of approximately 500 MW in generation during peak time—this is managed by rolling blackouts to reduce the load.

111. Similar to the lack of demand projections, there is a lack of comprehensive planning for power generation, on a least-cost, efficiency basis. DHPP/MOEP make future plans for hydropower development based on assessments of hydropower potential.

112. **Future power development.** Ninety-two large-scale (>10 MW) hydropower sites on Myanmar's main river basins have been identified, with an estimated total installed capacity of 46.1 GW. Table 16 shows the potential of each river basin.

113. Currently, HPGE operates 17 hydropower plants with a total capacity of 2,010 MW. MOEP is planning to build another 13 hydropower plants in the period to 2020, with a total capacity of 2,572 MW. Local enterprises will develop seven hydropower plants, with a projected combined capacity of 500 MW. A further 44 projects are planned as joint ventures with foreign investors, totaling approximately 42,146 MW (Appendix 5, Tables A5.3–A5.5).[31]

114. MOEP has also identified sites for three coal-fired power plants, with an installed capacity of 876 MW, earmarked for private sector development (Appendix 5, Table A5.6). It is hoped that these projects will proceed quickly, following offers to international developers in cooperation with MOEP.

[31] The Memorandum of Agreement for construction of a 500 MW gas power plants in Thaketa, Yangon was signed in October 2012.

Table 16 Hydropower Potential by River Basin (Including Tributaries)

No.	River Basin	No. of Promising Hydropower Projects	Installed Capacity (MW)
1	Ayeyarwaddy	34	21,821
2	Chindwin	8	3,015
3	Sittaung	11	1,128
4	Thanlwin	21	17,641
5	Mekong	4	720
6	Others	14	1,776
	Total	**92**	**46,101**

MW = megawatt.
Source: Ministry of Electric Power.

115. DHPP has prepared a list of potential joint venture power projects and is soliciting interest from possible investment partners. The approval process for a foreign investor includes the following steps:

i. the potential investor submits a proposal to MOEP, describing the investor's technical expertise and financial situation;

ii. on acceptance by the government, MOEP and the investor would sign an MOU with a 30-month validity;

iii. the investor begins preliminary investigation and pre-feasibility study;

iv. following acceptance of the pre-feasibility study, MOEP and the investor sign a memorandum of agreement with a duration of 18 months;

v. the investor then carries out a full feasibility study to determine the technical and financial viability of the project;

vi. once determined feasible, the parties will enter into negotiation of the joint-venture agreement (JVA); and

vii. the JVA defines the responsibilities and duties of both parties, and it is reviewed by line ministries and the Myanmar Investment Commission (MIC), which makes the final approval decision.[32]

116. For each joint venture, Myanmar is entitled to "free share" and "free power" (equivalent to royalties), in addition to commercial and income tax revenues. Free share and free power are negotiated individually but, as a general rule, free share is not less than 25% and free power is not less than 10%. Myanmar is entitled to buy up to 50% of the generated electricity. The purchase price for electricity is re-negotiated annually during the concession period, which normally has a duration of 30 years. This can be extended for 5 years at a time. At the end of the concession period, full ownership must be transferred to the government, with the facility in good condition as defined in the JVA. HPGE takes part in the operation of joint ventures, contributing one-third to the operation costs and maintenance staff.

4. Transmission System

117. The MEPE transmission system currently comprises an interconnected overhead grid of 230 kV, 132 kV, and 66 kV, which interconnects with all generation stations. There are plans to introduce 500 kV

[32] The Myanmar Investment Commission has approved three projects so far: Shweli-1; Dapein-1; and the 6,000 MW Myitsone hydropower project on which construction started but has now been suspended.

in the near future in order to connect the majority of the country's generation, which is predominately in the north with the main load centers in the south. The existing transmission lines are shown in Table 17 and Appendix 5, Figures A5.1 and A5.2.


Load Dispatch Center

118. Transmission lines are mostly single circuit, with relatively few double circuit connections. Structure designs are mostly lattice steel towers, with a variety of portal and conventional free standing towers, some with overhead lightning protection earthwires. Lines are generally in good condition. Transmission losses are in the order or 7%, as shown in Table 18.

Table 17 Existing Transmission Lines, 2012

Voltage (kV)	Number of Circuits	Circuit (km)
230	51	2,983
132	40	2,289
66	137	3,614
Total	**228**	**9,886**

km = kilometer, kV = kilovolt.
Source: Ministry of Electric Power.

Table 18 Transmission Loss (gigawatt-hour)

Year	Net Transmitted Energy	Net Received Energy Distribution Side	Energy Losses	Losses (%)
2012 (Jan)	836	777	59	7.11
2011	9,812	9,041	771	7.86
2010	7,614	7,042	573	7.52
2009	6,665	6,167	499	7.48
2008	6,281	5,921	361	5.74
2007	6,007	5,588	419	6.93

Source: Ministry of Electric Power.

5. Distribution Systems

119. Distribution in Myanmar comprises a network of 33 kV, 11 kV, and 6.6 kV emanating from the grid and zone substations to connect to the distribution transformers to supply single and three phase 400/230 V to the customers. The existing distribution lines are shown in Table 19.

120. The 33 kV is used to connect 33/11 kV zone substations, but it could be used in the future to directly supply 33/0.4 kV distribution transformers. The 6.6 kV, mostly in Yangon, is a relic voltage and needs to be phased out as soon as practical in order to improve the efficiency of the distribution network

Table 19 Existing Distribution Lines, 2012

Voltage (kV)	Length (km)	Capacity (MVA)
33	6,743	3,697
11	12,781	3,719
6.6	1,435	1,593
0.4	15,469	–
Total	**36,428**	**9,009**

– = unknown, km = kilometer, kV = kilovolt, MVA = million volt-ampere.
Source: Ministry of Electric Power.

and reduce losses. It is noted that some of the more recent distribution transformers purchased for the 6.6 kV system also have a 11 kV winding to facilitate the future changeover to 11 kV.

121. Sizes of the distribution transformer vary from 100 kilovolt amperes (kVA) up to 1,000 kVA and are mostly in reasonable condition, although oil leaks were not uncommon. In urban areas, some transformers are installed indoors in substation buildings; otherwise most are either ground mounted or on single or two pole structures.

122. The low voltage network comprises a 400/230 V three-phase four-wire system with the neutral solidly grounded. Frequency is nominally 50 hertz (Hz). Construction is generally overhead, base, open-wire construction using concrete poles. There is also some underground distribution in Yangon City area. Much of the construction is old and of insufficient cross-section for present-day loads. Some construction designs are outmoded; for example conductor guards for road and railway crossings (this practice has been superseded in most countries now as modern protection systems prove more reliable). Myanmar has not yet introduced aerial bundled conductor. It was observed that many service connections just used twisted connections instead of connectors—this is a bad practice as it will lead to high resistance connection with high losses and ultimately burning and failure of conductor. Although distribution losses are showing improvement over the last 5 years, they are still high as shown in Table 20.


132 kV Switchyard at Magwe

Table 20 Distribution Losses (%)

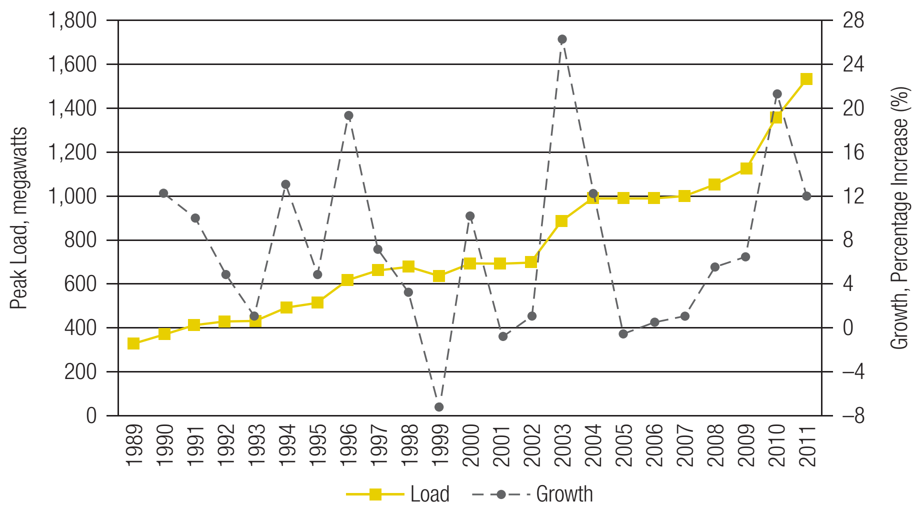
Year	Losses
2012 (Feb)	18.2
2011	19.2
2010	19.6
2009	19.4
2008	22.3
2007	21.6

Source: Ministry of Electric Power.

6. System Characteristics

123. Peak load or demand in Myanmar[33] increased from 322 MW in 1990 to 1,533 MW in August 2011, an average annual increase of 6.9%. The increase was fairly steady up to 2004, was negligible during the next 3 years to 2007, and then accelerated to about 8.8% annually to 2011. Figure 9 shows the long-term trend in peak load.

Figure 9 Growth in Peak Load



Sources: Asian Development Bank estimates; Ministry of Electric Power.

124. Peak load in Myanmar does not vary greatly from month to month during the year, although—as shown in Figure 10—there was a gradual increase from January to August 2011, from 1,380 MW to 1,530 MW. The system suffers from load shedding corresponding to about 1% in terms of energy, but at times exceeding 250 MW or about 15% of peak load.

125. The system experiences two peaks: in the morning from 6:00 a.m. to 11:00 a.m., and in the late afternoon to evening from 4:00 p.m. to 10:00 p.m. The average load factor for August 2011 was 53%, which is similar to the previous load factor from January to July. Daily load factors range from 79% to 86%.

126. Figure 11 shows load shedding of the power system,[34] in terms of megawatt-hours (MWh), experienced from January to August 2011. Load shedding appears to be heaviest during the morning peak. The system also suffers from unstable frequency control, but no details were available regarding this.

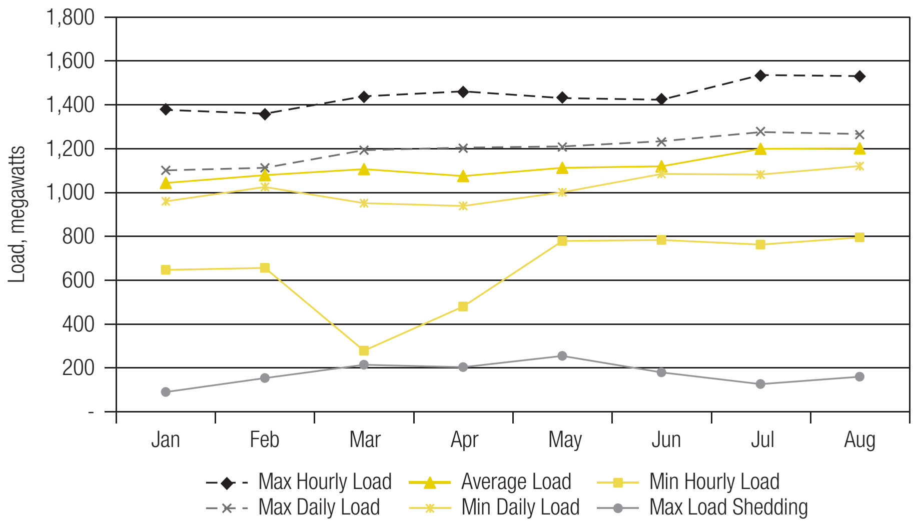
7. Power Demand

127. Electricity consumption almost doubled between 2001 and 2011, from 3,268 GWh to 6,312 GWh. With a population of approximately 60 million, Myanmar's per capita electricity consumption was

[33] Peak load is the peak demand or maximum power requirement of the system at a given time.

