

GREATER MEKONG SUBREGION ENERGY SECTOR ASSESSMENT, STRATEGY, AND ROAD MAP

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ENERGY SECTOR ASSESSMENT, STRATEGY, AND ROAD MAP

June 2016



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6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 632 4444; Fax +63 2 636 2444
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Abbreviations

ADB	Asian Development Bank
ASR	assessment, strategy, and road map
CSG	China Southern Power Grid
EDL	Electricité du Laos
EGAT	Electricity Generating Authority of Thailand
GDP	gross domestic product
GMS	Greater Mekong Subregion
IPP	independent power producer
MOU	memorandum of understanding
PRC	People's Republic of China
RPCC	Regional Power Coordination Center
RPTCC	Regional Power Trade Coordination Committee
SEF	Subregional Energy Forum
PPA	power purchase agreement
TA	technical assistance

Weight and Measures

GW	gigawatt
GWh	gigawatt-hour
km	kilometer
kV	kilovolt
mtoe	million tons of oil equivalent
MW	megawatt
TWh	terawatt-hour

I Sector Assessment: Context and Strategic Issues

A. Introduction

1. This sector assessment, strategy, and road map (ASR) documents the current assessment and strategic investment priorities of the Asian Development Bank (ADB) and the governments of the Greater Mekong Subregion (GMS) countries in the energy sector. It highlights sector performance, priority development constraints, government plans and strategy, past ADB support and experience, other development partner support, and future ADB support strategy. It will be updated as strategic developments and program changes are needed, and will help provide sector background information for investment and technical assistance (TA) operations in GMS countries. The ASR is linked to the strategic framework for the GMS countries for 2012–2022, adopted at the 4th GMS Summit in Nay Pyi Taw, Myanmar, in December 2011, which sets out the principles for partnership between the GMS and ADB over the said period.¹ The ASR also draws upon the ADB Strategy 2020 that guides ADB’s overall operations and the country partnership strategies for the GMS countries.²

B. Overall Sector Context

2. **Overall context.** GMS countries have experienced dynamic growth over the past few decades and a strong increase in trade with the rest of the world. Tables 1 and 2 present some demographic, social, economic, and financial indicators for the GMS excluding the Yunnan Province and Guangxi Zhuang autonomous region of the People’s Republic of China (PRC) (GMS5). The key drivers of energy demand are clearly visible: population growth, economic development, industrialization, and urbanization. The share of industrial output in gross domestic product (GDP) has grown remarkably since 1990. Most of the GMS5 countries have grown on average over the period 2008–2014 by between 5% and 6%. The economies have become more open as is shown by the significant increases in foreign direct investment and the rapid growth of external trade as a proportion of GDP.

3. Prospects for economic growth are good; industries in the GMS5 have become essential elements of global supply chains. Comparable time series are not available for Yunnan and Guangxi Provinces, but some similar indicators for 2012/13 are given in Table 3. Growth rates of these two provinces of the PRC are generally higher than for GMS5 countries, and per capita income is higher for all countries except Thailand. Their economies are less open than those of the GMS5 as indicated by the low proportion of trade in GDP and the low levels of foreign direct investment, which are also below the averages for the PRC as a whole.

4. **Role of the energy sector in social and economic growth and development.** A reliable supply of affordable energy of adequate quality is fundamental to all the socioeconomic achievements

¹ ADB. 2011. *GMS Strategic Framework 2012–2022*. Manila.

² ADB. 2008. *Strategy 2020: The Long-Term Strategic Framework of the Asian Development Bank, 2008–2020*. Manila.

Table 1: Demographic and Social Indicators for GMS5

	Population			Urbanization (% of Urban Population)		Per Capita GDP (2014)		Below Poverty Line <\$2 PPP/day	
	1990 (million)	2014 (million)	AAGR (%)	1990	2014	\$/person	AAGR ^a (%)	<\$2 PPP/day (%)	
Cambodia	8.6	15.2	2.4	14.8 ^b	22.5	1,090	6.6	75.2 (1994)	41.3 (2011)
Lao PDR	4.1	6.8	2.1	15.4	37.6	1,760	11.8	78.8 (1997)	62.0 (2012)
Myanmar	40.8	51.5	1.0	24.8	30.0	1,204	...	...	...
Thailand	55.8	67.0	0.8	18.0	44.5	5,520	9.9	16.1 (1996)	3.5 (2010)
Viet Nam	66.0	90.7	1.3	19.5	33.1	2,052	10.3	85.7 (1993)	12.5 (2012)
Total	175.3	231.2	1.2						

... = not available, AAGR = average annual growth rate, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic, PPP = purchasing power parity.

^a Between 2008 and 2014.

^b 1998 data.

Sources: ADB. 2015. *Key Indicators for Asia and the Pacific*. Manila; ADB. 2015. *Asian Development Outlook 2015*. Manila; World Bank. 2015. *World Development Indicators*. Washington, DC.

Table 2: Economic and Financial Indicators for GMS5

	AAGR 2008–2014 (%/year)		Share of Industrial VA in GDP (%)		FDI (\$ million)		
	Industrial		1990	2014	1990	2005	2013
	Total GDP	VA					
Cambodia	5.96	7.51	11.3	27.1	...	381	1,345
Lao PDR	7.87	12.77	14.5	34.7	6	28	427
Myanmar	8.64	13.74	10.5	34.4	161	235	2,255
Thailand	2.90	2.10	37.2	36.8	2,444	8,055	14,305
Viet Nam	5.76	6.03	22.7	38.5	180	1,954	8,900

	FDI (% of GDP)			Trade (% of GDP)		
	1990	2005	2013	1990	2005	2014
	Cambodia	0.7	6.1	8.8	17.8	108.5	107.2
Lao PDR	0.7	1.0	4.0	30.5	52.8	59.0
Myanmar	2.8	...	3.6	5.6	0.3	43.9
Thailand	2.8	4.3	3.4	63.5	121.2	105.0
Viet Nam	...	3.4	5.2	79.7	120.1	160.1

... = not available, AAGR = average annual growth rate, FDI = foreign direct investment, GDP = gross domestic product, GMS5 = Greater Mekong Subregion less the PRC, Lao PDR = Lao People's Democratic Republic, VA = value added.

Sources: ADB. 2015. *Key Indicators for Asia and the Pacific*. Manila; ADB. 2015. *Asian Development Outlook 2015*. Manila.

Table 3: Indicators for Yunnan Province and Guangxi Zhuang Autonomous Region

	Population (million)	Per Capita GDP (\$/person)	Growth Rate of GDP (%/year)	Growth Rate of Industrial VA (%/year)
Year	2013	2013	2012–2013	2012–2013
Yunnan	46.9	3,809	12.1	12.2
Guangxi	47.2	4,644	11.3	15.9

	Share of VA in GDP (%)	FDI (\$ million)	FDI (% GDP)	Trade (% GDP)
Year	2012	2012	2012	2012
Yunnan	33.5	2,189	1.23	11.2
Guangxi	40.5	749	0.34	13.46

FDI = foreign direct investment, GDP = gross domestic product, VA = value added.

Source: Deutsche Bank. 2014. *Deutsche Bank Research* citing *Statistical Yearbooks of Yunnan and Guangxi*. World Bank Atlas for exchange rate.

and ambitions of the GMS countries. Demand for energy across the countries of the GMS has risen strongly for several decades driven by the increasing use of electricity in a wide range of applications by a growing affluent residential sector and by flourishing commercial and industrial sectors.

5. **Primary energy.** Table 4 presents the total demand for commercial sources of primary energy over the period 2002–2011.³ In the PRC, only Yunnan and Guangxi are part of the GMS, but the entries in the Table relate to the entire PRC as data for the individual provinces are not easily available and their needs and potential cannot be isolated from the larger entity. For example, gas imports from Myanmar are used throughout the PRC, electricity trade will be with the entire China Southern Power Grid (CSG), and energy policy will be driven by the priorities of the country as a whole. The GMS countries, taken without the PRC, represent 1.07% of global energy production and 1.37% of consumption and, on inclusion of the PRC, represent 18.6% of global energy production and 21.3% of consumption.

6. The growth rates of both energy production and consumption have been high compared with the world average of about 2.8%. Because of the relatively good growth in production, the high rates of growth in demand have not reduced the level of self-sufficiency of the GMS, whether the PRC is included or not. There are some variations among the countries: Cambodia is almost totally dependent on imports; Myanmar has a high level of self-sufficiency; Viet Nam is well placed, but the ratio is falling; self-sufficiency in the PRC is deteriorating slowly but steadily.

7. Demand for primary energy in the GMS will grow rapidly. Table 5 shows country forecasts made by ADB for the Asian Development Outlook in 2013.⁴ The likely future rate of growth outside of the PRC is 3%–4% per annum but that of the PRC is less. However, it is likely that growth in demand

³ Data are taken from the Energy Information Administration (EIA) online database, <http://www.eia.gov/countries/data.cfm>. More recent figures are available for some countries from other sources, but the EIA database appears to be the most comprehensive and up-to-date for smaller countries and therefore has been adopted here. Figures from other sources will differ slightly from those given here for technical reasons.

⁴ ADB. 2013. *Asian Development Outlook: Asia's Energy Challenge*. Manila.

