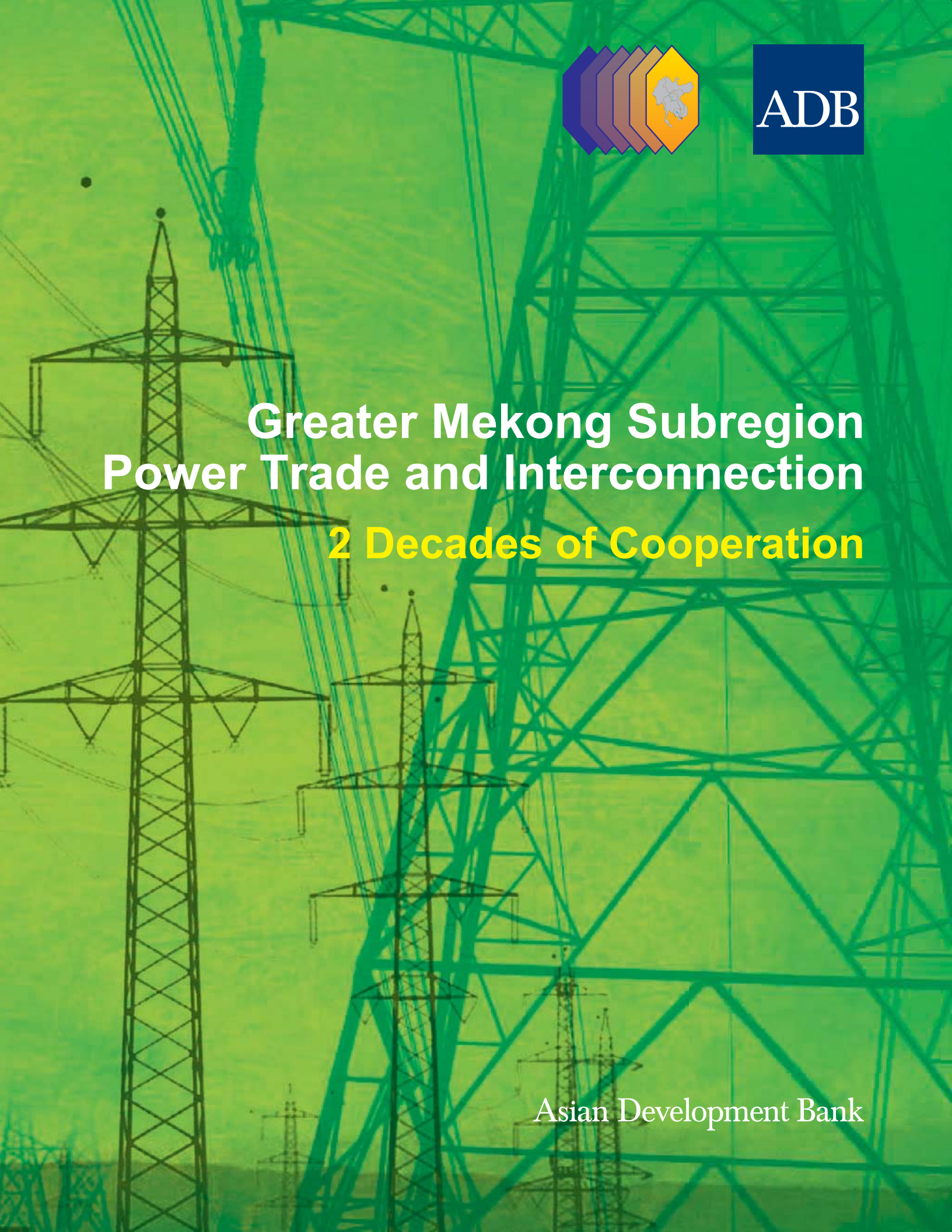

Greater Mekong Subregion Power Trade and Interconnection

2 Decades of Cooperation

Asian Development Bank

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September 2012

Asian Development Bank

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Abbreviations

ADB	–	Asian Development Bank
AFD	–	Agence Française de Développement
EGP	–	Experts Group on Power Interconnection and Trade
EPF	–	Electric Power Forum
GMS	–	Greater Mekong Subregion
IGA	–	inter-governmental agreement
MOU-1	–	GMS Memorandum of Understanding on the Guidelines for the Implementation of Stage 1 of the RPTOA
MOU-2	–	Memorandum of Understanding on the Road Map for Implementing the GMS Cross-Border Power Trading
PPA	–	power purchase agreement
RPCC	–	Regional Power Coordination Center
RPCC HQ	–	Regional Power Coordination Center Headquarters
RPT	–	regional power trade
RPTCC	–	Regional Power Trade Coordination Committee
RPTOA	–	Regional Power Trade Operating Agreement
Sida	–	Swedish International Development Agency