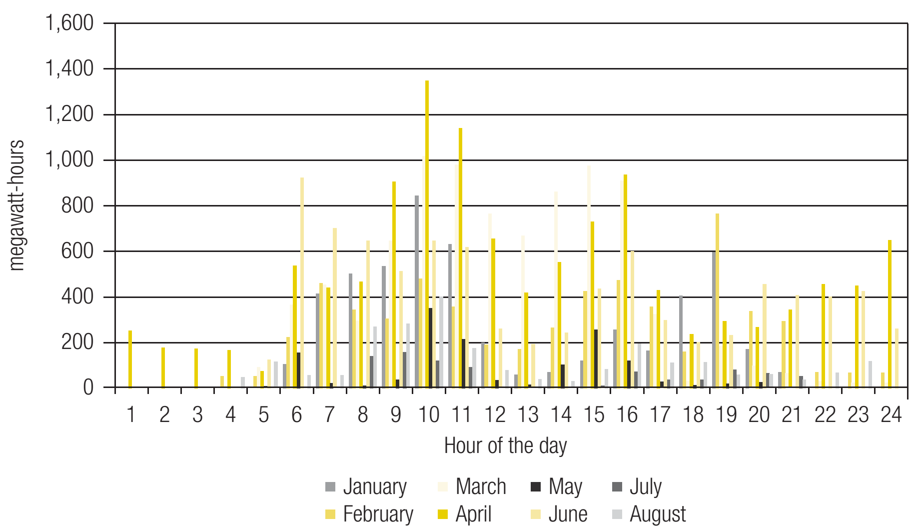
[34] Load shedding is the deliberate disconnecting of electric current on certain lines when demand exceeds supply.

Figure 10 Monthly Load (January–August 2011)



Sources: Asian Development Bank estimates; Ministry of Electric Power.

Figure 11 Load Shedding (January–August 2011)

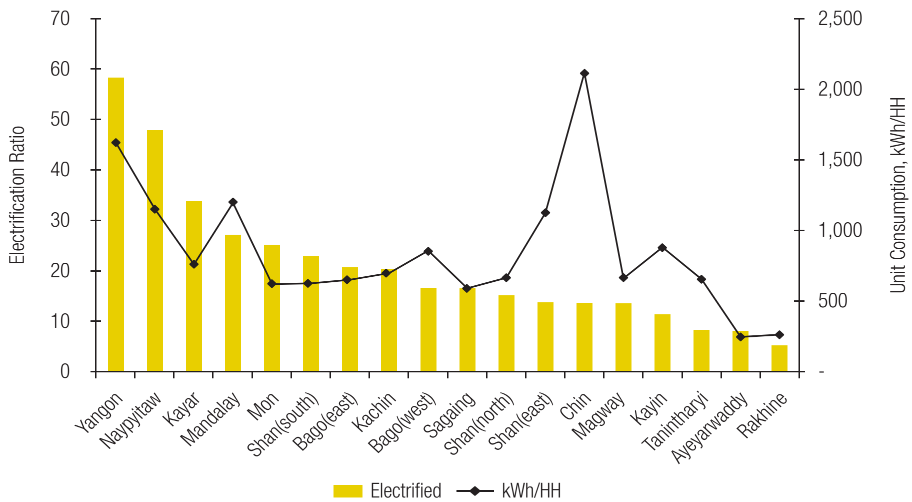


Sources: Asian Development Bank estimates; Ministry of Electric Power.

about 105 kWh per year. During the 10-year period, electricity consumption increased by 7% annually. Figure 12 shows domestic electricity sales in FY2010 by state and division and the number of households.

128. Low per capita electricity consumption is due to the low degree of electrification and industrial development. Myanmar's average degree of electrification (defined as the number of electrified households connected to the grid over the total number of households) increased from about 16% in 2006 to 26% in 2011. Yangon City has the highest electrification ratio (67%), followed by Nay Pyi Taw

Figure 12 Electrification and Unit Consumption



kWh/HH = kilowatt-hour per household.
Sources: Asian Development Bank estimates; Ministry of Electric Power.

(54%), Kayar (37%), and Mandalay (31%). Rural areas are poorly electrified, as reflected in ESE's average ratio of 16% for these areas. The areas with lowest electrification ratios are: Yakhine (6%), east of Yangon; Ayeyarwaddy (9%), west of Yangon in the Ayeyarwaddy Delta; and Tanintharyi (9%) in the southeast (Annex 5, Table A5.7).

129. Yangon City accounts for around 45% of total electricity drawn from the grid. Mandalay City ranks second in electricity sales (at about 16%), while Nay Pyi Taw, the capital, was fourth (behind Magway) with sales representing about 5.7% of the total. The largest end-use of electricity in the country is for "general purpose," representing households, accounting for approximately 42% of total end-use in 2011, followed by industry at 36% and commerce at 20%. Temporary uses and street lighting account for less than 1% (Appendix 5, Table A5.8). The average household in Yangon consumed about 1,760 kWh in FY2010 (ending 31 March 2011), compared to about 1,270 kWh in Nay Pyi Taw and Mandalay, about 680 kWh in Ayeyarwaddy and Tanitharyi, and about 270 kWh in Yakhine. The highest industrial consumption (supplied at 33 kV) was in Yangon, with sales of 549 GWh, followed by Mandalay (430 GWh) and Magway (265 GWh). Magway had the highest average sales by industrial consumers at 1.04 GWh, compared with 0.44 GWh in Yangon, 0.40 GWh in Nay Pyi Taw, and 0.37 GWh in Mandalay.

130. **Demand forecast.** The last demand projection by Department of Electric Power (DEP) was prepared in 2001 and has not been systematically updated since. The demand projection was simplistic, based on the assumption that any new supply would be fully consumed. Three scenarios were prepared: the base scenario assumed a growth rate of demand taking into account experience in Thailand; the low scenario assumed doubling of demand every 10 years; and the high scenario assumed the gross domestic product (GDP) growth rate of 7% per annum. There was no attempt to project demand based on consumer categories, drivers of energy demand, etc.; nor was there separation of domestic demand and export demand. The 2001 projections, however, greatly underestimated demand. In September 2011, MOEP contracted a consulting service (Colenco, Switzerland) to conduct preparatory work for a system planning study, including demand projections.

131. **System planning.** Power system planning in Myanmar is based on central planning. Apart from the above-noted study by DEP in 2001, planning for future demand and supply is essentially according to power development. The Department of Hydropower Planning (DHPP) develops a list of potential hydropower projects and then seeks potential developers. In parallel, the MOGE prepares its production plan and allocates gas for power generation. Based on the hydropower plan, connections between generation sources and load centers are then outlined and the tentative schemes for the voltage levels of the transmission lines and substations are proposed. The next step is to estimate the capital requirements and submit the overall plan to the cabinet. Upon budget determination, and upon clarification of investment by private sector developers, the power development plan is scaled accordingly for implementation in the coming year. This approach is based on supply availability and the assumption that all power generated will be consumed or exported. The linkages between future demand, resource availability, technical specifications, and cost parameters are not explicit in this planning approach.

8. Electricity Tariff

132. Electricity produced by hydropower and coal-fired power stations (owned by MOEP) is sold to MEPE at a constant price of 20 kyats/kWh. In addition, all generation by gas-fired power plants is supplied to MEPE. Generation costs of combined-cycle gas turbines have been estimated at 130 kyats/kWh.

133. Electricity generated by joint ventures (including free power and purchased power) is supplied to MOEP at an agreed price, which then supplies it to the Yangon City Electricity Supply Board (YESB) and the Electricity Supply Enterprise (ESE). As of January 2012, YESB and ESE have two categories for their electricity tariffs:[35]

i. 35 kyats/kWh for general purpose (households), street lighting, government offices, and low-voltage temporary users; and

ii. 75 kyats/kWh for domestic power, small power, bulk (for >30 kW supplied at 33 kV), and high-voltage temporary users.

134. Off-grid consumer tariffs vary depending on the cost of generation by diesel or other means (e.g., solar, mini-hydropower) and may range between 100 kyats/kWh and 300 kyats/kWh. A royalty is also due to ESE, of about 20–25 kyats/kWh.

H. Energy Efficiency

135. To advance energy security, energy efficiency and conservation are important objectives of Myanmar's energy policy.[36] In line with ASEAN's target, the government aims to save 5% of the total primary energy consumption by 2020 and 8% by 2030, compared to the base year 2005.

136. While the Ministry of Energy (MOE) is the focal point for energy sector coordination, the Research and Development Center under the Ministry of Industry (MOI) addresses energy efficiency. However, there is no legal and regulatory framework (e.g., standards) for energy efficiency and no dedicated organization at the national level. Consequently, Myanmar lacks a consolidated plan for energy efficiency.

[35] 12 cents/kWh for foreigners.

[36] As noted earlier, the main objectives of the Myanmar Energy Policy are to maintain the status of energy independence, and to promote wider use of new and renewable sources of energy, energy efficiency and conservation, and the use of alternative fuels by households.

137. Nonetheless, MOE, MOI, and the Myanmar Engineering Society[37] undertake a number of activities related to energy efficiency activities, including seminars and workshops for capacity building and participation in the ASEAN Energy Award Program and ASEAN Energy Manager Accreditation Scheme. Other initiatives have been construction of an energy-efficient urea fertilizer plant at Kyawzwa and a start in replacing privately-owned vehicles 40 years old or more. Under the Ayeyarwaddy-Chao Phraya-Mekong Economic Cooperation Strategy, Myanmar cooperates with the Department of Alternative Energy Development and Efficiency of Thailand concerning energy statistics, promotion of energy efficiency in rural villages,[38] and training in energy auditing.

138. In order to promote and enhance energy efficiency, the government has indicated the following requirements: (i) strong leadership and commitment by the government; (ii) a central and dedicated energy efficiency agency with confirmed roles; (iii) a well-defined energy efficiency policy and guidelines; (iv) detailed information on energy use; (v) institutional strengthening and capacity building; (vi) training and dissemination of energy efficiency and conservation practices; (vii) improved energy management practices for industrial and commercial sectors; (viii) an energy efficiency labeling program for appliance and energy service companies; and (ix) increased energy prices.

139. The Environmental Protection Law is under Parliamentary consideration and is expected to be promulgated in the near future. Under the law, a new Environmental Conservation Department is proposed, which will be responsible for environmental and social safeguards requirements. Extensive staff recruitment and capacity building will be needed to fully establish the new department. When the law is promulgated, an Environmental Impact Assessment Rule will be mandatory, requiring environmental and social impact reports for all major projects.