Table 4: Total Commercial Primary Energy: Production, Consumption, and Self-Sufficiency

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	AAGR (%) (2002–2011)
Production (mtoe)											
Cambodia ^a	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.2
Lao PDR	1.6	1.4	1.6	1.7	1.7	1.9	1.9	1.9	3.5	5.0	13.3
Myanmar	15.1	17.2	18.2	22.7	22.6	24.0	22.4	21.2	22.2	22.0	4.3
PRC	1,682	1,916	2,158	2,397	2,551	2,734	2,896	3,066	3,342	3,594	8.8
Thailand	56	62	63	69	72	77	82	86	93	97	6.4
Viet Nam	55	58	72	79	83	85	84	92	92	96	6.4
Total	1,810	2,055	2,313	2,570	2,731	2,921	3,087	3,267	3,554	3,814	8.6
GMS5	127	138	155	173	180	188	190	201	211	220	6.3
Consumption (mtoe)											
Cambodia	1.7	1.9	2.1	2.2	2.4	2.6	3.0	2.6	2.4	3.0	6.4
Lao PDR	1.4	1.3	1.5	1.5	1.6	1.7	1.9	1.8	3.5	4.9	14.8
Myanmar	7.5	8.4	8.6	11.4	10.6	11.5	10.3	9.6	9.6	9.8	3.0
PRC	1,725	1,984	2,298	2,547	2,793	2,971	3,135	3,452	3,799	4,116	10.1
Thailand	116	127	137	145	147	152	142	161	172	182	5.1
Viet Nam	36	39	44	48	51	56	65	67	73	83	9.8
Total	1,888	2,162	2,491	2,755	3,006	3,194	3,357	3,694	4,059	4,399	9.9
GMS5	163	178	193	208	213	224	222	241	260	283	6.3
Self-sufficiency (%)											
Cambodia	0.7	1.1	0.8	1.1	1.1	1.0	0.8	0.9	0.8	0.8	
Lao PDR	114	108	109	108	108	111	104	102	101	101	
Myanmar	202	205	211	199	213	208	217	222	232	225	
PRC	98	97	94	94	91	92	92	89	88	87	
Thailand	48	49	46	48	49	50	58	53	54	53	
Viet Nam	153	149	163	166	162	153	129	138	127	115	
Total	96	95	93	93	91	91	92	88	88	87	
GMS5	78	78	80	83	84	84	86	83	81	78	

AAGR = average annual growth rate, GMS Greater Mekong Subregion, GMS5 = GMS less PRC, Lao PDR = Lao People's Democratic Republic, mtoe = million tons of oil equivalent, PRC = People's Republic of China.

^a Data indicate that annual production of primary energy, although growing markedly, was well less than 100,000 mtoe during the period 2002 through 2008.

Source: ADB compilation from Energy Information Agency database of 16 August 2014.

in Yunnan and Guangxi would more closely resemble the other GMS countries. The consequence of this sustained growth is that demand by 2035 will be roughly double the present demand.

8. **Electricity.** Demand for electricity is also growing rapidly across the GMS, and this trend will continue, requiring extensive expansion of the power systems in the GMS. Table 6 shows the projected installed capacity by technology in the GMS according to the current power development

Table 5: Forecasts of Future Primary Energy Demand

	mtoe					AAGR (%)			
	1990	2009	2015	2020	2035	1990–2009	2009–2020	2020–2035	2009–2035
Cambodia	...	5	6	7	11	...	3.0	3.0	3.0
Lao PDR	1.2	3	5	5	9	4.5	6.1	3.4	4.5
Myanmar	10.7	15	17	21	35	1.8	3.3	3.3	3.3
Thailand	41.9	103	121	140	215	4.9	2.8	2.9	2.9
Viet Nam	24.3	64	83	99	185	5.2	4.0	4.3	4.2
PRC	863	2,257	2,798	3,156	4,034	5.2	3.1	1.6	2.3
Total	941	2,447	3,030	3,429	4,489	5.2	3.1	1.8	2.4
Total PRC	78	190	232	273	455	4.8	3.3	3.5	3.4

... = not available, AAGR = average annual growth rate, Lao PDR = Lao People's Democratic Republic, mtoe = million tons of oil equivalent, PRC = People's Republic of China.

Source: ADB. 2013. *Asian Development Outlook: Asia's Energy Challenge*. Manila.

Table 6: Projection of Future Installed Capacity

Fuel	Existing (2012)		Projected (2025)		Increase (2012–2025)		
	MW	Plants	MW	Plants	MW	%	Plants
Nuclear	0	0	7,160	4	7,160	–	4
Coal/lignite	34,058	41	84,341	83	50,283	148	42
Gas	27,959	39	52,287	54	24,328	87	15
Large hydro	49,727	116	160,963	254	111,235	224	138
Renewables	3,533	Unknown	16,475	Unknown	12,942	366	Unknown
Cogen + others	3,689	16	8,006	6	4,317	117	(10)
Total	118,967	212	329,232	401	210,265	177	

() = negative, Cogen = cogeneration, GMS = Greater Mekong Subregion, MW = megawatt.

Source: ADB. 2013. *Final Report of TA 7764 Ensuring Sustainability of GMS Regional Power Development*. Manila.

plans of the member countries. The total incremental capacity from 2012 to 2025 is projected at 210 gigawatt (GW). In association with increasing the generation capacity, the transmission and distribution system needs to be expanded as well.

9. To meet these ambitious targets, the mechanisms for attracting private investment in power generation through various forms of independent power producer (IPP) arrangements need to be further enhanced in much of the GMS. The private sector will make an important contribution to the investment toward power generation. As it is more difficult to attract private sector investments in transmission and distribution, it is likely that a large part of the investment in networks will continue to be funded from the public domain.

10. Behind this common characteristic of rapid and sustained growth lies a great deal of diversity. Cambodia has a relatively small electricity system. In 2014, the total installed capacity was 1,620 megawatt (MW), comprising 681 MW (38.6%) from hydro, 363 MW (26.3%) from import,

380MW (30.4%) from coal, and 140 MW (3.1%) from oil. Electricity import, mainly from the Lao PDR, Thailand, and Viet Nam, is a significant contributor to the supply of electricity in the border areas. In recent years, new hydro and coal-fired plants have been added, driving a rapid increase in electricity generation by 27.6% per annum since 2011. According to the country's power development plan, around 3,000 MW will be further added to the grid by 2020.⁵

11. In the Lao PDR, hydropower is a dominant source of power generation. Twenty-three hydro plants are in operation with a total capacity of 3,217 MW, producing 14.8 terawatt-hour (TWh) of power. Of this, 391 MW (12%) was owned by Electricité du Laos (EDL), 304 MW (10%) was owned IPPs and used for domestic consumption, and 2,520 MW (78%) was owned by IPPs and used for export. Additional hydropower generation capacity of 5,448 MW is under construction and is slated to be operational from 2014 to 2019.⁶

12. The power system in Myanmar is relatively underdeveloped; the peak demand in 2015 was 2,449 MW. The total installed capacity in 2015 was 4,715 MW of which 3,185 MW (67.6%) was from hydropower, 1,329 MW (28.2%) from gas, 120 MW (2.6%) from coal, and 5 MW (less than 1%) from renewable sources (mini hydro and solar energy). Only 35% of the population had access to electricity in 2014. The forecast for future demand is 3.8 GW by 2020 and 9.1 GW by 2030 for low growth case, and 4.5 GW by 2020 and 14.5 GW by 2030, which is expected to be met mainly by additional hydropower and also by coal to a lesser extent.⁷

13. The power system in the PRC is the largest in the world; the total installed capacity is 1,360 GW consisting of coal (915 GW), hydro (302 GW), wind (95.8 GW), solar PV (26.5 GW), and nuclear energy (21 GW). CSG covers the provinces of Yunnan, Guizhou, Guangxi, Guangdong, and Hainan. The total installed capacity in these five provinces in 2014 was 245 GW consisting of 125 GW (51.2%) from thermal, 99 GW (40.4%) from hydro, 7.2 GW (2.9%) from nuclear, 5.2 GW (2.1%) from wind, 4.8 GW (2.0%) from pump storage, and the rest 3.4 GW (1.4%) from other sources. The peak load in 2014 was 136 GW and the demand growth rate was 5.6%. Within this area, bulk power is transmitted from the west (rich hydro resource) to the east (major load centers) through eight alternate current and eight direct current high-voltage transmission lines. Guangdong Province accounted for 56.3% of the total electricity consumption among the provinces covered by CSG in 2014. With regard to the GMS countries, CSG exported 624 MW to Viet Nam and 63 MW to the Lao PDR, and imported 540 MW from Myanmar. Peak load is expected to grow to 235 GW by 2020 and installed capacity to 378 GW by 2020. Clean energy proportion will increase to 50% in 2020 from 40% in 2010.⁸

14. The power system in Thailand used to be the largest in the Lower Mekong Basin; peak demand in 2015 was 27.3 GW, which was supplied from a total installed capacity of 36.2 GW. Of this capacity, the majority was gas-fired combined-cycle plant (27.8 GW), but there was a substantial coal and lignite-fired plant (7.5 GW), with 5.5 GW of hydropower of which 2.1 GW are in the Lao PDR; and there is a small amount of biomass and diesel firing. The Electricity Generating Authority of Thailand (EGAT) is the largest single owner of power generation (15.5 GW); large IPPs produce 13.9 GW and independent plants under the small power plant scheme produce 3.8 GW of power; EDL owns 2.1 GW; and a small amount of power is imported from Malaysia. The long-term power development

⁵ Electricité du Cambodge, Cambodia. November 2015. *Updated Cambodia Country Report*. 19th Meeting of the Regional Power Trade Coordination Committee. Bangkok, Thailand.

⁶ Electricité du Laos (EDL), Lao PDR. November 2015. *Updated Laos Country Report*. 19th Meeting of the Regional Power Trade Coordination Committee. Bangkok, Thailand.

⁷ Ministry of Electric Power, Myanmar. November 2015. *Updated Myanmar Country Report*. 19th Meeting of the Regional Power Trade Coordination Committee. Bangkok, Thailand.