Weights and Measures

GW	–	gigawatt
GWh	–	gigawatt-hour
kV	–	kilovolt
MW	–	megawatt

Introduction

Energy cooperation in the Greater Mekong Subregion (GMS) began as part of the GMS Economic Cooperation Program (GMS Program) launched in 1992. The GMS groups Cambodia, the Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, Viet Nam, and the Guangxi Zhuang Autonomous Region and Yunnan Province of the People's Republic of China (PRC)[1] in an activity-based subregional economic cooperation program. The GMS Program aims at fostering regional cooperation to contribute to growth and poverty reduction and to address the provision of regional public goods. It was launched in 1992 in a subregion emerging from prolonged conflict with a majority of the GMS countries transitioning from centrally planned economies. The program marks its 20th year in operation in 2012. The Asian Development Bank (ADB) has provided vital support to the GMS since the program's founding, acting as its secretariat and providing coordination, financing, and technical expertise for all sectors covered in the program, including energy.

Energy was identified at the inception of the GMS Program as one of nine areas of subregional cooperation[2] in view of the benefits of sharing the subregion's diverse energy resources and of optimizing power supply to meet varying demand profiles across the region. The economic and environmental benefit of regional integration in the GMS energy sector is estimated at savings amounting to about 19% of total energy costs or about $200.0 billion.[3] The savings resulting from expanding the interconnection of GMS power systems alone are estimated at $14.3 billion,[4] mainly due to the substitution of fossil fuel generation with hydropower. Integration of power systems is also expected to result in slower growth of carbon emissions as compared to business as usual.[5]

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1 The PRC was initially represented in the GMS by Yunnan Province in 1992, with the Guangxi Zhuang Autonomous Region formally included in December 2004.

2 The nine areas covered by the GMS Program are agriculture, energy, environment, human resource development, investment, telecommunications, tourism, trade facilitation, and transport.

3 ADB. 2009. *Building a Sustainable Energy Future.* Manila.

4 ADB. 2010. *Update of the GMS Regional Master Plan.* Manila.

5 See footnote 2: Integration will be even more important should a higher-than-expected growth in energy demand occur, with carbon emissions in a high-growth scenario estimated to be two-thirds higher than in the integrated GMS scenario. See also footnote 3: The expansion of existing power interconnection in the subregion is estimated to result in 14.2 metric tons of annual carbon emissions reduction by 2020.

GMS Energy Resource Endowment and Power Demand

Recent estimates of the energy resources in the GMS include about 229 gigawatts (GW) of annual hydropower potential, as well as proven reserves of about 1.2 billion cubic meters of natural gas, 0.82 billion tons of oil, and 28.0 billion tons of coal. While the subregion is well endowed with energy resources, they are unevenly distributed (see map). The Lao PDR, Myanmar, Viet Nam, and the two PRC provinces account for about 94% of the hydropower resources in the region. The hydropower potential of the Lao PDR and of Myanmar, respectively, is substantial compared to their population size and expected power needs, while Viet Nam's hydropower potential is concentrated in northern Viet Nam. Myanmar, Thailand, and Viet Nam possess natural gas deposits; Viet Nam has the most oil reserves; and Yunnan Province, PRC holds the main coal deposits. Cambodia, Thailand, and the PRC provinces have mainly been net energy importers, while the Lao PDR, Myanmar, and Viet Nam are net energy exporters to other GMS countries and the rest of the world.[6] Similarly, for electric power, the Lao PDR and Myanmar have been generating electricity for export, beyond the supply requirements of their grid-connected domestic consumers (Appendix 1).