I. Climate Change

140. Development of Myanmar's climate change policy is under the responsibility of the National Environmental Conservation Committee. Although the government has not issued a formal policy statement concerning climate change, several ministerial provisions and statements relate to the concern.

141. With Myanmar's ratification of the United Nations Framework Convention on Climate Change (UNFCCC) on 25 November 1994, the government undertook initiatives to fulfill its commitment and obligations. Myanmar's Agenda 21, published in 1997, and the Constitution of the Union of Myanmar, adopted in May 2008, provide for protection of the environment. In 2009, the National Sustainable Development Strategy was announced.

142. Despite the above actions, Myanmar still lacks a national strategy and action plan for mitigating and adapting to climate change. However, several ministries are implementing sector-specific initiatives relevant to climate change:

[37] The Myanmar Engineering Society (MES) is a nongovernment organization that is actively participating in energy efficiency activities in Myanmar. It is Myanmar's representative under the ASEAN Energy Manager Accreditation Scheme, which aims to train and certify 50 energy managers over a 4-year period (2010–2013). As an NGO, MES has limited capability in acquiring accurate data and financial resources. Despite its limited resources, MES has undertaken energy audits of selected industries, such as: (i) Mann Petroleum Refinery in 2001 and a follow-up in 2004; (ii) Kyankhin Cement Plant in 2006; (iii) Thanlyin Oil Refinery, also in 2006; (iv) Mayangone Textile Factory No. 1 in 2008; and (v) Myanmar Automobile and Diesel Engine Industries in 2009.

[38] Workshops on energy efficiency promotion for rural villages were held in Su Ka Lat Village, Kungangone Township, Yangon Division in 2008–2009.

(i) The Myanmar Action Plan on Disaster Risk Reduction, 2009–2015 sets out projects and activities necessary to meet the Hyogo Framework for Action and the ASEAN Agreement on Disaster Management and Emergency Response Commitments.

(ii) The government has implemented the Initial National Communication project with the assistance of the Global Environment Facility. The report is ready for submission to UNFCCC.

(iii) The National Adaptation Program of Actions, funded by the Global Environment Facility, now includes Myanmar. The executing agency is the Department of Metrological and Hydrology in the Ministry of Transport, in cooperation with the Ministry of Environmental Conservation and Forestry (MOECAF).

(iv) MOE has initiated the Clean Fuel Program. As noted earlier, the government is endeavoring to reduce carbon dioxide emissions by increasing the use of natural gas in the industrial sector and for power generation; this includes converting gasoline, diesel, and liquefied petroleum gas (LPG) vehicles to compressed natural gas (CNG) vehicles.

143. MOECAF is the designated national authority for the clean development mechanism. To date, one hydropower project has been submitted to UNFCCC for clean development mechanism consideration.

J. Environmental and Social Safeguard Requirements for Energy Projects

144. The government established the National Commission for Environmental Affairs (NCEA) in February 1990. Until early 2011, NCEA acted as the national focal point and coordinating agency for environmental matters.

145. The 1995 Myanmar Forest Policy formalizes the commitment to sustainable development of forest resources for social, environmental, and economic purposes. Six imperatives identified in the policy are protection, sustainability, basic needs, efficiency, participation, and public awareness.

146. The National Environmental Conservation Committee was formed in 2004 and re-formed in April 2011, replacing NCEA, and now serves as the focal organization for environmental matters. It is chaired by MOECAF, formerly the Ministry of Forestry; the Committee's membership includes 19 ministries. The Director General of the Department of Planning and Statistics in MOECAF serves as the secretary. In September 2011, the name of the Ministry of Forestry was changed to Ministry of Environmental Conservation and Forestry (MOECAF) with the aim of developing a body dedicated to environmental conservation measures. Four institutions under MOECAF are performing their specific duties and responsibilities mainly related to environmental conservation and forestry.[39]

147. Environmental Conservation Department (ECD) has been opened in October 2012 and is carrying out its duties of environmental conservation activities. The Environmental Conservation Law was enacted by the Government in March 2012. The Environmental Conservation Law provides the legal basis for implementing a range of enhanced environmental management measures. Simultaneously, the Environmental Conservation Rule in draft corresponding regulations to enact legislation, including regulations and technical guidelines, and creating the enabling conditions for their effective implementation has been being drawn and submitted to authorized body.

[39] These are the Planning and Statistics Department, Forest Department, Myanmar Timber Enterprise, and Dry Zone Greening Department. A new department for Environmental Conservation is expected.

II Potential International Involvement

A. Data Requirements

148. Clearly, strengthening Myanmar's energy sector is critical to reducing poverty and enhancing the medium and long-term development prospects of the country. Electrification is an urgent requirement, without which whole areas of the country will be severely hampered in their efforts to advance economically. Social progress also depends on electrification, without which health, education, and other essential services inevitably suffer.

149. As this initial assessment of the energy sector has described, there are many dimensions to the sector and they must be addressed comprehensively and systematically so as to ensure efficient and effective use of resources. While electrification, especially of rural areas, is of primary concern, issues of sustainability and protection of the environment must be considered simultaneously.

150. The initial assessment outlined in this report is very preliminary. It does not draw from in-depth analytical work on the energy sector, hence at this stage it is difficult to determine capacity-building needs, desirable institutional structural reforms, gaps in the policy and regulatory framework, the least-cost and sequencing of infrastructure investments, energy conservation and climate change initiatives, and many other related issues. A comprehensive energy sector assessment for Myanmar is a priority foundation for forward planning. It would also serve as a basis for coordination with Myanmar's development partners and the private sector, which will be essential in mobilizing the financial and technical expertise needed. Yet another consideration is integration of Myanmar's energy potential with the GMS and ASEAN initiatives.

B. Areas of Possible Support for the Energy Sector

151. Drawing from this initial assessment of the energy sector, but with the caveat that a comprehensive assessment is needed, Myanmar's development partners—in consultation with the government—could begin considering support for the sector by focusing on several apparent priorities.

152. **Detailed energy sector assessment**. As noted, there is a need for a detailed and comprehensive energy sector assessment. Medium and long-term planning is lacking; demand projections and supply options have to be determined for power, petroleum, coal, and other sources of energy, together with the investment requirements for meeting the growing demand for energy. In this regard, extensive technical assistance will be required, managed so as to constructively involve the seven ministries concerned.

153. **Rehabilitation works in power generation, transmission, and distribution.** These three thrusts are needed throughout the country, perhaps especially in the Yangon area, where frequent blackouts

occur. As a medium-term solution, a 500-kV transmission line from the northern areas to Yangon should be considered.

154. **An integrated comprehensive development plan for hydropower.** Some 66 potential hydropower development projects have been identified, 44 by foreign investors. Development of Myanmar's huge hydropower potential should be guided by sustainable and least-cost principles. Environmental and social safeguards must also be guiding principles.

155. **Increased electrification.** To increase the overall electrification ratio (26% in 2011) and energy access in rural areas, transmission and distribution lines in Myanmar must be extended and improved together with addition of new power plants.

156. **Rehabilitation and upgrading of coal and gas-fired generation plants.** The one coal-fired power generation plant and 10 gas-fired power plants must be rehabilitated and upgraded. Proposed additional coal and gas-fired power generation plants will also need to be assessed.

157. **Development of the oil and gas subsector.** Private sector investment will lead this subsector. Myanmar's development partners could be third party facilitators, including assisting the government in streamlining and assessing the terms of production sharing contracts. More generally, the government could benefit from best practices regarding the investment climate for proactively attracting private sector participation.

158. **Rehabilitation and upgrading of refineries.** The existing refineries are old and in need of rehabilitation and upgrading, some of which is underway. The construction of a new refinery near Mandalay, with capacity of 20,000 barrels per day, is a potential public–private partnership project (crude oil would be supplied from the Myanmar–PRC crude oil pipeline).

159. **Rehabilitation and expansion of natural gas pipelines.** Since most natural gas pipelines are old, their rehabilitation is necessary. The expansion of distribution networks and the construction of a gas transmission pipeline from offshore to the area of Yangon could be considered.

160. **Renewable energy and energy efficiency.** In collaboration with the GMS Program, information must continue to be collected on the latest developments concerning renewable energy and energy efficiency in Myanmar. A prefeasibility study for solar power generation (solar park type) in the Central Dry Zone should be undertaken.

161. **Coal sector.** All investment in the coal sector should be undertaken by the private sector, through the production sharing contracts (PSCs). Myanmar's development partners could be third party facilitators, especially in regards to clean technology and environmental safeguards.

162. **Sector reform.** To promote energy efficiency, the pricing mechanism for electricity and petroleum products should be reassessed. The corporatization and privatization of various energy enterprises should also be considered (currently all enterprises are within the ministries), in line with the public sector reform program in Myanmar.

Appendix 1
Problem Tree

NATIONAL IMPACTS

Limited and inefficient socioeconomic developments of the country

SECTOR IMPACTS

Low electrification ratio; high technical losses; unreliable power supply because of low investment in generation, transmission, and distribution; inefficient use of natural resources as renewable energy investments are limited