⁸ China Southern Power Grid (CSG), PRC. November 2015. *Updated PRC Country Report*. 18th Meeting of the Regional Power Trade Coordination Committee. Bangkok, Thailand.

plan of EGAT envisages adding of 57.5 GW of capacity during 2015–2036, with 24.7 GW being retired, making a net addition of 32.8 GW and a total installed capacity of 70.3 GW by the end of the said period. Most of the additional plants will be gas-fired (about 17.5 GW), with large imports of hydropower from neighboring countries (11 GW) and substantial additions of renewable energy (12 GW) and coal (7.4 GW).⁹

15. The installed capacity in Viet Nam recently surpassed that of Thailand; in 2015, 38.5 GW served a peak demand of 25.8 GW. The system is largely composed of hydropower plants of 15.8 GW, along with 12.9 GW of coal-fired plants and 7.2 GW of gas combined-cycle plants. There are also small volumes of gas (1.6 GW) and oil-fired thermal generation and some imports from the Lao PDR and the PRC (1.2 GW). The recent growth rate of demand has been high: from 2005 to 2014, demand grew at an average annual rate of 11.7%. The load forecast for 2020 is a maximum demand of 42.1 GW and 265.4 TWh of consumption, rising to 90.7 GW and 571.75 TWh of consumption by 2030; at that time, 59% of installed capacity is expected to be coal thermal.¹⁰

16. The power systems of countries in the GMS show certain common traits but also considerable differences. They are all growing very strongly. Thailand expects to rely heavily in the future on imported gas. Viet Nam will substantially increase the use of coal, as will the PRC. The Lao PDR and Myanmar have relatively low demands and potential surpluses of hydropower. Therefore, there will be significant gains in interconnecting the national electricity systems to take advantage of this diversity. Interconnected systems can enable power exchange to achieve reduced system-wide cost through utilization of rich hydropower resources in the region, and increased energy security to manage shortages that may occur during dry seasons and from interruptions to imported coal and gas supplies.

17. **Energy security.** Table 7 shows the proven reserves of oil, gas, and coal in the member countries, their share of the world totals, and the reserves to production (R/P) ratio. There is much more coal in the region than oil and gas, and it is mainly located in the PRC. The subregion, including

Table 7: Reserve Data 2013, Share of World Total, and Reserve to Production Ratio

	Oil			Gas			Coal		
	toe (billion)	Share (%)	R/P (years)	m ³ (trillion)	Share (%)	R/P (years)	Tons (billion)	Share (%)	R/P (years)
Cambodia	...	...	...	...	...	...	...	...	...
PRC	2.5	1.1	11.9	3.3	1.8	28	114.5	12.8	31
Lao PDR	...	...	...	...	...	...	0.6	0.1	570
Myanmar	0.07	<0.05	6.8	0.3	0.2	21.6	...	...	...
Thailand	0.1	<0.05	2.5	0.3	0.2	6.8	1.2	0.1	69
Viet Nam	0.6	0.3	34.5	0.6	0.3	63.3	0.2	<0.05	4
Total	3.2	1.4	11.9	4.5	2.5	24.3	116.5	13.0	31
GMS5	0.7	0.3	12.1	1.2	0.7	17.8	2.0	0.2	35

... = not available, Lao PDR = Lao People's Democratic Republic, m³ = cubic meter, PRC = People's Republic of China, R/P = reserve to production ratio, toe = ton of oil equivalent.

Sources: *BP Statistical Review of World Energy 2014*, except for coal in Lao PDR and oil in Myanmar that are taken from the Energy Information Administration on-line database.

⁹ Electricity Generating Authority of Thailand, Thailand. November 2015. *Updated Thailand Country Report*. 18th Meeting of the Regional Power Trade Coordination Committee. Bangkok, Thailand.

¹⁰ Vietnam Electricity, Viet Nam. November 2015. *Updated Vietnam Country Report*. 18th Meeting of the Regional Power Trade Coordination Committee. Bangkok, Thailand.

the whole of the PRC, enjoys 1.4% of the world's known oil reserves, 2.5% of known gas reserves, and 13% of known coal reserves. These figures are well below the share of the subregion in global GDP indicating that it is generally disadvantaged with respect to energy resources. The figures for the GMS5 are 0.7% for oil reserves, 1.2% for gas reserves, and 2.0% for coal reserves. In GMS5, the R/P ratios are 12 years for oil, 18 years for gas, and 35 years for coal. These are much lower than the R/P ratios for the world, which are 53 years for oil, 55 years for gas, and 113 years for coal. The consequence of this rather poor endowment and the very high expected growth rates is that the subregion will have to contend in the future with a much higher import dependency than it has known up until now. This has strong implications for access, security of supply, and the level and volatility of prices.

18. **Hydropower resource.** The region has considerable potential for hydropower, particularly along the great Mekong River and its tributaries. The hydropower potential in the GMS is significant, approximately 225 GW in total, consisting of Yunnan and Guangxi (122 GW), Myanmar (40 GW), Viet Nam (35 GW), the Lao PDR (18 GW), and Cambodia (10 GW).¹¹ The hydropower resource of the Mekong River is divided into three parts: the upper Mekong, mainly in PRC; the main stream of the lower Mekong; and the tributaries of the Lower Mekong Basin. The PRC has constructed a series of dams in cascade and a navigation channel along the upper reaches of the Mekong. Thailand does not have a large tributary system to the Mekong and Viet Nam has developed some of the available hydro sites on its territory. Of the 124 tributary sites identified in the Mekong River Commission's hydropower database in 2009, more than 70% are in the Lao PDR and 10% are in Cambodia.¹² However, rivers have many other benefits that are often public goods. A strategic environmental assessment of mainstream dams on the Mekong published in 2010 under the auspices of the Mekong River Commission concluded that the construction of one or more of the hydropower schemes could have profound implications for the sustainable development of the basin and irreversibly affect the lives and livelihoods of millions of people in all four Lower Mekong Basin countries.¹³ The study suggested a 10-year moratorium on dam construction on the mainstream Mekong.

19. **Renewable energy.** Resource estimates for renewable energy are subject to many uncertainties. The physical characteristics of wind and solar energy have been well documented in solar and wind atlases, but the practical difficulties of converting the ambient energy to useful energy may depend on local factors that are hard to generalize. A wind atlas for Southeast Asia has been prepared for the World Bank; the resource in the GMS member countries except the PRC is relatively small: a little more than 10 GW, and it is concentrated in offshore Viet Nam and in the hilly areas of the Lao PDR.¹⁴ An assessment of the solar energy resources within the GMS except the PRC has been performed by ADB under a TA project.¹⁵ The total technical potential is estimated at around 80 GW, but this includes areas with relatively low insolation. The potential in areas with insolation above 1,800 kilowatt-hour/year is about 34 GW, which is still significant. This capacity would produce about 52 TWh/year. The costs of the technology for the capture of renewable energy are falling rapidly and performance is improving. Overall, there is a strong potential for the GMS countries to undertake a significant effort in renewable energy, but achievements to date, outside of the PRC and Thailand, are modest.

¹¹ This number refers to technically exploitable capability using the World Energy Council data for hydropower using the assumption of 0.4 capacity factor.

¹² Mekong River Commission. 2011. *State of the Basin Report 2010*. Vientiane.

¹³ ICEM. 2010. *Mekong River Commission Strategic Environmental Assessment (SEA) of Hydropower on the Mekong Mainstream*. Ha Noi.

¹⁴ Lahmeyer. 2014. *Renewable Energy Developments and Potential in the GMS*. ADB. Manila. Data reused from Wind Energy Resource Atlas of Southeast Asia (World Bank, 2001) due to difficulties in estimating wind potential with limited data on wind speeds, which are only available through site-specific analysis.

¹⁵ Lahmeyer. 2014. *Renewable Energy Developments and Potential in the GMS*. Manila, ADB.

20. The climatic conditions of the GMS are favorable for biomass production and the possibility of producing bioethanol and biodiesel for the transport sector has received much interest. Within the subregion, ethanol is produced mainly from sugarcane and cassava. The main feedstock for biodiesel is palm oil, which is mainly cultivated in large-scale plantations, much of which is exported. The first-generation technologies used for biofuel production in Southeast Asia use crops or land that could be used to grow food, and therefore there is inevitably a trade-off between energy and food production. A study supported by ADB in the GMS has shown how the adoption of second-generation technologies could transform the prospects for biofuels. The analysis concluded that expansion of biofuels involving surplus land, smallholder-based production, and an emphasis on nonfood crops and second-generation biofuels could pave the way for sustainable utilization of biofuels in the GMS and create new jobs and value chains in rural areas (footnote 15).

C. Regional Power Trade

21. **Power trade.** Before 1992 when the GMS Program began, the only significant power transmission links in the GMS were 115 kilovolt (kV) lines; double circuit and single circuit lines brought power to northeast Thailand from the Nam Ngum 1 Hydropower Plant commissioned in 1971, and another single circuit 115 kV line connected the southern grid of the Lao PDR to the Thai system to transfer power from the Xeset hydropower plant.¹⁶ Low-voltage lines also connected parts of central Lao PDR with the Thai system and connected the Lao PDR with contiguous parts of Cambodia to distribute power to remote border regions. Over 2 decades, however, 10 major high-voltage (220 kV and above) power interconnections have been built and operated.

Regional Power Interconnections among Greater Mekong Subregion Countries

Lao PDR–Thailand	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing	<ul style="list-style-type: none"> • 2 links of 500 kV lines <ul style="list-style-type: none"> (i) Nam Theun 2 HPP–Roi Et 2 substation, 500 kV, 304 km (2009) (ii) Nam Ngum 2 HPP–Ou done 3, 500 kV, 187 km (2011)^a • 2 links of 230 kV lines <ul style="list-style-type: none"> (i) Theun Hinboun HPP–Sakhonnakhon, 230 kV, 176 km (1998) (ii) Houayho HPP–Ubon 2, 230 kV, 230 km (1999) 	<ul style="list-style-type: none"> • 6 links of 115 kV lines <ul style="list-style-type: none"> (i) Phontong S/S (Vientiane)–Nongkhai (EGAT) (ii) Thanaleng (Vientiane)–Nongkhai (EGAT) (iii) Pakxan S/S (Borikhamxay)–Bungkan (EGAT) (iv) Thakhek S/S (Khammoun)–Nakhonphanom (EGAT) (v) Pakbo S/S (Savannakhet)–Mukdahan 2 (EGAT) (vi) Bang Yo S/S (Champasack)–Sirinthon P/S (EGAT) • 7 links of 22/35 kV lines <ul style="list-style-type: none"> (i) Houayxai District (Bokeo)–Chiangkhong (PEA) (ii) Thon Pheung District (Bokeo)–Chiang Saen (PEA) (iii) Khenthao (Xayabuly)–Thali (PEA) (iv) Khob District (Xayabuly)–Ban Houak (PEA) (v) Ngeun District (Xayabuly)–Houay kone (PEA) (vi) Xiang Hon District (Xayabuly)–Ban Mai (PEA) (vii) Boten District (Xayabuly)–Danxai (PEA)

^a It is currently energized by 230 kV but after 2019 when there will be a new connection from Nam Niep 1, it will be converted to 500 kV.