The peak power demand in the GMS, which stood at about 83 GW in 2010, is expected to more than triple to about 277 GW by 2025.[7] Thailand has the largest power system and currently accounts for about 29% of peak power demand. Viet Nam, the Guangxi Zhuang Autonomous Region, and Yunnan Province each carry about 20% of peak demand. Simulations undertaken for the latest update of the GMS Master Plan for power interconnection forecast that by 2025 Thailand's share of peak power in the GMS will decrease to about 20%, while Viet Nam's rapid economic growth will increase its peak load share to more than a quarter of GMS peak load. The combined demand of the Guangxi Zhuang Autonomous Region and Yunnan Province in the PRC will continue to account for about half of all GMS peak demand. Thailand, Viet Nam, and the PRC will account for 96% of GMS peak demand by 2030 with greater reliance on gas- and coal-fired electricity generation. Meanwhile, the power requirements of Cambodia, the Lao PDR, and Myanmar will similarly grow but are expected to retain only about a 4% share of the subregion's overall power demand. The latter three countries have substantially smaller national power systems but are expected to benefit from developing power exports to the rest of the GMS, considering their substantial energy resource potential relative to their electricity needs (Appendix 2).

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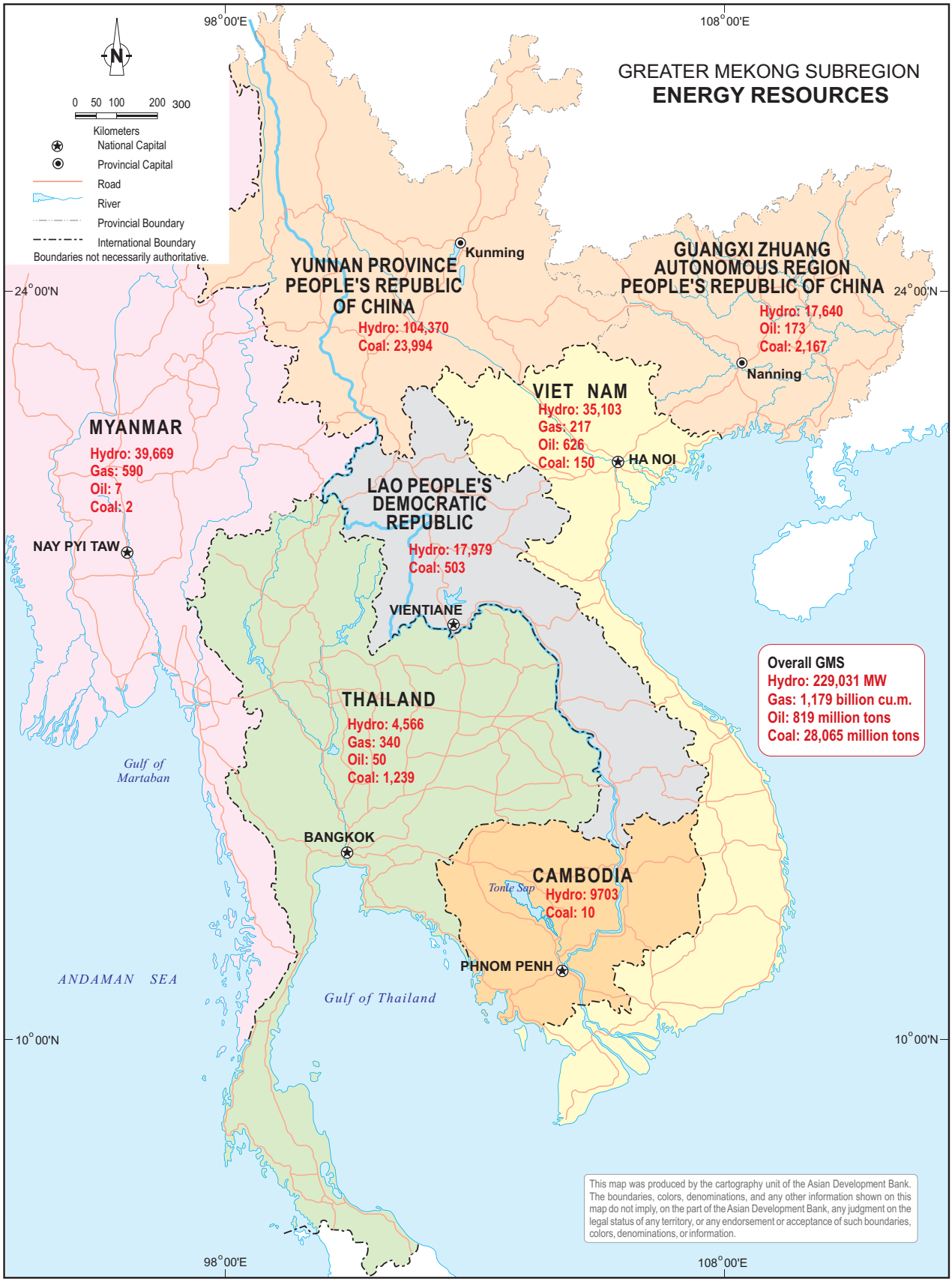
6 The Lao PDR and Myanmar shifted from being net importers to net energy exporters by 2000. See Appendix 1.