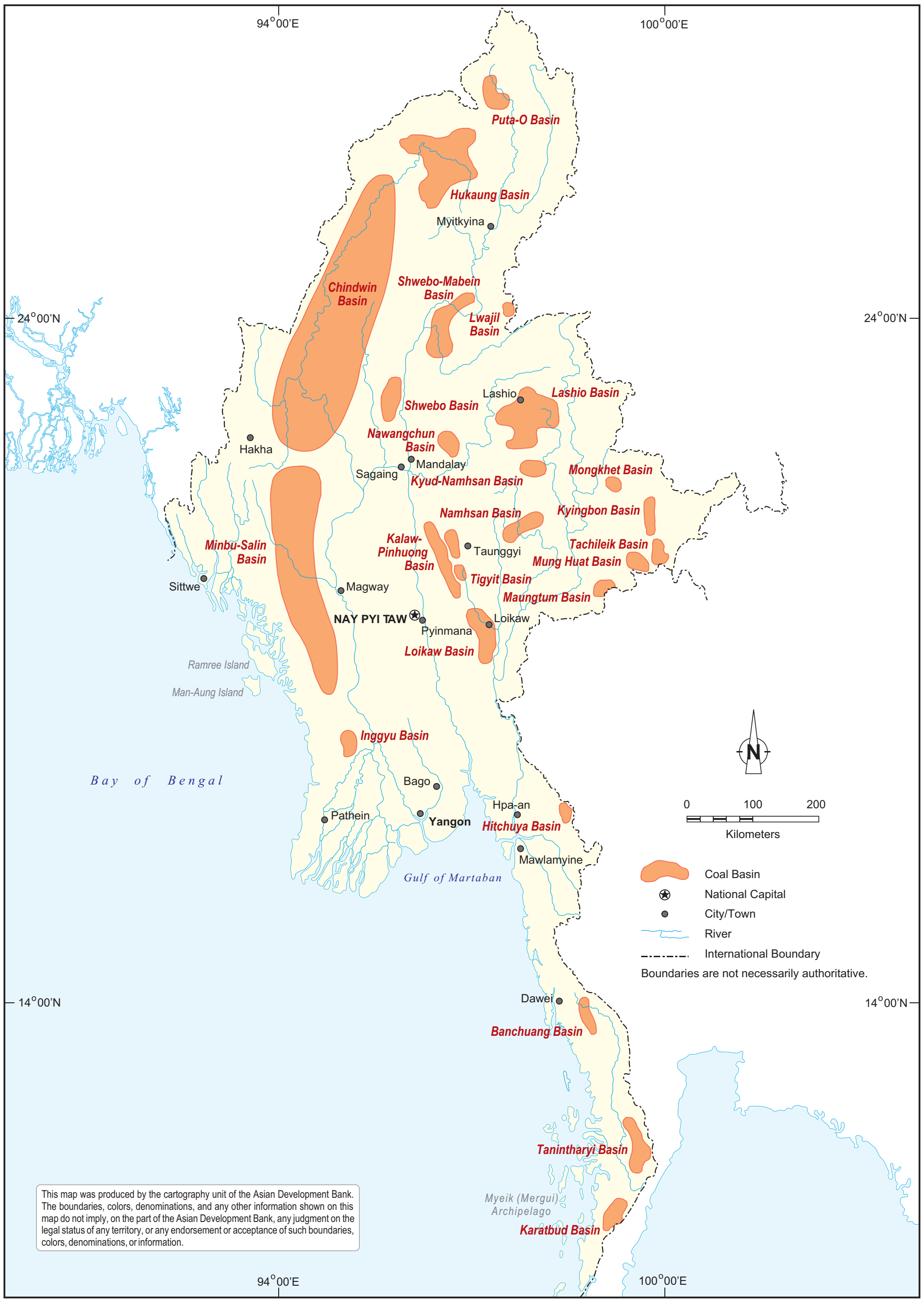
CORE SECTOR PROBLEMS

Poor and inadequate infrastructure, institutional, and human resources capacity to provide reliable and sustainable energy resources

Main Cause	Lack of coordination and poor long-term integrated energy planning and development	Limited investment in energy sector	Lack of sector support for social, environmental, and economic sustainability	Ineffective energy institutions and lack of capability and capacity of staff
Deficient Sector Output	(i) No consolidated energy demand projections or supply planning (ii) Inefficient institutional coordination and cooperation among eight concerned ministries (iii) Absence of coordinated energy sector policy (iv) Lack of transparency and energy policy and pricing mechanism	(i) Low electrification ratio (ii) High losses in transmission and distribution networks for power and natural gas (iii) Persistent blackouts in Yangon in dry seasons (iv) Low electricity tariff (v) Poor operation and maintenance of power generation, transmission, and distribution networks	(i) No integrated hydropower development plan for sustainable and inclusive development to utilize abundant hydropower potential (ii) No legal requirements for environmental and social safeguards for energy infrastructure	(i) Energy sector activities are scattered among eight ministries (ii) Within each ministry, the function of policy, regulation, and implementation and operation exists. (iii) Eight enterprises related the energy sector are within the concerned ministries (iv) Limited number of staff dedicated to energy policy and regulation (v) Weak coordination for energy efficiency and renewable energy development

Appendix 2
Coal

Figure A2 Coal Basins of Myanmar



Source: Ministry of Mines, September 2011.

Table A2.1 Major Coal Deposits in Myanmar (as of 30 September 2011)

No.	Location	Township	State/Region	Tonnage (millions)	Category	Coal Rank
1.	Kalewa	Kalewa	Sagaing	4.615	Positive	Sub-bituminous
				17.831	Probable	Sub-bituminous
				65.335	Possible	Sub-bituminous
2.	Darthwekyauk	Tamu	Sagaing	33.000	Possible	Lignite to
				5.000	Potential	sub-bituminous
3.	Paluzawa	Mawlike	Sagaing	89.000	Potential	Sub-bituminous
4.	Mawleikgyi Ch.	Mawlike	Sagaing	0.810	Possible	Sub-bituminous
5.	Kyopin	Kawlin	Sagaing	2.230	Probable	Lignite to sub-bituminous
6.	Lweji	Bamoh	Kachin	0.200	Possible	Lignite
7.	Kawmapyin	Tanintharyi	Tanintharyi	2.030	Probable	Lignite to sub-bituminous
8.	Mawtaung	Tanintharyi	Tanintharyi	1.800	Probable	Lignite to
				1.800	Possible	sub-bituminous
				1.220	Potential	
9.	Karathuri	Bokpyin	Tanintharyi	1.500	Potential	Sub-bituminous
10.	Banchaung	Dawe	Tanintharyi	0.280	Possible	Lignite to sub-bituminous
11.	Wungyichaung	Seikphyu	Magwe	0.808	Probable	Sub-bituminous
12.	Tasu-Letpanhla	Pauk	Magwe	1.030	Probable	Lignite
13.	Kyesi-Mansan	Kyesi-Mansan	Shan (South)	18.110	Probable	Sub-bituminous
14.	Kholan	Namsam	Shan (South)	3.490	Probable	Lignite
15.	Tigyit	PinLaung	Shan (South)	20.700	Probable	Lignite to sub-bituminous
16.	Kyasakan- Minpalaung	Ywangan	Shan (South)	0.220	Possible	Sub-bituminous
17.	Mankyaung	Tanyang	Shan (North)	1.052	Possible	Sub-bituminous
18.	Manpan-Monma	Tanyang	Shan (North)	3.365	Probable	Sub-bituminous
				3.841	Potential	Sub-bituminous
19.	Harput	Tanyang	Shan (North)	5.240	Probable	Lignite to
				0.469	Possible	sub-bituminous
				5.462	Potential	
20.	Sale (Mansele)	Lashio	Shan (North)	0.149	Possible	Lignite to
				1.213	Potential	sub-bituminous
21.	Sanya	Lashio	Shan (North)	0.048	Probable	Lignite
				0.072	Possible	
				0.851	Potential	
22.	Sintaung	Lashio	Shan (North)	5.825	Probable	Lignite
				0.683	Possible	
23.	Namma	Lashio	Shan (North)	2.800	Probable	Sub-bituminous
				3.704	Potential	
24.	Narkon	Lashio	Shan (North)	0.692	Probable	Lignite
				1.044	Possible	
				0.925	Potential	

continued on next page

Table A2.1 *continued*

No.	Location	Township	State/Region	Tonnage (millions)	Category	Coal Rank
25.	Narlan	Lashio	Shan (North)	1.574	Probable	Lignite
26.	Namlinhkan	Lashio	Shan (North)	0.048 0.339 0.549	Probable Probable Potential	Lignite
27.	Sanlaung	Thipaw	Shan (North)	1.870	Probable	Lignite to sub-bituminous
28.	Mahkaw	Thipaw	Shan (North)	1.000 0.256	Probable Potential	Lignite to sub-bituminous
29.	Wankyan (Namlap)	Kyaington	Shan (East)	16.660	Probable	Lignite
30.	Hoko	Kyaington	Shan (East)	1.190	Probable	Lignite
31.	Mainghkok	Maingsat	Shan (East)	117.700 3.680	Probable Possible	Lignite to sub-bituminous
32.	Narparkaw	Maington	Shan (East)	10.930	Possible	Lignite
33.	Kywesin	Ingapu	Ayeyawadi	1.500	Potential	Sub-bituminous
Total				**465.740**		

Source: Ministry of Mines.

Table A2.2 Chemical Analysis of Coal Deposits in Myanmar

No.	Region	Location Township	State/ Division	Fix Carbon (%)	Volatile (%)	Chemical Analysis Moisture (%)	Chemical Analysis Ash (%)	Calorific Value (Btu/lb)	Sulphur (%)
1.	Kalewa	Kalewa	Sagaing	52.51	38.62	9.70	8.87	11,720	–
2.	Darthwekyauk	Tamu	Sagaing	50.00	–	–	1.00	12,000	<1.00
3.	Paluzawa	Mawlike	Sagaing	41.47	45.32	–	–	–	–
4.	Mawlikegyi	Mawlike	Sagaing	49.70	43.85	8.60	6.40	11,800	1.12
5.	Kyopyin	Kawlin	Sagaing	31.00	34.40	8.30	34.40	8,174	1.48
6.	Lweji	Bamoh	Kachin	17.59	38.90	14.36	43.49	6,396	0.69
7.	Kawmapyin	Taninthayi	Tanintharyi	36.66	34.82	5.51	21.75	9,977	2.00
8.	Mawtaung	Tanintharyi	Tanintharyi	43.59	–	–	–	9,754	2.24
9.	Karathuri	Bokpyin	Tanintharyi	37.60	–	–	–	9,810	0.32
10.	Wungyichaung	Seikphuy	Magwe	31.71	41.80	–	26.40	8,365	3.60
11.	Tasu-letpanhla	Pauk	Magwe	34.60	48.40	–	16.90	9,349	2.50
12.	Kyesi-Mansan	Kyesi	Shan (South)	35.60	48.98	13.29	15.36	10,153	2.56
13.	Kholan	Namsan	Shan (South)	14.77	56.26	21.32	28.90	7,355	
14.	Tigyit	Pinlaung	Shan (South)	33.81	34.40	18.51	13.27	9,169	
15.	Makyaning	Tayang	Shan (North)	26.86	50.86	12.65	22.27	9,187	1.08
16.	Manpan-Monma	Tayang	Shan (North)	35.58	55.00	19.45	9.33	9,889	0.80
17.	Harput	Tayang	Shan (North)	27.57	56.26	28.40	13.16	8,244	0.99
18.	Sale (Mansele)	Lashio	Shan (North)	33.00	54.02	15.98	12.98	9,881	1.40
19.	Sanya	Lashio	Shan (North)	35.47	58.32	17.77	6.21	10,420	0.64
20.	Sintaung	Lashio	Shan (North)	33.67	96.99	28.28	9.34	8,770	2.56
21.	Namma	Lashio	Shan (North)	34.54	44.31	8.64	20.69	10,083	1.44
22.	Narkon	Lashio	Shan (North)	38.01	59.49	15.98	2.52	11,080	0.64
23.	Narlan	Lashio	Shan (North)	33.42	41.83	16.57	17.14	9,370	6.97
24.	Namlinhkan	Lashio	Shan (North)	35.71	52.97	13.25	11.32	10,440	4.69
25.	Sanlaung	Thipaw	Shan (North)	30.52	51.36	12.16	18.06	9,772	5.82
26.	Mahkaw	Thipaw	Shan (North)	35.26	61.30	19.88	6.43	10,430	0.64
27.	Wankyan	Kyaington	Shan (East)	23.00	23.00	40.00	8.50	5,890	0.40
28.	Hoko	Kyaington	Shan (East)	44.45	56.50	–	15.41	11,233	1.17
29.	Mainghkok	Maingsat	Shan (East)	45.00	–	–	1.86	10,185	
30.	Narparkaw	Maington	Shan (East)	25.93–28.07	26.31–31.89	–	14.83–15.39	7,720–8,370	0.96
31.	Kywesin	Ingapu	Ayeyarwaddy	41.10	18.24	1.16	40.70	8,163	0.93
32.	Kani	Dawei	Taninthayi	42.30	48.80	–	9.51	8,885	0.74

– = unknown, Btu/lb = British thermal units per pound.
Source: Ministry of Mines.