¹⁶ ADB. 2012. *Greater Mekong Subregion Power Trade and Interconnection: Two Decades of Cooperation*. Manila; ADB. 2014. *Documents for Regional Power Trade and Interconnection in the GMS*. Manila; GMS country presentations. 19th RPTCC meeting. Bangkok.

Under construction	<ul style="list-style-type: none"> (i) Hongsā–Maemoh, 500 kV (COD 2015) (ii) Ban Lak 25–Ubon 3, 500 kV (COD 2018) (iii) Xayabuly–Loei 2, 500 kV (COD 2019) 	<ul style="list-style-type: none"> (i) Paklay–Thali, 115 kV (COD 2016)
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Lao PDR– Viet Nam	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing	<ul style="list-style-type: none"> • 1 link of 220 kV line (i) Sekaman 3 (Sekong)–Thanh My (EVN) 	<ul style="list-style-type: none"> • 6 links of 22/35 kV lines (i) Moung Kua (Phonsaly)–DianBian (EVN, PC1) (ii) Pahang (Huaphanh)–Mokchao (EVN, PC1) (iii) Dansavan (Savannakhet)–Laobao (EVN, PC3) (iv) Dakchung (Sekong)–DakOc (EVN, PC3) (v) Samouay (Saravane)–Are Ngor (EVN, PC3) (vi) Vangtut Mining (Attapeu)–(EVN, PC3) (vii) Adeus (Sekong)–(EVN, PC3)
Under construction	<ul style="list-style-type: none"> • 1 link of 220 kV line (i) Sekaman 1–Pleiku, 220 kV (COD 2016) 	
Planned	<ul style="list-style-type: none"> • 1 link of 500 kV line (i) Luang Prabang–Nho Quan (after 2020) • 1 link of 220 kV line (i) Nam Mo–Ban Ve, 220 kV (in negotiation) (after 2020) 	

Lao PDR– PRC	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing		<ul style="list-style-type: none"> • 1 link of 115 kV line (i) Na Mo (Oudomxai)–La District • 3 links of 22/35 kV lines (i) Pangthong (Sing District)–Mang District (ii) Boten Dankham–Bohan (iii) Ngot Ou (Phonsaly)–Jang xeun District
Planned	<ul style="list-style-type: none"> • 1 link of 500 kV line (i) Na Mo–Ban Na, 500 kV (study) 	

Lao PDR– Cambodia	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing		<ul style="list-style-type: none"> • 2 links of 22 kV lines Ban Hat–Kampong Sralau (EDC) (i) Ban Hat–Chiang Teng (EDC)
Planned	<ul style="list-style-type: none"> • 1 link of 230 kV line (i) Ban Hat–Stung Treng (2017–2018) 	

Viet Nam– Cambodia	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing	<ul style="list-style-type: none"> • 1 link of 220 kV line (i) Chau Doc–Takeo 	<ul style="list-style-type: none"> • 19 links of 22/35 kV lines
Planned	<ul style="list-style-type: none"> • 1 link of 220 kV line (i) Stung Treng–Tay Ninh 	<ul style="list-style-type: none"> • 3 links of 22/35 kV lines

Thailand– Cambodia	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing		<ul style="list-style-type: none"> • 1 link of 115 kV line • 7 links of 22 kV lines
Planned		<ul style="list-style-type: none"> • 7 links of 22/35 kV lines

PRC– Viet Nam	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing	<ul style="list-style-type: none"> • 2 links of 220 kV lines (i) Xinqiao–Lao Cai (double circuits) (ii) Malutang–Ha Giang 	<ul style="list-style-type: none"> • 3 links of 110 kV lines (i) Maomaotiao–Hà Giang (ii) Hekou–Lao Cai (iii) Fangcheng (Guangxi)–Mong Cai
Planned	<ul style="list-style-type: none"> • 1 link of 500 kV line (under study) 	

Myanmar– PRC	High-voltage connections (220 kV and above)	Medium- and low-voltage connections (115 kV and below)
Existing	<ul style="list-style-type: none"> • 1 link of 500 kV line (i) Dapein-1 HPP (240 MW)–Yunnan Province near Dehong, 500 kV, 120 km (2011) • 1 link of 220 kV line (i) Shewli-1 HPP (600 MW)–Dehong (Yunnan), 220 kV, 2x120 km (2008) 	

COD = commercial operations date, EDC = Electricité du Cambodge, EGAT = Electricity Generating Authority of Thailand, EVN = Vietnam Electricity, km = kilometer, kV = kilovolt, Lao PDR = Lao People's Democratic Republic, MW = megawatt, PEA = Provincial Electricity Authority, PRC = People's Republic of China.

Source: ADB compilation.

22. As a result, power trade flows between the GMS countries as follows: (i) Cambodia has been importing from the Lao PDR (south) since 2010, Thailand since 2009, and Viet Nam (south) since 2008; (ii) the Lao PDR (north) has been importing from Thailand since late 1990s and the Yunnan Province since 2009; (iii) Thailand has been importing from the Lao PDR since 1971; (iv) Viet Nam (north) has been importing from the Yunnan Province since 2004; and (v) the Yunnan Province has been importing from Myanmar since 2008. Table 8 shows the exchanges of electricity within

Table 8: Exchanges of Electricity within the GMS in 2010 and 2014
(GWh)

2010						
To	From	Lao PDR	Myanmar	PRC	Thailand	Viet Nam
Cambodia		6.6			385	1,155
Lao PDR		–		112.5	1,042	163
Myanmar			–			
PRC			1,720	–		
Thailand		6,938			–	
Viet Nam				5,599		–

2014						
To	From	Lao PDR	Myanmar	PRC	Thailand	Viet Nam
Cambodia		13.77			396	1,219
Lao PDR		–		221	1,286	35
Myanmar			–			
PRC			1,496	–		
Thailand		11,936			–	
Viet Nam		small		1,976		–

– = not applicable, GWh = gigawatt-hour, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.

Source: ADB compilation and estimates.

the GMS in 2010 and 2014. In 2010, the main exchanges were between the PRC and Viet Nam and between the Lao PDR and Thailand. The total volume of transfers has increased from 17.1 TWh in 2010 to 18.6 TWh in 2014. There is a fall in the PRC–Viet Nam trade, whereas the Lao PDR–Thailand trade has now become dominant.

23. Table 9 summarizes the tariffs that governed the exchanges in 2010 and 2014. There is some sign that tariffs have converged, but comparison is difficult as there are often several tariffs between a pair of countries depending on voltage; the tariffs are generally time-of-use or two-part and average tariffs depend on volume.

Table 9: Tariffs for Exchange 2010 and 2014
(US cents/kWh)

2010						
To	From	Lao PDR	Myanmar	PRC	Thailand	Viet Nam
Cambodia		7.02			10.29	6.14
Lao PDR		–		115 kV 6.21 35 kV 9.39	6.20	6.00
Myanmar			–			
PRC			...	–		
Thailand		4.80			–	
Viet Nam				5.10		–
2014						
To	From	Lao PDR	Myanmar	PRC	Thailand	Viet Nam
Cambodia		9.05			variable	8.35
Lao PDR		–		115 kV 6.66 35 kV 8.56	115 kV 4.14 22 kV 11.62	7.67
Myanmar			–			
PRC			3.32	–		
Thailand		3.56			–	
Viet Nam				6.28		–

... = not available, – = not applicable, GWh = gigawatt-hour, kV = kilovolt, kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.

Source: ADB compilation and estimates.

D. Core Sector Issues, Causes, and Effects

24. **Core sector issues.** The key sector issue is to ensure adequate supplies of affordable energy as the basis for future economic growth without negatively affecting environment and social impacts. The security of supply is a growing concern, particularly in Thailand where there is considerable popular opposition to greater use of coal and lignite and where the development plan places a heavy emphasis on imported natural gas. Viet Nam faces similar but less problems as it proposes to rely heavily on imported coal that is more widely available. Most countries except the PRC are vulnerable to interruptions in the supply and price of crude oil and products because local production is minimal, and they have little influence over producers and supply routes. In the case of electricity, it is also necessary to ensure adequate investment in generating capacity and transmission.

25. For energy security, therefore, fuel must be sourced; physical assets created; and energy produced, minimizing adverse impact to the environment and people. In this aspect, effective integration of regional power systems and facilitation of power trade have major potential benefits. Integration reduces capital expenditure, by allowing the pooling of plants and flattening of a combined peak load; it reduces operating costs by driving systems to lower marginal costs through economic dispatch; and it allows large volumes of renewable energy to be redistributed over integrated systems and so reduces the overall cost of intermittency. In the longer term, integration promotes competition and therefore improves operational efficiency of the interconnected power system.

26. **Critical elements of infrastructure are missing.** Despite such benefits, there is in reality limited connectivity in the power systems of the GMS; most of the high-voltage transmission lines are simply power lines that run from power stations in host countries to substations in importing countries. The grid of the importing country is effectively expanded on to foreign territory. In this case, the intervening transmission line cannot be used for third-party access, and in some cases the power purchase agreements (PPAs) forbid third-party access. A consequence of this form of development is that the transmission line makes relatively little contribution to the national grid of the host country. However, the transmission investments actually can change the dynamics of the power exchange and trade in the region. In particular, the creation of a 500 kV backbone in the Lao PDR as well as interconnections with the systems of Thailand and Viet Nam would enable the Lao PDR to offer power from a favorable hydro site to a wider variety of prospective buyers and obtain a better price. Furthermore, most of the GMS cross-border transmission, high-voltage direct current interconnection technologies can be considered, which will allow each country to easily protect its own power system as necessary and to significantly reduce the cost of interconnections.