7 ADB. 2010. *Update of the GMS Regional Master Plan.* Manila.


GREATER MEKONG SUBREGION
ENERGY RESOURCES
98°00'E
108°00'E
24°00'N
10°00'N
N
0 50 100 200 300
Kilometers
National Capital
Provincial Capital
Road
River
Provincial Boundary
International Boundary
Boundaries not necessarily authoritative.
YUNNAN PROVINCE PEOPLE'S REPUBLIC OF CHINA
Hydro: 104,370
Coal: 23,994
Kunming
GUANGXI ZHUANG AUTONOMOUS REGION PEOPLE'S REPUBLIC OF CHINA
Hydro: 17,640
Oil: 173
Coal: 2,167
Nanning
MYANMAR
Hydro: 39,669
Gas: 590
Oil: 7
Coal: 2
NAY PYI TAW
VIET NAM
Hydro: 35,103
Gas: 217
Oil: 626
Coal: 150
HA NOI
LAO PEOPLE'S DEMOCRATIC REPUBLIC
Hydro: 17,979
Coal: 503
VIENTIANE
THAILAND
Hydro: 4,566
Gas: 340
Oil: 50
Coal: 1,239
BANGKOK
CAMBODIA
Hydro: 9703
Coal: 10
Tonle Sap
PHNOM PENH
Gulf of Martaban
ANDAMAN SEA
Gulf of Thailand
Overall GMS
Hydro: 229,031 MW
Gas: 1,179 billion cu.m.
Oil: 819 million tons
Coal: 28,065 million tons
This map was produced by the cartography unit of the Asian Development Bank. The boundaries, colors, denominations, and any other information shown on this map do not imply, on the part of the Asian Development Bank, any judgment on the legal status of any territory, or any endorsement or acceptance of such boundaries, colors, denominations, or information.

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GMS Energy Cooperation in Its Initial Years

Village in Lao People's Democratic Republic with access to electricity

The initial years of the energy cooperation, from its inception in 1992 until the late 1990s, were focused on networking and building trust, and mechanisms for subregional collaboration among GMS members. In this initial period, various regional studies and subregional and national consultations crucial to nascent GMS cooperation were conducted (Appendix 3). The initial activities (i) underpinned regional policy development, project preparation, information sharing, and familiarization with the regulatory and institutional structures of the national power systems of the GMS members; (ii) encouraged collaboration and issues resolution with goodwill and a cooperative spirit; and (iii) fostered an environment that helped enable GMS members to buy deeper into the benefits of subregional cooperation (Appendix 4).

The earliest energy study with a GMS-wide focus, the Subregional Energy Sector Study initiated in 1993 with ADB assistance and completed in November 1994,[8] was especially important in furthering the process of identifying the scope, opportunities, and mechanisms for energy cooperation among GMS members. The sector study helped define the parameters for the development of the energy sector in the subregion, build consensus on the initial shortlist of priority subregional energy projects, and provide the initial base for pursuing detailed feasibility and design studies for these subregional projects.

The recommendations of the energy sector study led to the formation of the subregional Electric Power Forum (EPF) in April 1995 as part of the institutional framework for sustaining energy cooperation in the GMS. Each GMS member had two representatives in the EPF—a senior official from the government agency dealing with policy and planning in the power sector and another from a key power utility. The EPF, which met at least once a year, helped provide a broad framework for subregional power sector coordination as well as an ongoing mechanism for knowledge sharing and collaboration among GMS members and their

[8] ADB. 1995. *Subregional Energy Sector Study for the Greater Mekong Subregion*. Manila.

development partners[9,10] (Appendix 5.A). Regional power trade and grid interconnection quickly became the major focus of GMS energy cooperation activities in the early years.[11] The EPF adopted a two-pronged approach to developing the GMS power market—one focused on the policy and institutional framework for promoting power trade and another focused on facilitating physical interconnections to facilitate cross-border dispatch of power.