Table A2.3 Coal Production and Consumption (thousand tons)

Year	Production	Cement	Steel	Consumption Briquetting	Electricity	Other	Export
1981–82	18.04	0.58	8.39	–	4.18	4.89	–
1982–83	28.66	0.93	15.81	–	2.66	9.26	–
1983–84	35.4	2.29	21.14	–	3.48	8.13	–
1984–85	43.53	0.68	35	–	3.00	4.85	–
1985–86	43.15	0.81	37.57	–	3.00	1.77	–
1986–87	37.5	–	32.02	–	2.94	2.55	–
1987–88	38.71	–	20.03	–	3.42	15.26	–
1988–89	29.78	–	12.48	–	3.04	14.26	–
1989–90	38.67	–	35.96	–	2.16	0.55	–
1990–91	32.77	1.00	19.18	–	3.16	9.43	–
1991–92	41.06	–	24	–	2.34	14.72	5.23
1992–93	54.05	–	25.28	–	0.84	27.93	17.14
1993–94	66.14	–	24.38	–	2.13	39.63	33.31
1994–95	63.78	–	27.82	–	1.86	34.1	32.8
1995–96	34.71	–	23.99	3.41	–	7.31	–
1996–97	30.84	–	21.53	3.2	–	6.11	–
1997–98	29.57	–	13.86	2.93	–	12.78	–
1998–99	53.61	24.79	26.08	13.03	–	0.40	–
1999–00	122.49	17.53	24.68	7.06	–	1.08	90.36
2000–01	571.14	64.83	20.78	42.70	–	4.40	401.88
2001–02	571.14	64.83	7.76	26.90	–	2.18	531.25
2002–03	550.20	76.12	9.33	28.71	–	6.24	439.87
2003–04	925.42	133.78	10.82	38.26	–	5.30	737.26
2004–05	992.00	51.34	24.08	25.63	88.64	2.43	799.88
2005–06	1,182.50	136.87	20.44	30.46	340.26	31.17	623.30
2006–07	1,313.62	140.52	25.67	39.64	507.19	85.39	515.21
2007–08	1,117.29	202.16	15.36	48.12	472.76	150.30	228.59
2008–09	564.48	227.25	18.61	30.47	245.06	43.09	43.09
2009–10	386.74	102.08	26.55	20.26	207.85	30.00	30.00
2010–11	692.90	362.34	–	–	290.09	40.47	–

– = unknown.
Source: Ministry of Mines.

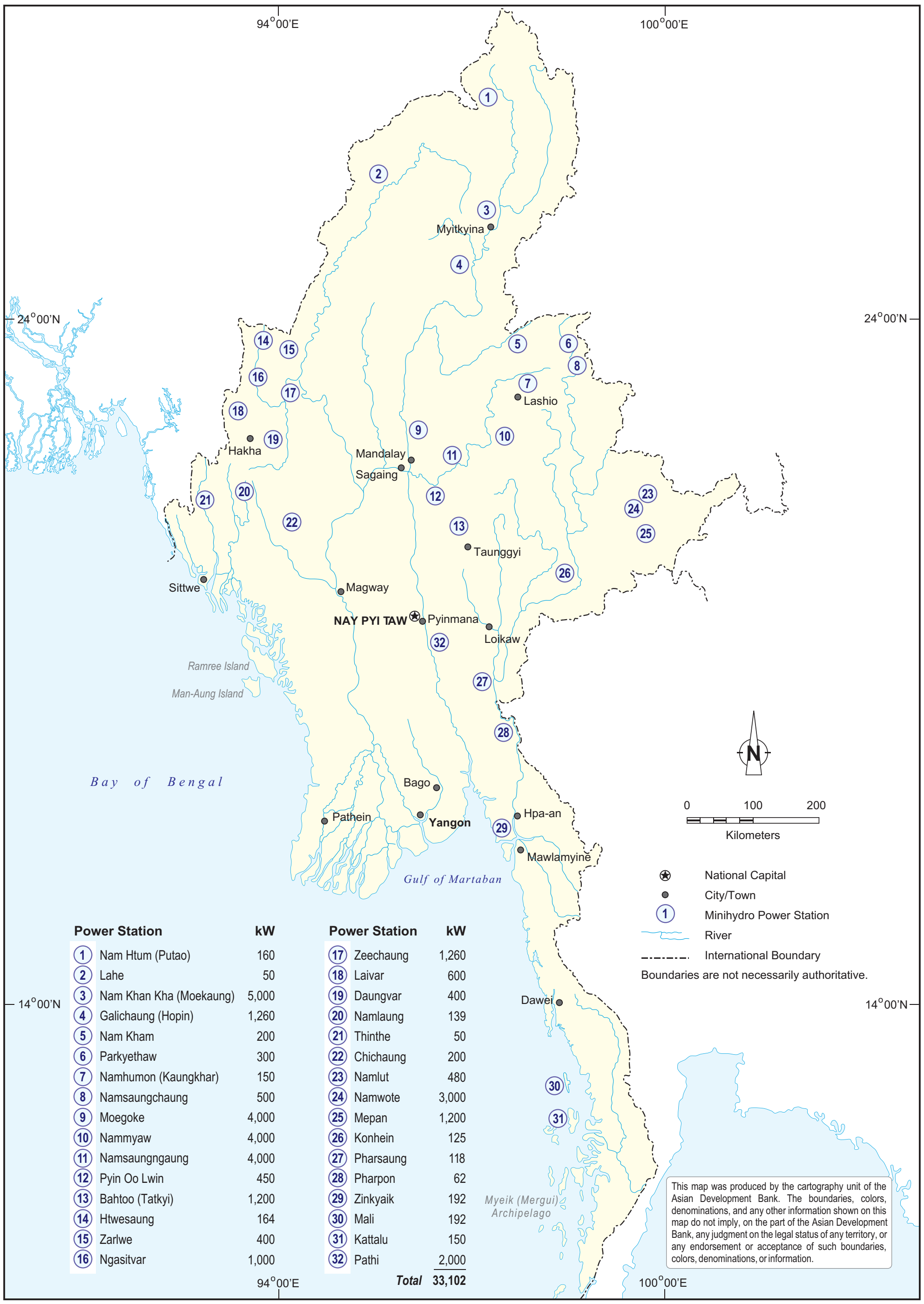
Appendix 3
Oil and Gas

Figure A3 Location Map of Oil and Gas Fields in Sedimentary Basins of Myanmar

Source: Ministry of Energy, September 2011.

Appendix 4
Renewable Energy

Figure A4 Location Map of Mini-Hydropower Stations

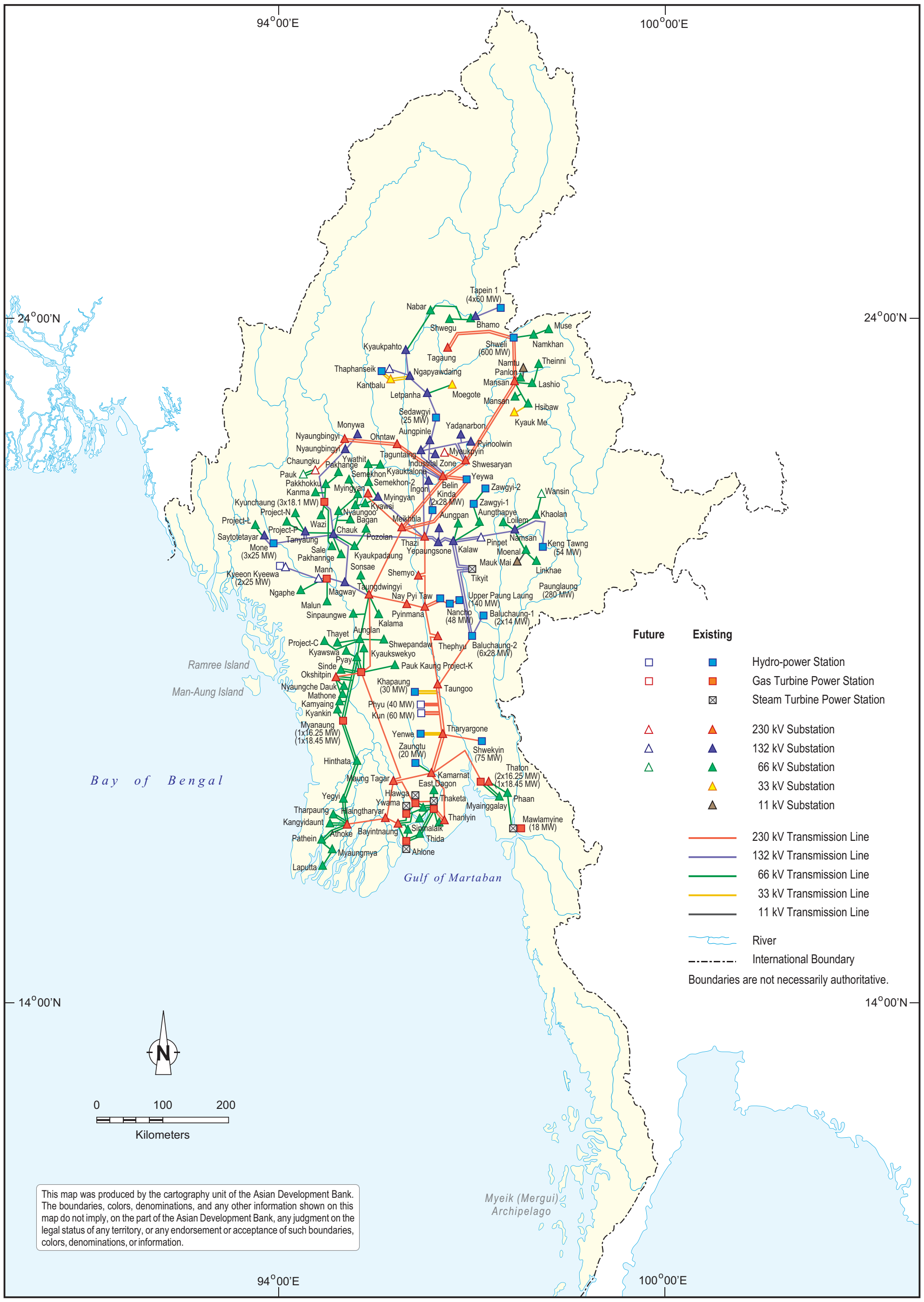


Power Station	kW	Power Station	kW
1 Nam Htum (Putao)	160	17 Zeechaung	1,260
2 Lahe	50	18 Laivar	600
3 Nam Khan Kha (Moekaung)	5,000	19 Daungvar	400
4 Galichaung (Hopin)	1,260	20 Namlaung	139
5 Nam Kham	200	21 Thinthe	50
6 Parkyethaw	300	22 Chichaung	200
7 Namhumon (Kaungkhar)	150	23 Namlut	480
8 Namsaungchaung	500	24 Namwote	3,000
9 Moegoke	4,000	25 Mepan	1,200
10 Nammyaw	4,000	26 Konhein	125
11 Namsaungngaung	4,000	27 Pharsaung	118
12 Pyin Oo Lwin	450	28 Pharpon	62
13 Bahtoo (Tatkyi)	1,200	29 Zinkyaik	192
14 Htwesaung	164	30 Mali	192
15 Zarlwe	400	31 Kattalu	150
16 Ngasitvar	1,000	32 Pathi	2,000
		Total	33,102

Source: Ministry of Energy.