27. **The regulation of national markets is not supportive.** The regulation of national markets has to meet minimum requirements and uniformity if an integrated system is to operate properly. The basic requirements are: all countries should permit third-party access under nondiscriminatory, transparent rules; there must be a published list of use-of-system charges; and there should be clear procedures for handling congestion and disputes. However, even the minimum requirements are not met at present. Furthermore, IPPs can be an obstacle to all forms of regional trade if they have exclusive rights over transmission lines. Where the IPPs also have long-term PPAs with a single buyer lock-in, this can impede any form of competition that seeks to permit users to buy directly from generators.

II Sector Strategy

A. Government Sector Strategy, Policy, and Plans

28. **National power development plans.** All GMS countries have power system development plans, but the level of detail and the quality are very variable. Myanmar has recently completed its first power master plan study using the least-cost approach. Cambodia and the Lao PDR published their power development plans but with little indication of the underlying assumptions and power development planning process. Thailand has regularly updated a detailed power development plan. Viet Nam has a periodic power development planning process and includes a fairly detailed summary of intentions as part of the government decision that implements the plan. The PRC does not have such a plan. The government sets targets on generation capacity requirements from different technologies and then it is up to the provincial governments and state-owned enterprises in the energy sector to plan for investments. A summary status of national power plans is provided in Table 10.

29. **National policies for energy efficiency.** Performance across the GMS in energy efficiency is variable. The PRC has a very comprehensive program for energy efficiency improvement specially targeting large energy-consuming enterprises. The provinces have been set targets to reduce energy intensity of the GDP and energy intensity in industrial sector, and specific targets have been set for per unit energy consumption of energy-intensive industrial sectors. The obsolete and inefficient industrial plants are required to be phased out and provincial governments are mandated to meet these requirements. Thailand has engaged with energy efficiency program since 1992 with a supporting law, fund, and voluntary standards. Viet Nam is now initiating a comprehensive approach with a new law, reasonably demanding targets, and some appropriate instruments. In general, enforcement appears to remain a challenge; regulations on audits, reporting, and standards require enforcement, which are administratively demanding. For the rest of the GMS countries, there is only minimal effort comprising isolated projects driven largely by donor engagement. Table 11 summarizes the status.

30. **National policies for renewable energy.** In most countries, the commitment to renewable energy is modest except in the PRC and Thailand. The PRC has set a target to increase the share of nonfossil energy, including hydro and nuclear, in primary energy to 20% by 2020 and 30% by 2030 and set targets for installed capacity of different renewable energy technologies. These targets have also been set for the provinces and there are feed-in tariffs to encourage renewable energy investments. In Thailand, there is a long history of promoting renewable energy, a substantial planning effort with stretch targets, and a series of interventions that partially support the intent. Viet Nam is investing in grid-connected wind farms and planning to expand to solar power development. In Cambodia and the Lao PDR, renewable energy is seen largely as a possible component of off-grid electrification; there is little attempt to incorporate large volumes into the national energy supply. Myanmar is considering renewable energy both for off-grid electrification and grid-connected power generation. The effectiveness of the policy has been limited by several alterations of policy and withdrawal of incentives. Table 12 summarizes the situation.

Table 10: Summary of the Status of Power System Planning

	Status and Process	Cross-Border Interconnections	Private Participation
Cambodia	Previous Power Development Master Plan established in 2006. A systematic approach for demand forecasting and energy system analysis is being applied to update the master plan.	Cambodia imports power from Viet Nam and Thailand.	This is significant both for large-scale and small-scale generation.
Lao PDR	A list of projects in construction and at various stages of planning is available, but there is no indication of systematic planning underlying the selection of projects.	Many cross-border connections are planned mainly for the export of power to Thailand and Viet Nam.	Very strong in generation and potentially will enter transmission. Mainly investors with an interest in importing power.
Myanmar	National Electricity Master Plan study completed. A schedule of intended projects is available.	Links to the PRC exist. Very large new interconnections were proposed earlier, but those to Thailand seem to be in abeyance and those to the PRC have not progressed.	Many private finance projects were proposed by investors with an interest in importing power; their present status is uncertain. BOTs permitted under new legislation.
PRC (Guangxi and Yunnan)	No power system expansion plan is publicly available.	Some links with Myanmar; others are foreseen but uncertain. An HVDC connection with Thailand has been delayed. There are several small links to Viet Nam.	Some private participation in IPPs, mostly domestic and in large part from corporatized subsidiaries of the SOEs.
Thailand	A detailed and regularly updated power system expansion plan is easily available.	There are strong connections with the Lao PDR and several planned cross-border connections with Cambodia. Connection plans with the PRC have lapsed, and are under consideration with Myanmar.	IPPs are a significant part of the expansion plan owned by local investors.
Viet Nam	A PDP is prepared, regularly updated, and a summary is published as a decree.	There are several lines to the PRC; greater connectivity to Cambodia is likely.	Private finance was successful in the early 2000s but dried up since then. Reforms have been made.

BOT = build-operate-transfer, HVDC = high-voltage direct current, IPP = independent power producer, Lao PDR = Lao People's Democratic Republic, PDP = power development plan, PPP = public-private partnership, PRC = People's Republic of China, SOE = state-owned enterprise.
Source: ADB compilation.

Table 11: Summary of the Status of Energy Efficiency Policy

	Energy Conservation Law	Strategy and Targets	Energy Conservation Fund	Standards and Labels
Cambodia	None	None	None	None
Lao PDR ^a	None	None	None	None
Myanmar ^b	EE&C Act being drafted	Yes. Energy consumption reduction targets set as 12% by 2020, 16% by 2025, and 20% by 2030 (base year 2012).	None	Air conditioner MEPS being prepared
PRC (Guangxi and Yunnan)	Yes. From 1997.	Yes. Set out in Five-year plans	Included in the original law	Yes. Many MEPS and labels
Thailand	Since 1992	Yes. Detailed strategy and 25% saving target	ENCON Fund financed from a tax on fuels	Voluntary labels since 1994 Mandatory standards being implemented
Viet Nam	Law agreed upon in 2010	Yes. Objective is to save 8% by 2015	No. Present in early drafts of the law but removed	Law provides for standards and labeling being implemented according to law and regulations (decree, circular)

EE&C = energy efficiency and conservation, ENCON Fund = Energy Conservation Promotion Fund, Lao PDR = Lao People's Democratic Republic; MEPS = minimum energy performance standards, PRC = People's Republic of China.

^a The draft national policy for energy efficiency and conservation in the Lao PDR has been prepared under ADB-financed project (G0195-LAO: GMS Northern Power transmission Project).

^b The national energy efficiency and conservation policy, strategy and roadmap was prepared under ADB-financed project (TA 8356-MYA: Institutional Strengthening of National Energy Management Committee in Energy Policy and Planning) and approved by the government of Myanmar in February 2016.

Source: ADB compilation.

Table 12: Summary Status for Renewable Energy

	Renewable Energy Law and Policy	Targets	Feed-In Tariff or Other Incentives
Cambodia	No law. The REAP was conceived as a supplement to rural electrification.	Yes. 20% by 2020.	No.
Lao PDR	No law. There is a national strategy to 2025.	Yes. 30% by 2025.	Discussed but not in place.
Myanmar	General provisions in National Energy Policy.	No.	Discussed but not in place.
PRC (Guangxi and Yunnan)	Well-designed law and subsequent regulation.	Yes.	Yes. For wind and solar energy.
Thailand	No law. Detailed strategy.	Yes. 20% by 2020.	Yes. A well-designed feed-in tariff differentiated by technology and scale plus other support.
Viet Nam	No law. Most recent strategy is for 2020 outlook to 2050.	Yes. 4.5% in 2020.	Yes, but tariffs are assessed to be low. Revision of tariff under consideration.

Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China, REAP = renewable energy action plan.

Source: ADB compilation.

B. Regional Sector Strategy, Policy, and Plans

31. The Subregional Energy Sector Study, the earliest energy study with a GMS-wide focus, was initiated in 1993 with ADB assistance and completed in November 1994.¹⁷ A first Regional Master Plan for Interconnection in the GMS was prepared in 2002 under ADB's TA.¹⁸ The report addressed directly the key needs for a genuinely integrated power system—that is, the construction of synchronous links between the two large grids in Thailand and Viet Nam, the incorporation of the Lao PDR as a main supplier, the absorption of Cambodia in the system, and finally building out toward Myanmar.

32. Following the preparation of the master plan, an intergovernmental agreement on Regional Power Trade in the GMS was signed on the occasion of the First GMS Summit on 3 December 2002. The intergovernmental agreement confirmed the commitment of the GMS member countries to advance power trade and harmonize development of their power systems based on the principles of cooperation, gradualism, and environmental sustainability; it also established a Regional Power Trade Coordination Committee (RPTCC) with the specific responsibility to elaborate the rules that should govern regional trade in electricity. The RPTCC has since met one to two times a year; responsibility for organizing meetings rotates among the member states.

33. At the request of the GMS countries, ADB supported the preparation of the Regional Power Trade Operating Agreement for the GMS, with the work being monitored by the RPTCC. A final report on the design of the Regional Power Trade Operating Agreement was submitted in October 2004.¹⁹ The report proposed a gradual approach through four successive stages:

- (i) Stage 1: Bilateral cross-border connections through PPAs;
- (ii) Stage 2: Grid-to-grid power trading between any pair of GMS countries, eventually using transmission facilities of a third regional country;
- (iii) Stage 3: Development of transmission links dedicated to cross-border trading; and
- (iv) Stage 4: Most of the GMS countries have moved to multiple sellers–buyers regulatory frameworks, so a wholly competitive regional market can be implemented.

34. Based upon this proposal, a memorandum of understanding (MOU) on the Guidelines for the Implementation of the Regional Power Trade Operating Agreement Stage 1 was signed on 5 July 2005 by the ministers of energy of the six GMS countries. The second MOU on the Road Map for Implementing the GMS Cross-Border Trading was prepared and signed in March 2008 by the GMS ministers of energy. This MOU was designated MOU-2 and the MOU from 2005 became MOU-1. The road map, which is attached to MOU-2, covers the period (2008–2012) intended to implement Stage 1 of the regional power trading and to prepare for Stage 2.