[9] The Terms of Reference of the EPF, endorsed at the Inception Meeting of the EPF on 24 April 1995 in Yangon, Myanmar, specify the EPF's objectives to (i) act as a cooperative link among government agencies and related institutions, such as power utilities that are directly involved in power supply and power system development; (ii) act as a promotional and advisory organization to emphasize the development of efficient power systems; (iii) identify and promote opportunities for mutually beneficial cooperation projects in the power sector; (iv) promote financing of priority projects related to the development of subregional power systems by the governments and power utilities concerned, donor agencies, and the private sector; (v) provide a venue for addressing software issues, such as planning tools and pricing principles related to cooperation power projects, and organize seminars and workshops to discuss studies dealing with these issues; (vi) provide and disseminate information to participating countries and communicate and cooperate with regional and international organizations involved in the energy sector; and (vii) facilitate training and other human resource development initiatives to support the development of power systems.

[10] The meetings also helped generate better understanding of energy plans and policies among the GMS members, including major concerns and issues that they face, and provided a forum for bringing about a better understanding of cross-border environmental and social issues.

[11] Energy cooperation in the GMS is expanding its focus from regional power trade to also address renewable energy development and energy efficiency as well as energy poverty and security. The regional energy sector strategy study forming the bases for expanded energy cooperation in the GMS was released in 2009 and such expansion is formally embodied in the 2009 GMS Road Map for Expanded Energy Cooperation.

Policy and Institutional Framework for Regional Power Trade

To lay the groundwork for physical interconnection, the preparation of the Regional Indicative Master Plan on Power Interconnection was initiated with ADB assistance in 2000 and completed in 2002. The master plan identified levels of energy demand and the priority interconnection projects up to 2020 necessary to support regional power trade.[12] A subsequent update to this master plan was later completed in 2010.[13] Simulations under the latest master plan update anticipate Thailand, Viet Nam, and the PRC to be the net power importers in the region, while the Lao PDR and Myanmar will be net exporters, with Cambodia expected to transition from a net power exporter to a net importer.

Recognizing that a more focused approach involving key personnel associated with transmission development was needed to promote regional power trade, the EPF established the Experts Group on Power Interconnection and Trade (EGP) in 1998. The EGP oversaw the preparation of the Regional Master Plan for Interconnection in the GMS. It was also tasked to help determine the institutional, legal, and other arrangements to develop and manage the interconnected power network. The EGP met nine times from its inception in 1998 up to 2003. Its establishment addressed the need for continuity and more permanent country representation in the follow-up and expert coordination of regional power trade issues (Appendix 5.B).

The adoption of a Policy Statement on Regional Power Trade in the GMS in October 1999 and its subsequent endorsement at the GMS Ministers' Meeting in January 2000 was likewise facilitated by the EPF.[14] The policy statement set the stage for GMS governments to develop and sign an inter-governmental agreement (IGA) to implement the policy statement. The IGA, signed by all GMS countries during the First GMS Summit in Phnom Penh in November 2002, provided the legal authority and broad framework to implement power trade among the GMS members.[15] The same IGA called for the establishment of a

[12] ADB. 2000. *Technical Assistance for the Regional Indicative Master Plan on Power Interconnection in the Greater Mekong Subregion.* Manila (TA 5920-REG, $900,000, approved on 10 July 2000, financed by the TA Special Fund and the Government of Norway).

[13] ADB. 2007. *Technical Assistance for Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the Greater Mekong Subregion.* Manila (TA 6440-REG, $5 million, approved on 19 December 2007, financed by the Government of Sweden). A small component of the *Technical Assistance for GMS Regional Power Trade Coordination and Development* (TA 6304-REG) also undertook some simulations to update the regional indicative master plan.

[14] Policy Statement on Regional Power Trade in the Greater Mekong Subregion, adopted at the Sixth Electric Power Forum Meeting on 28 October 1999 in Phnom Penh, Cambodia.

[15] Inter-Governmental Agreement on Regional Power Trade in the Greater Mekong Subregion, signed on 3 November 2002 in Phnom Penh, Cambodia.