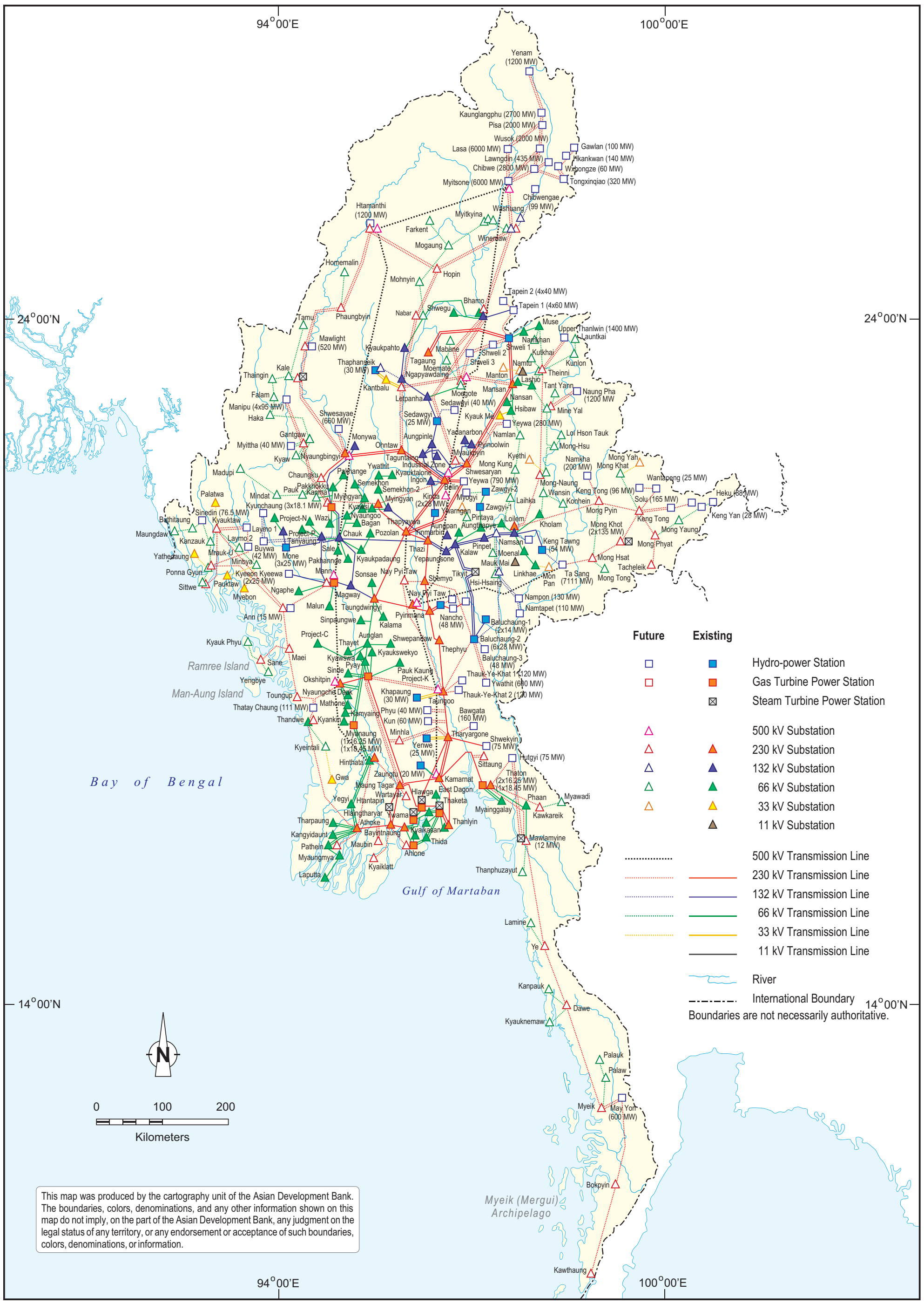
Appendix 5
Power

Figure A5.1 Existing Transmission System



Source: Ministry of Electric Power, September 2011.

Figure A5.2 Planned Transmission System



Source: Ministry of Electric Power, August 2010.

Table A5.1 Installed and Available Generation, 2012

Type	Power Station	Location	Operation Start Date	Installed Capacity (MW)		Firm Capacity[a] (MW)	Annual Production (GWh)
Hydropower	Baluchaung BHP (1)	Kayah	1992	2 x 14	28.0	140	200.0
	Baluchaung BHP (2)	Kayah	1974	6 x 28	168.0	20	1,190.0
	Kinda	Mandalay	1985	2 x 28	56.0	20	165.0
	Sedawgyi	Mandalay	1989	2 x 12.5	25.0	12	134.0
	Zawgyi (1)	Shan	1995	3 x 6	18.0	6	35.0
	Zawgyi (2)	Shan	1998	2 x 6	12.0	5	30.0
	Zaungtu	Bago	2000	2 x 10	20.0	15	76.0
	Thaphanseik	Sagaing	2002	3 x 10	30.0	20	117.2
	Mone	Magwe	2004	3 x 25	75.0	190	330.0
	Paunglaung	Mandalay	2005	4 x 70	280.0	30	911.0
	Ye'new	Bago	2007	2 x 12.5	25.0	15	123.0
	Khabaung	Bago	2008	2 x 15	30.0	15	120.0
	KengTawn	Shan	2008	3 x 18	54.0	175	377.6
	Shweli (1)	Shan	2008	6 x 100	600.0	38	4,022.0
	Yeywa	Mandalay	2010	4 x 197.5	790.0	630	3,550.0
	Tapein (1)[b]	Kachin	2011	4 x 60	240.0	30	1,065.0
	Shwegyin	Bago	2011	4 x 18.8	75.0	35	262.0
	Kun	Bago	2011	3 x 20	60.0	38	190.0
	Kyee ON Kyee Wa	Magwe	2012	2 x 37	74.0	70	370.0
Subtotal Hydropower					2,660.0	1,504	13,267.8
Coal-Fired	Tigyit	Shan	2005	2 x 60	120.0	26.7	600.0
Gas Turbine	Kyunchaung	Magwe	1974	3 x 18.1	54.3	44.5	300.0
	Mann[c]	Magwe	1978	2 x 18.45	36.9	0	0
	Myanaung	Ayarwaddy	1975	1 x 16.25	34.7	14.5	200.0
			1984	1 x 18.45			
	Shwedaung	Bago	1984	3 x 18.45	55.35	36.5	300.0
	Ywama	Yangon	1980	2 x 18.45	70.3	31.0	238.0
			2004	1 x 24.0			
			2004	1 x 9.4			
	Thakayta	Yangon	1990	3 x 19.0	92.0	68.5	568.0
			1997	1 x 35.0			
	Ahlone	Yangon	1995	3 x 33.3	154.2	91.0	990.0
			1999	1 x 54.3			
	Hlawga	Yangon	1995	3 x 33.3	154.2	97.0	990.0
			1999	1 x 54.3			
	Thaton	Mon	1985	1 x 18.45	50.95	40.0	300.0
			2001	2 x 16.25			
	Mawlamyaing	Mon	1980	2 x 6.0	12.0	3.6	60.0
Subtotal Gas Turbine					714.9	427.0	3,946.0
Total					**3,495**	**1,957**	**17,814**

GWh = gigawatt-hour, MW = megawatt.
[a] Capacity as of August 2012.
[b] Temporarily out of service.
[c] Production stopped in 2005.
Source: Ministry of Electric Power.

Table A5.2 Existing Generating Plants for Hydropower, 2011

	Power Station	Installed Capacity (MW)	Firm Power (MW)	Dependable Capacity (MW)	Annual Energy Generation (GWh)	Commissioning Date
1.	Baluchaung-2	84	155.00	30.0 (Min) 75.0 (Max	595	1960
	Baluchaung-2	84		30.0 (Min) 80.0 (Max)	595	1974
2.	Kinda	56	21.00	24.0 (Min) 63.0 (Max	165	1985
3.	Sedawgyi	25	20.00	7.8 (Min) 28.0 (Max)	134	1989
4.	Baluchaung-1	28	26.00	27.5 (Min) 28.8 (Max)	200	1992
5.	Zawgyi-1	18	4.00	18.0	35	1995
6.	Zawgyi-2	12	3.20	6.4 (Min) 12.0 (Max)	30	1998
7.	Zaungtu	20	5.00	9.0 (Min) 21.0 (Max)	76	2000
8.	Thaphanseik	30	3.00	15.0 (Min) 30.0 (Max)	117	2002
9.	Mone	75	15.00	8.0 (Min) 75.0 (Max)	330	2004
10.	Paunglaung	280	39.00	50.0 (Min) 288.0 (Max)	911	2005
11.	Yenwe	25	7.50	5.0 (Min) 23.0 (Max)	123	2007
12.	Kabaung	30	5.00	5.0 (Min) 30.0 (Max)	120	2008
13.	Kengtawng	54	25.00	54.0	378	2009
14.	Shweli-1	600	174.80	600.0	4,022	2009
15.	Yeywa	790	175.00	206.0 (Min) 788.0 (Max)	3,550	2010
16.	Dapein (1)	240	30.05	240.0	1,065	2011
17.	Shwegyin	75	50.60 (firm peak capacity, 8 hours)	10.1 (Min) 79.2 (Max)	262	2011
	Total	**2,526**	**708.55**	**1,345.8 (Min) 2,533.0 (Max)**	**12,708**	

GWh = gigawatt-hour, MW = megawatt.
Source: Ministry of Electric Power.

Table A5.3 Annual Energy Generation for Hydropower, 2007–2011 (gigawatt-hour)

	Power Station	Estimated Annual Energy Generation	Actual Energy Generation				
			2007	2008	2009	2010	2011[a]
1.	Baluchaung-2	1,190	1,268	1,273	1,273	765	588
2.	Kinda	165	177	144	111	79	57
3.	Sedawgyi	134	141	149	141	122	98
4.	Baluchaung-1	200	226	226	230	120	95
5.	Zawgyi-1	35	36	42	44	3	55
6.	Zawgyi-2	30	59	57	37	13	29
7.	Zaungtu	76	62	69	67	50	52
8.	Thaphanseik	117	172	169	151	159	124
9.	Mone	330	334	291	234	237	181
10.	Paunglaung	911	918	957	780	629	389
11.	Yenwe	123	129	152	142	79	66
12.	Kabaung	120		113	40	26	68
13.	Kengtawng	378		11	330	325	182
14.	Shweli-1	4,022					
	Domestic	2,011		170	1,457	1,529	1,090
	Export	2,011			1,540	1,521	1,446
15.	Yeywa	3,550				1,520	1,913
16.	Dapein-1	1,065					
	Domestic	107				5	11
	Export	958				243	277
17.	Shwegyin	262				2	235
	Domestic	**9,739**	**3,522**	**3,823**	**5,038**	**5,663**	**5,233**
	Export	**2,969**	**0**	**0**	**1,540**	**1,764**	**1,723**
	Total	**12,708**	**3,522**	**3,823**	**6,578**	**7,425**	**6,721**

[a] 2011 figures are estimated.
Source: Ministry of Electric Power.