35. The expectations of the road map were largely met, mainly as a consequence of the regional master plan study supported for the period 2009–2025, focusing particularly on the cross-border connections.²⁰ The analysis concludes that new interconnections should be developed along the following three main poles:

- (i) A North–West pole connecting the PRC, Myanmar, and Thailand to replace coal and gas-fired power generation in the PRC and Thailand by hydro power from Myanmar (about 26,000 MW).

¹⁷ ADB. 1995. *Subregional Energy Sector Study for the Greater Mekong Subregion*. Prepared by Norconsult.

¹⁸ ADB. 2002. *Indicative Master Plan on Power Interconnection in GMS Countries*. TA 5920. Manila.

¹⁹ ADB. 2004. *Regional Power Trade Operating Agreement-General Design, Final Report: Study for a Regional Power Trade Operating Agreement in the Greater Mekong Sub-Region*. Manila.

²⁰ ADB. 2007. *Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the Greater Mekong Subregion*. Manila.

- (ii) An East–West pole to connect Thailand, northern Lao PDR, and northern Viet Nam to substitute Lao hydro for thermal generation (about 4,500 MW).
- (iii) A Southern pole to connect southern Lao PDR to central Viet Nam, and to a lesser extent, Cambodia and southern Viet Nam to strengthen supply in these regions and to displace coal and possibly some gas-fired plants (about 1,100 MW).

36. The absence of a permanent secretariat under the RPTCC to follow-up and monitor activities was a significant constraint on progress. To address this issue, the concept of a Regional Power Coordination Center (RPCC) was developed. An intergovernmental MOU to establish the RPCC was signed by all GMS countries at the 19th GMS Ministerial Meeting in December 2013; it explicitly states that the signatories are convinced of the need to synchronize power system operation and harmonize the regulatory framework.

37. In parallel, two working groups of the RPTCC were established. Terms of reference for the working groups were agreed at the 12th Meeting of the RPTCC in March 2012. The working group on regulatory issues is to ensure compatibility in the technical operations of national power systems and the functioning of new financial mechanisms at the regional level. The working group on performance standards and grid codes is to establish performance standards and grid codes and implement common standards for operational security, reliability, and the quality of supply of the GMS interconnected system; to encourage an integrated planning of power system expansion; and to ensure nondiscriminatory access to the interconnected system for users. The creation of the two working groups is an interim measure prior to the establishment of the RPCC, and their functions will eventually be absorbed within the RPCC.

38. The GMS members have also extended cooperation to a wider spectrum of energy activities beyond power sector cooperation. The Subregional Energy Forum (SEF) was created in 2004, following a request from the GMS members to extend the scope of cooperation in the energy sector. In this regard, a Road Map for Expanded Energy Cooperation was prepared and presented to the SEF-2 in Ho Chi Minh City in November 2008. Subsequently, the road map was finalized at a special SEF meeting in Bangkok in March 2009 and was then endorsed at the 15th GMS Ministerial Meeting held in Thailand in June 2009. The road map identifies four main strategic objectives in the energy sector up to 2022:

- (i) Enhance access to energy for all sectors and communities, particularly the poor in the GMS, through promotion of best energy practices in the subregion;
- (ii) Develop and utilize more efficiently indigenous, low carbon, and renewable resources, while reducing the subregion's dependence on imported fossil fuels;
- (iii) Improve energy supply security through cross-border trade while optimizing the use of subregional energy resources; and
- (iv) Promote public–private partnerships and private sector participation, particularly through small and medium-sized enterprises for subregional energy development.

C. ADB's Sector Support Program and Experience

39. **ADB program to date.** ADB has provided extensive support to regional cooperation and national programs in the energy sector in the GMS. ADB has contributed to financing various key infrastructure projects and promoting an adequate institutional framework for regional power trade through the RPTCC. Lending projects have been implemented through sovereign loans to the affected countries. Table 13 provides a summary of the most significant loans.

Table 13: ADB-Financed Lending Projects of GMS Significance

Project Title	Project Description
<p>1. Loan 846/1063-LAO: Xeset Hydropower Project (sovereign loan)</p> <ul style="list-style-type: none"> • ADB-approved financing: \$15.5 million • Period: 25 February 1988 to 30 June 1992 • Executing agency: Electricité du Laos 	<p>The Xeset hydropower plant (45 MW), run-of-river dam, has exported 40% of the generated power to Thailand and used the rest for domestic consumption.</p>
<p>2. Loan 1214-LAO: Nam Song Hydropower Development Project (sovereign loan)</p> <ul style="list-style-type: none"> • ADB-approved financing: \$31.5 million • Period: 13 April 1993 to 21 April 1997 • Executing agency: Electricité du Laos 	<p>A concrete weir 21 m in height was constructed on the Nam Song river to divert water into the existing Nam Ngum reservoir to generate additional 137 GWh power at Nam Ngum power plant for export to Thailand. In addition, three local villages were electrified.</p>
<p>3. Loan 1329-LAO: Theun-Hinboun Hydropower Project (sovereign loan)</p> <ul style="list-style-type: none"> • ADB-approved financing: \$60 million • Period: 8 November 1994 to 14 October 1998 • Executing agency: Theun-Hinboun Power Company Limited 	<p>The Lao PDR's first joint venture hydropower project with the private sector supports the country's economic growth by increasing foreign exchange earnings through export of electricity to Thailand. It entailed the construction of a 210 MW hydropower plant and related power transmission line to Thailand.</p>
<p>4. Loan 1456-LAO: Nam Leuk Hydropower Project (sovereign loan)</p> <ul style="list-style-type: none"> • ADB-approved financing: \$52 million • Period: 10 September 1996 to 13 March 2003 • Executing agency: Electricité du Laos 	<p>The Nam Leuk hydropower plant (60 MW) exported its total capacity to Thailand until the electricity produced was needed for domestic use in 2007. Since then, all generated electricity has been used for domestic consumption.</p>
<p>5. Loan 2052-CAM: GMS Transmission Project (sovereign loan)</p> <ul style="list-style-type: none"> • ADB-approved financing: \$44.3 million • Period: 15 December 2003 to 31 December 2010 • Executing agency: Electricité du Cambodge 	<p>The construction of a 109 km, 230kV transmission line, associated substations and distribution facilities from the Vietnamese border to Phnom Penh allows Electricité du Cambodge to import up to 200 MW capacity power from Viet Nam.</p>
<p>6. Loan 2162-LAO: Nam Theun 2 Hydroelectric Project (sovereign loan)</p> <ul style="list-style-type: none"> • ADB financing: \$20 million • Period: 4 April 2005 to 2 February 2011 • Executing agency: Lao Holding State Enterprise <p>Loan 7210-LAO (nonsovereign loan)</p> <ul style="list-style-type: none"> • ADB financing: \$50 million • Period: 4 April 2005 to 3 October 2010 • Executing agency: Nam Theun 2 Power Company Limited <p>Political Risk Guarantee</p> <ul style="list-style-type: none"> • ADB financing: \$50 million • Period: 4 April 2005 to 3 October 2010 • Executing agency: Nam Theun 2 Power Company Limited 	<p>Nam Theun 2 hydropower plant (1,070 MW) generates revenues by exporting 1,000 MW power to Thailand to finance poverty reduction and environmental programs in the Lao PDR and by supplying 70 MW power for domestic use.</p>

continued on next page

Table 13 *continued*

Project Title	Project Description
<p>7. Loan 2818/2819-LAO: Greater Mekong Subregion Nam Ngum 3 Hydropower Project (sovereign loan)</p> <ul style="list-style-type: none"> • ADB financing: \$115.1 million • Period: It was approved in November 2011 but cancelled in November 2013 • Executing agency: Lao Holding State Enterprise <p>Loan 7341-LAO (nonsovereign loan)</p> <ul style="list-style-type: none"> • ADB financing: \$350 million • Period: It was approved in November 2011 but cancelled in January 2013 • Executing agency: Nam Ngum 3 Hydropower Company 	<p>Nam Ngum 3 hydropower plant (440 MW) was planned to be developed for export to Thailand. However, tariff negotiations with Electricity Generating Authority of Thailand prolonged longer than anticipated. As a result, the government decided not to develop the project and consequently, the approved loan was cancelled.</p>
<p>8. Loan 3153/3154-LAO: Nam Ngiep 1 Hydropower Project (nonsovereign loan)</p> <ul style="list-style-type: none"> • ADB financing: \$144 million • Period: It was approved in August 2014. The implementation is envisaged until January 2019 • Executing agency: Nam Ngiep 1 Power Company Limited 	<p>Nam Ngiep 1 hydropower plan (290 MW) will be constructed: 272 MW for export to Thailand and 18 MW for domestic use. A 125 km, 230 kV transmission line will also be constructed to connect the power station to the Nabong substation near Vientiane.</p>
<p>9. G0195-LAO: GMS Northern Power transmission Project</p> <ul style="list-style-type: none"> • ADB financing: \$20 million • Period: 23 November 2010 to 30 June 2016 • Executing agency: Electricité du Laos 	<p>The project aims to (i) construct 398 km of 115 kV transmission line with associated 115/22 kV substation and about 1,100 km of 22 kV new feeders; (ii) provide no-interest credit for power to poor households; (iii) provide consulting services for supporting energy efficiency and conservation program; and (iv) increase access to two-way power trade between the Lao PDR and Thailand.</p>

ADB = Asian Development Bank, km = kilometer, kV = kilovolt, Lao PDR = Lao People's Democratic Republic, m = meter, MW = megawatt.

Source: ADB compilation.