The ninth meeting of the Subregional Electric Power Forum in 2002

Regional Power Trade Coordination Committee (RPTCC) to coordinate and follow up on the IGA's implementation.[16]

As of the end of 2011, the RPTCC created under the IGA has met 12 times since its establishment in 2004 and has helped provide strategic direction and overall management of the interim stage of GMS power trade (Appendix 5.C). The RPTCC is supported by two working groups that meet as necessary.[17] Among the RPTCC's first tasks was to oversee preparation of a draft Regional Power Trade Operating Agreement (RPTOA) that would constitute the initial technical and commercial guidelines to support the establishment of a regional power market in the GMS.[18] The draft initial RPTOA guidelines were completed in April 2005. Their preparation served not only as groundwork for fleshing out the operations and mechanisms of expanded regional power trade, but also cultivated a process of learning and consultations that have helped countries and stakeholders more clearly envisage the future structure of the GMS power market.

Following the IGA of 2002, the first Memorandum of Understanding on the Guidelines for the Implementation of Stage 1 of the RPTOA (MOU-1) was subsequently signed by GMS members at the Second GMS Summit in Kunming, PRC in July 2005. MOU-1 sets out the institutional structure and guidelines for the conduct of bilateral power trade in the so-called Stage 1 of regional power trade. Due to the differences in the regulatory frameworks and transmission networks in the GMS, the subregional power market is expected to evolve in approximately four stages (Appendix 6).[19] Stage 1, at which GMS regional power trade

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16 Greater Mekong Subregion Guidelines for the Regional Power Trade Coordination Committee, adopted at the first meeting of the RPTCC on 14 July 2004 in Guilin, PRC.

17 The two RPTCC working groups are the RPTCC Focal Group, which coordinates the implementation of day-to-day activities of the RPTCC in each GMS country, and the RPTCC Planning Working Group, which coordinates the planning of GMS cross-border transmission lines.

18 Article 1.1(a) of the Memorandum of Understanding on the Guidelines for the Implementation of Stage 1 of the RPTOA (MOU-1) in 2005 provides that the draft RPTOA presented in the Third Meeting of the RPTCC on 7–8 April 2005 in Vientiane, Lao PDR, be agreed upon by GMS members as the initial guidelines for the future development of cross-border interconnections and regional power trading.

19 ADB. 2004. *Study for a Regional Power Trade Operating Agreement in the Greater Mekong Subregion.* Consultant's report. Manila (TA 6100-REG); 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, DC.

is currently, is characterized mainly by bilateral trade via power purchase agreements (PPAs) involving independent power producers, with trades in excess of these being largely opportunistic and utilizing any surplus capacity of the transmission lines associated with existing PPAs.

Another MOU on the Road Map for Implementing the GMS Cross-Border Power Trading (MOU-2) was signed at the Third GMS Summit in Vientiane, Lao PDR in March 2008. MOU-2 defined the key activities and timelines up to 2012 intended to fully realize Stage 1 and to prepare for Stage 2 of GMS power trading. Stage 2 would begin when trading is possible between any pair of GMS members, eventually using transmission facilities of a third GMS member. The key activities defined in the road map include the necessary preparatory studies and the update of the "Indicative Regional Master Plan on Power Interconnection in the GMS" in 2010.

Physical Interconnection for Cross-Border Dispatch of Power

Before 1992 and at the start of the GMS Program, the only significant power transmission links in the GMS were those between the Lao PDR and Thailand for the export of Lao PDR hydropower. These consisted of double- and single-circuit 115-kilovolt (kV) lines to northeast Thailand from the Vientiane network when the Lao PDR commissioned Nam Ngum 1 hydropower plant[20] in 1971 and the single circuit 115 kV line connecting the Lao PDR's southern grid to the Thai system in 1991 to deliver power from the Xeset hydropower plant.[21, 22] Low voltage lines also connected certain areas in central Lao PDR with the Thai system as well as the Lao PDR with Cambodia, to distribute power to remote border regions. Discussions to supply remote areas along the borders between the Lao PDR and Viet Nam had also been initiated, although physical connections were yet to be built. Bilateral power trade, however, was already expected to intensify as various MOUs for the export of power were progressively being signed between governments in the subregion.

While the first decade of subregional energy cooperation served primarily to advance planning and policy and institutional coordination, GMS energy cooperation also facilitated implementation of high-priority power projects with subregional impacts. Within the first decade, two hydropower plants in the Lao PDR exporting power to Thailand were implemented with private sector participation and ADB assistance.[23, 24] The second decade

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20 Nam Ngum 1 was the first large hydropower development in the Lao PDR and was the first power station built under a strategy of large-scale hydropower development for export. The implementation of Nam Ngum 1's 150-megawatt (MW) capacity involved three stages—two 15 MW generators were constructed in 1971, then two 40 MW generators were added in 1978, and a third 40 MW generator was added in 1984. ADB supported this early effort with technical assistance for the Nam Ngum project development.