Table A5.4 Hydropower Projects Implemented by the Ministry as Sole Investment

Construction Bureau No.	Projects	Installed Capacity (MW)	Annual Energy (GWh)
1	Upper Paunglaung	104	454
1	Nancho	40	152
1	Middle Paunglaung	100	500
2	Shweli (3)	1,050	3,500
3	Kun	60	190
3	Phyu	40	120
4	Upper Yeywa	280	1,600
4	Bawgata	160	500
5	Manipur	380	1,903
6	Tha-htay	111	386
6	Ann	10	44
6	Upper Buywa	150	534
7	Upper Keng Tawng	51	267
	Total	**2,572**	**10,150**

GWh = gigawatt-hour, MW = megawatt.
Source: Ministry of Electric Power.

Table A5.5 Power Projects Implemented by Local Entrepreneurs on Build-Operate-Transfer Basis

No.	Projects	Installed Capacity (MW)	Annual Energy Generation (GWh)
1.	Thaukyegat-2	120	604.7
2.	Baluchaung-3	52	334.0
3.	Middle Paunglaung	29	134.4
4.	Shweli (3)	9	38.0
5.	Kun	64	236.0
6.	Phyu	280	1,512.0
7.	Upper Yeywa	6	44.7
	Total	**560**	**2,903.8**

GWh = gigawatt-hour, MW = megawatt.
Source: Ministry of Electric Power.

Table A5.6 Hydropower Projects to be Implemented by Foreign Direct Investments

No.	Project	Installed Capacity (MW)	Annual Energy (GWh)
1.	Myitsone	6,000	30,860
2.	Chipwi	3,400	17,770
3.	Wutsok	1,800	10,140
4.	Kaunglanhpu	2,700	14,730
5.	Renam	1,200	6,650
6.	Hpizaw	2,000	11,080
7.	Laza	1,900	10,440
8.	Chipwinge	99	599
9.	Dapein (2)	168	775
	Ngawchankha	**1,055**	**5,796**
10.	GawLan	100	552
11.	Wu Zhongze	60	327
12.	Hkan Kawn	140	769
13.	Tongxingqiao	320	1,746
14.	Lawngdin	435	2,401
15.	Upper Thanlwin (Kunlong)	1,400	7,338
	Naopha/ Mantong	**1,200**	**6214**
16.	Naopha	1,000	5,290
17.	Mantong	200	924
18.	Upper Thanlwin (Mongton)	7,110	35,446
19.	Hutgyi	1,360	7,325
20.	Tamanthi	1,200	6,685
21.	Shwezaye	660	2,908
22.	Saingdin	76.5	236
23.	Lemro	600	3,576
24.	Lemro (2)	90	273
25.	Ywathit	4,000	21,789
26.	Nam Tamhpak	180	920
	Nam Pawn	**585**	**3,015**
27.	Htu Kyan	105	551
28.	Hseng Na	45	234
29.	Tha Hkwa	150	776
30.	Palaung	105	536
31.	Bawlake	180	918
32.	Taninthayi	600	3,476
33.	Shweli (2)	520	2,814
	Namlwe	**452**	**3,265**
34.	Keng Tong	96	536
35.	Wan Ta Pin	25	138
36.	So Lue	165	742
37.	Mong Wa	50	274
38.	Keng Yang	28	155
39.	He Kou	88	483
40.	Nam Kha	200	937
42.	Mawlaik	520	3,310
44.	Nam Tamhpak	200	1,106
	Total	**41,276**	**219,472**

GWh = gigawatt-hour, MW = megawatt.
Source: Ministry of Electric Power.

Table A5.7 Coal-Fired Power Plant Projects to be Implemented by Foreign Direct Investments

No.	Projects	Installed Capacity (MW)	Annual Energy Generation (GWh)	Year of Completion
8	Kawthoung (local entrepreneur)	6	45	?
41	Yangon Coal-fired Thermal Power Plant	270	674~945 = 810 (average)	2012
43	Kalewa Coal-fired Thermal Power Plant	600	3,000~4,200 = 3,600 (average)	2013
	Total	**560**	**2,903.8**	

GWh = gigawatt-hour, MW = megawatt.
Source: Ministry of Electric Power.

Table A5.8 Electricity Consumption, April 2010–March 2011

Location	General Purpose	Industrial	Commercial	Street Lighting	Temporary	Departmental	Total	%
1. Yangon	1,409,234,820	914,648,321	548,659,900	15,530,614	1,753,486	3,112,060	2,892,939,201	45.8
2. Mandalay	389,009,017	429,781,222	215,848,790	2,683,873	295,702	815,867	1,038,434,471	16.5
3. Magway	93,154,674	265,209,706	92,470,698	2,559,966	74,527	502,541	453,972,112	7.2
4. Naypyitaw	78,513,210	71,050,934	193,259,650	6,679,442	7,742,438	1,588,749	358,834,423	5.7
5. Sagaing	103,799,613	130,854,418	46,754,610	2,685,764	172,788	506,196	284,773,389	4.5
6. Ayeyarwaddy	78,963,585	110,073,746	34,073,496	2,532,558	46,582	408,424	226,098,391	3.6
7. Bago (east)	87,895,967	73,065,202	34,285,972	1,449,961	46,823	2,092,738	198,836,663	3.2
8. Kayin	20,558,576	147,310,895	2,634,289	416,354	77,110	35,055	171,032,279	2.7
9. Shan (south)	87,879,117	27,554,608	52,032,074	1,423,653	169,665	319,504	169,378,621	2.7
10. Bago (west)	51,600,175	67,987,104	26,073,004	788,004	26,048	376,380	146,850,715	2.3
11. Mon	66,975,677	38,956,007	25,971,071	1,017,709	2,644,258	174,241	135,738,963	2.2
12. Shan (north)	65,145,414	7,384,792	19,483,091	906,364	834,970	319,657	94,074,288	1.5
13. Shan (east)	45,024,601	34,310	2,849,480	125,937	0	5,940	48,040,268	0.8
14. Kachin	34,429,948	675,567	5,886,877	654,117	89,114	183,674	41,919,297	0.7
15. Kayar	16,595,119	2,021,247	5,151,985	336,184	422,583	35,681	24,562,799	0.4
16. Tanintharyi	13,235,045	37,497	127,360	432,193	0	70,596	13,902,691	0.2
17. Rakhine	7,907,321	150	0	217,708	50	22,835	8,148,064	0.1
18. Chin	3,415,331	116,539	820,739	66,262	0	124,800	4,543,671	0.1
Total	**2,653,337,210**	**2,286,762,265**	**1,306,383,086**	**40,506,663**	**14,396,144**	**10,694,938**	**6,312,080,306**	**100.0**
%	**42.04**	**36.23**	**20.70**	**0.64**	**0.23**	**0.17**	**100.00**	

Source: Ministry of Electric Power.

Table A5.9 Domestic Electricity Consumption, April 2010–March 2011

Location	No. of Households	General Purpose (kWh)	Electrified (%)	kWh per household
Yangon	1,270,090	801,949	63	1,757
Naypyitaw	116,995	60,660	52	1,247
Kayar	47,514	17,396	37	823
Mandalay	1,060,762	311,876	29	1,294
Mon	340,971	92,945	27	672
Shan (south)	382,428	94,596	25	678
Bago (east)	556,540	124,615	22	705
Kachin	217,309	48,094	22	757
Bago (west)	448,323	80,662	18	929
Sagaing	862,616	154,404	18	640
Shan (north)	326,799	53,461	16	721
Shan (east)	131,549	19,637	15	1,219
Chin	81,055	12,001	15	2,293
Magway	770,123	113,214	15	716
Kayin	221,825	27,171	12	954
Tanintharyi	207,153	18,659	9	709
Ayeyarwaddy	1,335,968	116,522	9	267
Rakhine	527,654	29,650	6	285
Total	**8,905,674**	**2,177,512**	**24**	**1,219**

kWh = kilowatt-hour.
Source: Ministry of Electric Power.

Appendix 6
The Government of Myanmar's Plan for the Power Subector (September 2012)

1. The power sector in Myanmar needs significant investment (i) to address the current shortage of power generation; (ii) to reinforce the transmission grid and associated substations; (iii) to improve and upgrade the low-voltage system, especially in Yangon and Mandalay; and (iv) to extend the low-voltage system to connect more customers, particularly in rural areas.[1]

A. Power Planning

1. Growth in Demand

2. The expected growth in demand over the next decade is shown in Table A6.1. This is based on an annual increase in gross domestic product (GDP) of 10.5% and a population growth rate of 1.1%.

Table A6.1 Estimated Growth in Power Demand

Year	Individual Consumption (kilowatt-hour)	Total Annual Consumption (gigawatt-hour)	Maximum Demand (megawatt)
2012–13	203.90	12,459	2,155
2013–14	227.04	14,025	2,426
2014–15	252.91	15,795	2,732
2015–16	281.86	17,797	3,078
2016–17	314.91	20,102	3,477
2017–18	351.99	22,717	3,929
2018–19	393.61	25,683	4,442
2019–20	440.35	29,049	5,025
2020–21	492.88	32,873	5,686
2021–22	550.13	37,096	6,416

Source: Ministry of Electric Power.

2. Short Term Plans

3. Ministry of Electric Power (MOEP) short-term plans provide for an increase in generation for the years 2013 through 2016, especially for the summer months (February to May) when reduced water flows lessen the available hydropower generation and at the same time loads increase due to greater use

[1] ADB. 2012. *Consultant's Report: Assessment of Myanmar Power Sector*. Manila.

of air conditioning. Traditionally, loads are lower in April when industries close for the annual two-week break over the Myanmar New Year.

4. In the current generation mix during the summer months, thermal power plants provide 26.5% of the demand compared with 73.5% from hydroelectric; whereas during the cooler wet period, the hydropower contribution increases to 76.9%. MOEP recognizes the need to involve independent power producers to provide additional generation and overcome the power shortage, even though the generation costs per unit will be higher than existing.

5. Specific measures proposed in the short term over the next 3 years include:

(i) Scheduled by March 2013:

(a) increase energy purchased from the Shweli-1 hydropower plant (HPP) (100 megawatt [MW] base);

(b) increase generating capability of Frame-6 gas turbines (GTs) under rehabilitation process (80 MW base);

(c) ongoing major repairs at Ywama GT (30 MW base); and

(d) construction of a 66 kV link to connect to Chibwe-nge hydropower project (HPP) (18 MW base).

(ii) Additional potential actions that could be completed by March 2013:

(a) request Shweli-1 HPP for additional 100 MW base power purchase agreement (PPA) (total 400 MW);

(b) relocation to Ahlone of 120 MW base GT and PPA with Electricity Generating Authority of Thailand (EGAT);

(c) hiring of two 25-MW base mobile GTs; and

(d) supply of 120 thousand cubic feet (MCF) of natural gas supply for the above.

(iii) New HPP scheduled by March 2014:

(a) Phyuu: 40 MW plant to generate 120 gigawatt-hour (GWh);

(b) Thaukyaykhat-2: 120 MW plant to generate 605 GWh;

(c) Nancho: 40 MW plant to generate 152 GWh; and

(d) Baluuchaung-3: 52 MW plant to generate 334 GWh.