40. ADB has provided a total of eight regional TA projects amounting to \$10.4 million to improve understanding of the benefits and issues related to regional power trade and cross-border interconnection, to establish relevant institutions including RPTCC, and to conduct feasibility studies for specific potential projects of high priority. Among others, ADB has supported key regional studies including a GMS energy sector study (1995) (footnote 17), GMS regional interconnection study (2002) (footnote 18), GMS regional master plan (2010),²¹ GMS energy sector assessment (2013),²² and institutional development required for regional power trade.²³ ADB also assisted GMS countries in sustainable power sector development by understanding the potential of renewable energy and energy efficiency in the region,²⁴ and applying a strategic environmental assessment in

²¹ ADB. 2010. *Update of the GMS Regional Master Plan—Main Report*. TA 6440. Manila.

²² ADB. 2013. *Assessment of the GMS Energy Sector: Progress, Prospects and Regional Investment Priorities*. Manila.

²³ ADB. 2012. *Greater Mekong Subregion Power Trade and Interconnection: Two Decades of Cooperation*. Manila; ADB. 2014. *Documents for Regional Power Trade and Interconnection in the GMS*. Manila.

²⁴ ADB. 2010. *Promoting Renewable Energy, Clean Fuels, and Energy Efficiency in the Greater Mekong Subregion*. Manila.

power development planning.²⁵ ADB will continue to be a critical partner in achieving the objectives of energy cooperation in the GMS countries.

D. Other Development Partner Support

41. The World Bank has financed several important interventions, particularly concerning the workings of the interconnected power market infrastructure, including regional studies on power trade strategy (1999) and GMS power trade market structure (2006).²⁶ The World Bank also participated in the financing of Nam Thuen 2 and in the implementation of monitoring and reporting procedures. In 2007, the World Bank under its GMS Power Trade Project financed the construction of the cross-border, 115 kV transmission line linking the Lao PDR (Ban Hat) and Cambodia (Stung Treng).²⁷

42. The Government of France supported the river basin study for Se Kong-Se San and Nam Theun River in Cambodia, the Lao PDR, and Viet Nam amounting to \$2 million in 1996. The Government of Norway cofinanced ADB's TA project on regional indicative master plan on power interconnection in the GMS amounting to \$750,000 in 2000. The Swedish International Development Cooperation Agency provided \$5 million in cofinancing to ADB's TA project to support the update of the regional master plan for interconnection in 2007. The Agence Française de Développement participated in the financing of Nam Thuen 2 and in the implementation of monitoring and reporting procedures and provided cofinancing of \$1.2 million to develop the GMS energy sector strategy in 2006. Subsequently, Agence Française de Développement and ADB signed a cofinancing agreement on 14 December 2011, providing €2 million for implementing the strategic environmental assessment in the power sector in two phases.

E. Lessons Learned

43. ADB has been assisting GMS countries to achieve a common vision of integrated grid operations and regional power market development following the four successive steps. Until now, GMS countries have reached Stage 1 where bilateral trade has been made and are moving to Stage 2 and beyond. At this stage, the institutional setup is critical as strong coordination in planning and grid operation is required to optimize the use of resources on multiple systems to meet the load on the interconnected systems. Particularly related to third-party access to the grid and wheeling obligation, a pricing and regulatory environment must be established. In this regard, a major decision was made in December 2013 when all GMS countries signed the intergovernmental MOU for establishment of the RPCC, which will be governed by RPTCC.

44. The progress of GMS countries to Stage 2 has been slow. This is partly due to the fact that proper operation of regional power trade market requires surplus generation and reliable transmission so that the exchange of electricity between participants can be optimized. In the GMS, only a few countries have such surplus generation and most of the countries lack supply and have relatively weak grid systems. In addition, generation is open to the private sector through IPP but through PPAs with a single buyer and not through competitive market. In terms of market structure, therefore, GMS countries have not been ready to proceed to the regional market operation. Furthermore, there is a

²⁵ ADB. 2010. *Ensuring Sustainability of Greater Mekong Subregion Regional Power Development*. Manila.

²⁶ World Bank. 2006. *Options for the Structure of the GMS Power Trade Market: A First Overview of Issues and Possible Options*. ESMAP Technical Paper 108/06. Washington.

²⁷ The Government of Cambodia requested cancellation of the grant in 2011 and subsequently, the scope of work in the Lao PDR was reduced.

lack of a systematic approach in examining and substantiating the benefits of regional power trade and cross-border interconnection within national policies and plans in terms of achieving lower prices, more secure supplies, less environmental and social adverse impacts, more jobs, and greater competitiveness. Lessons drawn from successful regional power trade initiatives in Europe confirm that a systematic approach (i.e., common analytical frame) is needed to substantiate the benefits of regional power trade, prioritize investments in generation and transmission resources, identify opportunities for mutually beneficial power exchange, and compute available transmission capacity and wheeling charges.

45. The outlook for regional power trade and regional grid integration, however, becomes much brighter in the forthcoming years. First, RPCC will be operationalized once the hosting country is determined. This institution will have a legal identity owned by six GMS countries and be fully dedicated to managing cross-border power infrastructure interconnection and trade in the GMS. Second, generation surplus of the region is growing particularly in the Lao PDR due to its export strategy and in the PRC due to slowdown of economic growth. Third, Viet Nam, which is now the second largest and the fastest growing country in terms of electricity demand in the GMS, is now establishing a wholesale market which will allow generators to bid and sell their electricity through the market. It will create investment opportunities not only within Viet Nam but also in other countries that can compete on costs with imported coal generation such as hydropower. Fourth and last, GMS countries' grid systems are getting stronger, and low-cost and efficient grid interconnection technologies such as high-voltage direct current are available and commonly used for interconnection in Europe and North America. Yet, there will still be challenges, especially building technical skills and critical infrastructure, connecting different power systems, and establishing common analytical framework for coordinated regional planning in the GMS.

F. ADB's Sector Forward Strategy

46. **GMS Strategic Framework (2012–2022).** The GMS Strategic Framework has established broad guidelines for the development of the GMS over the next decade.²⁸ In summary, they are as follows:

- (i) A shift from hardware to software—that is, from infrastructure to policy and institutional development—and an increased emphasis more broadly on knowledge generation and management related to program initiatives and cross-country coordination.
- (ii) Less emphasis on information sharing and a greater focus on decision-making on issues that are clearly regional in nature. This should lead to more tangible results and greater impact.
- (iii) More clarity on which regional issues should be covered by the GMS Program and which are better left to other regional organizations.
- (iv) More attention on the linkages across different sectors (e.g., between energy, agriculture, and food security, and the environment), and recognize climate change as a broader development issue as well as an environment issue.

47. For the energy sector, the strategic framework identifies the following four priorities: (i) promoting environmentally sustainable regional power trade planning, coordination, and development; (ii) improving energy efficiency through demand-side management and energy conservation; (iii) promoting the development of renewable energy resources and clean fuels such as compressed natural gas; and (iv) promoting a policy framework for facilitating renewable energy development and energy efficiency.

²⁸ ADB. 2011. *The Greater Mekong Subregion Economic Cooperation Program Strategic Framework, 2012–2022*. Manila.

48. **Regional Investment Framework Pipeline of Potential Projects (2013–2022).** The Regional Investment Framework for 2013–2022, endorsed by ministers at the 19th GMS Ministerial Conference held in Vientiane in 2013, consists of a pipeline of investment and TA projects following the strategic directions of the GMS.²⁹ Projects from the Regional Investment Framework were further prioritized for implementation in the near to medium term period of 2014–2018 at the 16th RPTCC meetings in Siem Reap, Cambodia, on 26 June 2014. The prioritized energy projects, which include 13 investment projects at \$3.2 billion and 8 TA projects at \$11.5 million, were approved by the GMS leaders at the 5th GMS Summit on 19–20 December 2014 in Bangkok, Thailand.³⁰ The summary of key priority projects is presented in Table 14.

Table 14: Investment Projects within the Regional Investment Framework, 2013–2022

Investment Projects	Concerned Countries	Priority Score of RPTCC	Cost (\$ million)
1. Lao PDR–Viet Nam Power Transmission Interconnection (Hatxan–Pleiku)	Lao PDR, Viet Nam	14	600–800
2. Nabong 500 kV Substation Transmission Facility Project	Lao PDR	14	278
3. PRC–Lao PDR–Thailand 600 kV Interconnection	PRC, Lao PDR, Thailand	12	50
4. Reinvestigation of Thailand–Lao PDR–Viet Nam Interconnection	Lao PDR, Thailand, Viet Nam	11	100
5. East–West Corridor Power Transmission and Distribution Project in the Lao PDR	Lao PDR	11	400
6. Continued Projects in Rural Electrification and Off-Grid Power Development	Cambodia, Lao PDR	10	60
7. Design and Funding of a Backbone Grid for the Lao PDR	Lao PDR	10	400–600
8. Conventional Rural Electrification Programs in Myanmar	Myanmar	10	10
9. Viet Nam–PRC 500 kV Power Interconnection	PRC, Viet Nam	9	250–400
10. Extension of Energy Access in Myanmar from Nodes in Thailand and in the PRC	Myanmar	9	640
11. Feasibility Study and Extension of the East–West Energy Corridor (EWEC) to Mawlamyine (as part of a concerted and planned extension of the EWEC): Myanmar	Myanmar, Thailand	9	80
12. 500 kV Line from Mawlamyine to the Main Grid	Myanmar	7	
13. Demonstration of Second–Generation Biofuel Technologies and Associated Biomass Value Chains	All GMS countries	6	

kV = kilovolt, Lao PDR = Lao People’s Democratic Republic, PRC = People’s Republic of China, RPTCC = Regional Power Trade Coordination Committee.

Source: ADB compilation.

²⁹ ADB. 2013. *Regional Investment Framework Pipeline of Potential Projects (2013–2022)*. Manila.

³⁰ ADB. 2014. *Greater Mekong Subregion Regional Investment Framework Implementation Plan (2014–2018)*. Manila.