(iv) Under processing for March 2014 to reinforce the Yangon load center:

(a) Phase 1: 500 MW gas turbine combined-cycle (GTCC) project at Hlawga to generate 123 MW;

(b) Phase 1: 500 MW GTCC project at Thaketa to generate 166 MW;

(c) possible relocation of two 50-MW base GTs at Ywama; and

(d) supply of 115 MCF of natural gas supply for the above.

(v) New HPP scheduled by March 2015:

(a) Upper Baluchaung: 29 MW to generate 120 GWh; and

(b) Upper Paunlaung: 140 MW to generate 454 GWh.

(vi) Under processing for March 2015 to reinforce Yangon load center:

(a) Phase 2: 500 MW GTCC project at Hlawga to generate 246 MW;

(b) Phase 2: 500 MW GTCC project at Thaketa to generate 166 MW; and

(c) supply of 120 MCF of natural gas supply for the above.

3. Long Term Plans

6. MOEP's long term plans provide for additional generation and strengthening of the national grid in two categories: (i) projects already under construction to be completed after 2016; and (ii) plans being developed now for completion after 2016. These long term plans are still subject to confirmation and should be reviewed as part of a Power System Master Plan. Specific plans include:

(i) New HPPs under construction for completion after 2016:

(a) Anm: 10 MW plant to generate 44 GWh;

(b) Thuhtay: 111 MW plant to generate 386 GWh;

(c) Upper Yeywa: 280 MW plant to generate 1,330 GWh;

(d) Upper Kengtang: 51 MW plant to generate 267 GWh; and

(e) Shweli-3: 1,050 MW plant to generate 3,500 GWh.

(ii) Plans being developed for completion after 2016, to reinforce the Yangon load center:

(a) Phase 3: 500-MW GTCC project at Hlawga to generate 123 MW;

(b) Phase 3: 500-MW GTCC project at Thaketa to generate 166 MW;

(c) 430-MW thermal power plant project; and

(d) 800-MW thermal power plant project.

(iii) Reinforcement of the national grid 500-kV backbone transmission system in order to balance system power flow, allow redundant power transfer to new load centers, and reduce transmission losses and short circuit capacity; and

(iv) Control and operation of the national grid with Supervisory, Control and Data Acquisition or Energy Management System in order to allow economic dispatch, increase power quality, and improve reliability.

B. Required Assistance

7. MOEP has identified high-priority projects for consideration by ADB. These include:

(i) a 500 kV north-south transmission link;

(ii) a new 500 MW combined-cycle gas turbine (CCGT) in Yangon;

(iii) augmentation of various grid substations and transmission lines;

(iv) a SCADA/EMS system for installation in the proposed National Control Centre (NCC), plus optical ground wire (OPGW) and remote terminal units (RTUs) to connect existing substations and power stations;

(v) upgrading of four single-cycle gas turbines to combined cycle to increase outputs, improve efficiency, and reduce emissions;

(vi) additional equipment for testing digital meters;

(vii) static volt ampere reactive (VAr) compensation equipment to improve power factor (PF) and power quality; and

(viii) augmentation of distribution systems in Yangon and Mandalay to improve service to customers and reduce losses, and extension of the medium voltage (MV) and low voltage (LV) network into unelectrified areas to connect new customers.

In addition, there is a need for:

(i) A resident adviser for capacity and institutional development within MOEP, including:

(a) policy and regulations: review of existing Electricity Act, Electricity Law, and Electricity Rules and recommend changes to reflect current international best practice in governance and to facilitate and encourage private participation in the power sector;

(b) grid code: development of a grid code suitable for the Myanmar power sector based on current international best practices, definition of appropriate guidelines and requirements for independent power producers to connect to the Myanmar national grid; and

(c) rural electrification law: a review of the existing legislation for rural electrification and proposal for more appropriate requirements to facilitate and encourage rural electrification (currently this is administered by both MOEP and Ministry of Industry (MOI) through a Poverty Reduction Committee and the process needs to be better aligned between the two ministries and the procedure made more efficient).

(ii) A procurement adviser for training MOEP staff in ADB procedures for international procurement, including the various types of international competitive bidding (ICB) and national competitive bidding (NCB), standard and special conditions of contract, standard technical specifications for major equipment, contract administration, inspection and factory acceptance tests, shipping procedures, and the like.

(iii) A transmission and substations technical adviser to assist with modern power systems operation and maintenance, including:

(a) introduction of modern international design practice for the transmission and substation systems, use of International Electrotechnical Commission (IEC) standards, application of n-1 design to provide for continued supply during equipment failure, and provision of automated features to allow remote monitoring and control;

(b) safety procedures for substation operators, transmission maintenance, including live-line practice, MV & LV linemen operation, basic first aid, and cardiopulmonary resuscitation (CPR); and

(c) introduction of substation operation techniques including use of on-load tap charger (OLTC), auto-reclosers for quick clearing of transient faults, use of an oil-retention facility in the event of transformer oil spillage, standard procedures for securing the hazard areas in a switchyard, review of transmission protection including distance protection and multifunction digital relays, review of metering techniques, and so on (all to improve the quality and reliability of supply);

(iv) A technical consultancy to assist MOEP with the preparation of a power system master plan to set out a planned development program for generation, transmission, and substations in the short (1–3 years) and medium term (3–5 years) which would include a power systems model and analysis[2] of the complete transmission grid inclusive of generation and load centers.

[2] It is acknowledged that AF-Consultant is already assisting MOEP in this regard with an ongoing model of the transmission system using NetPlan software.

C. Generation Program

8. MOEP is already undertaking a number of initiatives to increase the available hydropower and thermal generation. The potential investments are summarized in Table A6.2; committed short term investments are shown in Table A5.3. The expected timing of the potential generation components has not yet been identified by MOEP.

Table A6.2 Potential Generation Investment

Type of Investment	No. of Stations	Proposed Capacity (megawatt)
Ministry of Electric Power	13	2,572
Local companies on BOT basis	7	560
Foreign companies on BOT basis	48	48,570
Total	**68**	**51,702**

BOT = build-operate-transfer.
Source: Ministry of Electric Power.

D. Transmission and Substations Program

9. The Myanmar Electric Power Enterprise (MEPE) proposes the following measures as part of its Transmission Losses Reduction Program:

(i) Short term:

(a) installation of reactive power compensation devices (capacitor bank, static VAr Compensator [SVC]) at grid and zone substations;

(b) installation of digital multi-function meters and bidirectional kWh meters at all power stations and substations for precise recording and live monitoring of energy; and

(c) calibration and testing of existing measuring equipment at all distribution substations.

(ii) Long term:

(a) upgrading the system voltage to 500 kV;

(b) using quad-bundle conductors for the 230-kV transmission line;

(c) analyzing the power factor and voltage drop in every power station and substation after installation of digital multifunction meters as above;

(d) using automatic OLTC in main transformers at new substations;

(e) increasing load sharing by installing two units of transformers in primary substations; and

(f) constructing a new 500 MW combined cycle power plant near Yangon.

10. Table A6.3 summarizes MOEP's Short Term Three -Year Plan (from 2013–2014 to 2015–2016).

Table A6.3 Potential Transmission and Substation Investment ($ million)

State/Division	2013–2014	2014–2015	2015–2016	Total Project Cost ($)
Kachin State	86.6	109.4	51.4	247.5
Kayar State	35.8	18.0	–	53.7
Kayin State	1.6	15.4	15.9	33.0
Chin State	19.3	12.2	3.0	34.5
Mon State	9.0	20.4	12.2	41.5
Rakhaing State	101.7	36.0	7.1	144.8
Shan State (South)	16.5	12.4	–	28.9
Shan State (North)	15.8	15.5	10.8	42.1
Sagaing Division	18.7	28.2	–	46.9
Mandalay Division	74.1	97.6	28.7	200.4
Magway Division	26.1	58.4	46.1	130.6
Bago Division (East)	24.6	57.5	76.6	158.7
Bago Division (West)	12.7	1.0	–	13.7
Ayeyarwaddy Division	64.1	16.5	38.5	119.1
Yangon Division	14.6	27.7	6.4	48.7
Tanintharyi Division	–	12.8	12.7	25.5
	521.2	**538.8**	**309.6**	**1,369.6**

– = unknown.
Note: Totals may not add up due to rounding.
Source: Ministry of Electric Power.

E. Distribution Program

1. Mandalay City

11. Mandalay Division of the Electric Supply Enterprise has submitted a proposed program of works which include:

(i) 7 CCGT stations located around Mandalay District, with 34 units of 500 MW each, totaling 1,700 MW;

(ii) 240 kilometer (km) of rehabilitation and extension of the 33 kV overhead distribution system;

(iii) 310 km of rehabilitation and extension of the 11 kV overhead distribution system;

(iv) 650 km of rehabilitation and extension of the LV overhead distribution system;

(v) installation of 1,150 11/0.4 kV distribution transformers;

(vi) replacement of 4,385 wooden power poles with concrete poles; and

(vii) various other associated works.

2. Yangon City

12. Table A6.4 shows total proposed projects from 2013 to 2016 for Yangon City from their Five-Year Plan. Table A6.5 summarizes Yangon City Electric Supply Board's proposed priority projects selected from the 2013–14 projects.

Table A6.4 Summary of Yangon City Electric Supply Board's Proposed 2013–2016 Program for Yangon City ($ million)

Year	Material Cost	Installation Cost	Total
FY2013–14 Projects	67.7	5.8	73.5
FY2014–15 Projects	70.0	3.8	73.8
FY2015–16 Projects	84.8	5.0	89.8
Total	**222.5**	**14.6**	**237.1**

FY = fiscal year.
Note: Totals may not add up due to rounding.
Source: Yangon Electricity Supply Board.

Table A6.5 Summary of Yangon City Electric Supply Board's Priority Projects for Yangon City, 2013–2014 ($ thousand)

Project	Material Cost	Installation Cost	Total
66 kV substation and related work	7,981	2,657	10,637
33 kV substation and related work	3,104	162	3,266
66 kV UG cable and OH line subjects	6,359	360	6,719
Replacement of OMR, AMR, and insulated cable	12,989	38	13,026
Total	**30,432**	**3,216**	**33,648**

Note: Totals may not add up due to rounding.
Source: Yangon Electricity Supply Board.

Myanmar: Energy Sector Initial Assessment

The Asian Development Bank (ADB) is preparing sector assessments to help align future ADB support with the needs and strategies of developing member countries and other development partners. This assessment is a working document that helps inform the development of country partnership strategies. This energy sector initial assessment outlines development issues, needs, and strategic assistance priorities of the Government of the Republic of the Union of Myanmar for ADB's reengagement. It highlights sector performance, priority development constraints, the government's strategy and plans, past ADB support, and possible future ADB assistance, including knowledge support and investments. The product serves as a basis for further dialogue on how ADB and the government can work together to tackle the challenges and opportunities to ensure efficient and effective use of energy resources for sustainable development of the energy sector in Myanmar in coming years. This publication also aims to help stakeholders understand energy situations in Myanmar, recognize the potential of energy resources development, and enhance regional cooperation for inclusive and sustainable economic development of Myanmar.

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