49. Among the investment projects, the first two projects are underway. The interconnection project between Hatxan in the Lao PDR and Pleiku in Viet Nam has been changed to the 220 kV interconnection from Xekaman 1 power plant in the Lao PDR to Pleiku in Viet Nam. The private developer of Xekaman 1 power plant is constructing the interconnection link on the Lao PDR side and the Viet Nam Electricity National Power Transmission is constructing the interconnection link on the Viet Nam side. This cross-border interconnection is scheduled to be energized in March 2016. An alternative to the Nabong 500 kV Substation Transmission Facility Project is planned to be financed by ADB's Private Sector Operations Department with the Japan Bank for International Cooperation and four Thai commercial banks.

50. The investment projects are largely based on the following three opportunities.³¹ First, cross-border interconnections of adjacent border regions due to the cost-effectiveness of sourcing power from nearby generating plants across the border rather than sourcing and transmitting electricity from nationally owned but remotely located power supply systems. In this context, the low-voltage, cross-border interconnection projects are pursued for rural electrification in the GMS countries. Second, interconnections arising from differences in natural resource endowments, which are evident in the economic evacuation of power from hydro-resource-rich countries to other GMS countries with high electricity demand. Third, interconnections arising from differences in peak load profiles, through synchronous operation of power systems, which allows generation capacities to be shared to meet different peak loads in different load centers. In this context, three main regional integrated grid systems were identified in the regional master plan, namely (i) a north-west pole connecting the PRC, Myanmar, and Thailand; (ii) an east-west pole to connect Thailand, northern Lao PDR, and northern Viet Nam; and (iii) a southern pole to connect southern Lao PDR to central Viet Nam, and to Cambodia and southern Viet Nam.

51. Among the TA projects, the first two projects are in progress with ADB assistance. These projects aim to, among others, (i) strengthen the institutional development and capacity building for regional power trade and cross-border interconnections that are coherent with the directions under the GMS's strategic framework and (ii) improve sustainability of power sector development through applying an integrated resource planning with strategic environmental assessment and promoting renewable energy and energy efficiency regional plans (see Table 15).

52. Going forward, ADB will continue to coordinate with other development partners and support the GMS countries in advancing their energy cooperation through TA projects and loans. For regional power trade and cross-border interconnection development, ADB will assist the GMS countries to reach Stage 2 by 2020. Necessary steps are presented in Table 16, which are modified from the road map for Implementing the GMS Cross-Border Trading to prepare Stage 2 contained within MOU 2. The essential inputs in the process will be (i) establishment of the RPCC as a center of expertise and project management, (ii) reassurance of the political mandate in the MOU that establishes the RPCC to synchronize power system operation and to harmonize the regulatory framework, and (iii) contribution of key elements of the infrastructure.

53. For extended energy cooperation through the SEF, ADB will assist the GMS countries to adopt specific, measurable targets for renewable energy and energy efficiency improvements over a precise period that can be monitored against a well-defined baseline and to develop the action plans defining clearly the public policy interventions. Through these activities, the achievement of national and regional targets can be monitored, and national standards can be harmonized under regional standards, which will accelerate the process of increasing the use of clean energy in the GMS countries.

³¹ ADB. 2012. *Greater Mekong Subregion Power Trade and Interconnection: Two Decades of Cooperation*. Manila.

Table 15: Technical Assistance Projects within the Regional Investment Framework, 2013–2022

Technical Assistance Projects	Concerned Countries	Priority Score of RPTCC	Cost (\$ million)
1. Harmonizing GMS Power Systems to Facilitate Regional Power Trade (formerly Support to RPTCC in Completion of Performance Standards, Grid Codes, Market Rules, and Subregional Transmission Expansion Plan)	All GMS countries	10	1.5
2. Integrated Resource Planning with Strategic Environmental Assessment for Sustainable Power Sector Development in the GMS (formerly Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the GMS, Phase 2)	All GMS countries	12	1.0
3. Development of GMS Coordination Center for Regional Power Trade	All GMS countries	10	3.0
4. Provision of Continuing Institutional Support for the Subregional Energy Forum	All GMS countries	10	1.0
5. GMS: Renewable Energy Development, Phase 2	All GMS countries	9	2.0
6. Deployment of Coherent Renewable Energy Action Plans Across the Subregion	All GMS countries	9	1.0
7. Development of Coherent Energy-Efficiency Action Plans Across the Subregion	All GMS countries	8	1.0

GMS = Greater Mekong Subregion, RPTCC = Regional Power Trade Coordination Committee.

Source: Asian Development Bank.

Table 16: Road Map for Implementing the GMS Cross-Border Trade to Achieve Stage 2

Milestone	Activities	Schedule
Study to identify the regulatory barriers to the development of power trade and implementation of Stage 2	Complete the study to identify the regulatory barriers to develop power trade and consider for adoption the measures and institutional arrangements to address regulatory barriers	2016
Study on a GMS Grid Code (operational procedures, performance standards, technical requirements, and regional planning)	Complete the study on a GMS grid code and consider for adoption the findings of the study, which include: <ul style="list-style-type: none"> (i) GMS performance standards (ii) Coordination procedures between system operators to schedule and control across border flows, management of deviations (iii) Metering and communications (iv) Process and analytical framework for coordinated regional planning (v) Sharing of power reserves and supporting during emergencies 	2017
Study on Stage 2 Transmission Regulations to allow third-party access in interconnections, with priority to contracts/PPAs, including Stage 2 power trade rules, and a Dispute Resolution Mechanism	Complete the study on Stage 2 transmission regulations and consider for adoption the findings of the study, which include: <ul style="list-style-type: none"> (i) Development of payment agreements/tariffs for third-party use, to compensate countries that host flows linked to third parties' trading (ii) Power trade rules for short-term cross-border trading (iii) Power trade rules for settlement of deviations to scheduled power trade in grid-to-grid interconnections 	Mid-2019
Final review of Stage 2 readiness	Complete necessary legal, regulatory, and operation procedures to launch Stage 2	September 2019
Launch of Stage 2	Grid-to-grid power trading between any pair of GMS countries using transmission facilities of a third regional country	January 2020

GMS = Greater Mekong Subregion, PPA = power purchase agreement; TPA = third-party access.

Source: ADB compilation.

III

Sector Road Map and Results Framework (2015–2020)

Subregion Sector Outcome		Subregion Sector Outputs		ADB Sector Operations	
Outcomes with ADB Contributions	Indicators with Targets and Baselines	Outputs with ADB Contributions	Indicators with Incremental Targets	Planned and Ongoing ADB Interventions	Main Outputs Expected from ADB Contributions
Improved energy security of GMS member countries in an environmentally sustainable manner	<p>21 TWh of cross-border trade by 2020 (2014 baseline: 18.6 TWh)</p> <p>Share of renewable energy in total energy consumption increased</p> <ul style="list-style-type: none"> • Cambodia: Renewable energy-related policy or law or target to be established • Lao PDR: 30% by 2020 (2013 baseline: 5%) • Myanmar: 15% by 2020 (2013 baseline: 5%) • PRC: 15% by 2020 (2010 baseline: 10%) • Thailand: 25% by 2021 (2013 baseline: 12%) • Viet Nam: 4.5% by 2020 (2010 baseline: 3.5%) <p>Energy efficiency improved^a</p> <ul style="list-style-type: none"> • Cambodia: Reduce final energy consumption by 10% by 2020 • Lao PDR: By 10% by 2020 • Myanmar: Reduce primary energy consumption by 5% by 2020 	<p>Increased power exchanges of electricity among GMS countries</p> <p>Enhanced government capacity in developing environmentally sustainable power sector as well as renewable energy and energy efficiency potentials in GMS countries</p>	<p>Regional Power Coordination Center established and operated</p> <p>Subregional Energy Forum enhanced and extended</p>	<p>Planned key activity areas</p> <ul style="list-style-type: none"> • Electric power transmission, electric power distribution, rural electrification, distribution loss reduction • Solar, small hydro, biomass, and other renewables • Policy and regulation, public-private partnership, sector-wide approaches, and market promotions <p>Planned projects</p> <ul style="list-style-type: none"> • Integrated Resource Planning and Strategy Environmental Assessment Support (\$1 million, 2015) • Development of GMS Coordination Center for Regional Power Trade (\$3 million, 2017) <p>Ongoing projects</p> <ul style="list-style-type: none"> • Harmonizing the GMS Power System to Facilitate Regional Power Trade (\$1.5 million, 2014) 	<p>Planned key activity areas and projects in the pipeline:</p> <ul style="list-style-type: none"> • Regional Power Coordination Center established • GMS performance standards and grid codes, GMS regulatory framework guidelines, and transmission tariff methodology to be established • GMS renewable energy and energy efficiency development studies • GMS Strategy Environmental Assessment workshops and training <p>Ongoing projects</p> <ul style="list-style-type: none"> • Regional Power Trade Coordination Center meetings • GMS renewable energy and energy efficiency publications • GMS Strategy Environmental Assessment publications

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Sector Road Map and Results Framework (2015–2020) *continued*

- PRC: Reduce CO₂ emissions per unit of GDP by 40%–45% from 2005 level by 2020
- Thailand: By 22% by 2030
- Viet Nam: By 5%–8% by 2015

ADB = Asian Development Bank, CO₂ = carbon dioxide, GDP = gross domestic product, GMS = Greater Mekong Subregion, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China, TWh = terrawatt per hour.

^a ADB. 2013. *Smart Energy More Power: Accelerating Energy Efficiency in Asia*. Manila.

Source: ADB estimates.

Greater Mekong Subregion

Energy Sector Assessment, Strategy, and Road Map

This is the first energy sector assessment, strategy, and road map (ASR) of the Southeast Asia Energy Division of the Asian Development Bank (ADB) for the Greater Mekong Subregion (GMS). It highlights energy sector performance, regional power trade, major development constraints, government plans and strategy, strategic investment priorities, GMS energy cooperation, past ADB support and experiences, other development partner support, and future ADB support strategy in the GMS. The ASR is linked to the Strategic Framework for the GMS countries for 2012–2022, adopted at the 4th GMS Summit in Nay Pyi Taw, Myanmar in December 2011.

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ASIAN DEVELOPMENT BANK

6 ADB Avenue, Mandaluyong City

1550 Metro Manila, Philippines

www.adb.org