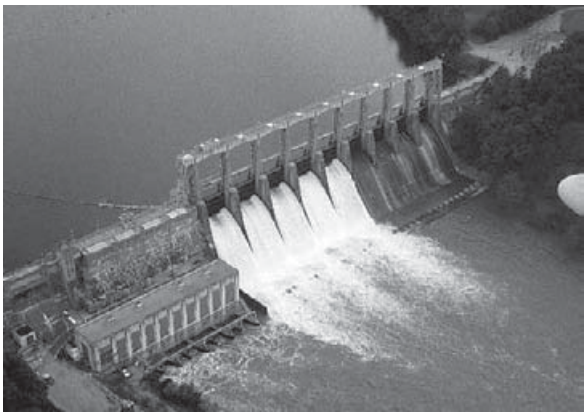
21 ADB. 1980. *Technical Assistance to the Lao PDR for Xe Set Hydropower.* Manila (TA 0374-LAO, $246,000, approved on 14 November 1980, financed by the TA Special Fund); ADB. 1987. *Technical Assistance to the Lao PDR for Xe Set Hydropower.* Manila (TA 0909-LAO, $1,760,000, approved on 27 October 1987, financed by the United Nations Development Programme); ADB. 1990. *Technical Assistance to the Lao PDR for Xe Set Hydropower (Supplementary)*. Manila (TA 0909-LAO, $1,000,000 approved on 14 December 1990, financed by the Government of Norway).

22 ADB. 1984. *Loan to the Lao PDR for Xe Set Hydropower.* Manila (Loan 0698-LAO, $1 million, approved on 23 October 1984, financed by the Asian Development Fund); ADB. 1984. *Loan to the Lao PDR for Xe Set Hydropower.* Manila (Loan 0846-LAO, $15.5 million, approved on 27 October 1984, financed by the Asian Development Fund); ADB. 1990. *Loan to the Lao PDR for Xe Set Hydropower.* Manila (Loan 1063-LAO, $3.0 million, approved on 11 December 1990, financed by the Asian Development Fund).

23 ADB. 1994. *Loan to the Lao PDR for Theun–Hinboun Hydropower Project.* Manila (Loan 1329-LAO(SF), $60 million, approved on 8 November 1994, financed by the Asian Development Fund); ADB. 1996. *Loan to the Lao PDR for Nam Leuk Hydropower Project.* Manila (Loan 1456-LAO(SF), $52 million, approved on 10 September 1996, financed by the Asian Development Fund).

24 ADB. 1992. *Loan to the Lao PDR for Nam Song Hydropower Development.* Manila (Loan 1214-LAO, $31.5 million, approved on 21 December 1992, financed by the Asian Development Fund). A project

of the GMS Program saw a quickened pace of project implementation by GMS governments with donor and development partner assistance and private sector initiative. Up to the end of 2011, a total of 20 technical assistance projects with subregional implications for energy cooperation were processed by ADB to support analytical and advisory work and project preparation. A number of these technical assistance projects also supported regional water basin development and the mitigation of potential social and environmental impact of the extensive development of hydropower resources. Overall, ADB provided $699.42 million in loan assistance for six capital investment projects for GMS regional projects and processed some $21.1 million in technical assistance funds from ADB's own resources and cofinancing sponsors from 1992 to 2011 (Appendix 7).


Nam Theun 2 hydropower plant

Completed power projects in the GMS that have subregional impacts and that were implemented after 1992 with ADB assistance include the 200-megawatt (MW) capacity 230 kV transmission line connecting Cambodia to Viet Nam completed in 2008 and a total of 1,358 MW new capacity from three hydropower plants in the Lao PDR, built primarily for electricity exports.[25] The 115 kV transmission line comprising the northwest grid of the Cambodian system and enabling access to more affordable power imports from Thailand was energized in 2007. Ongoing interconnection projects linking the Lao PDR to Thailand and Viet Nam to Cambodia are also expected to be completed by 2013. Another 440 MW of hydropower capacity from Nam Ngum 3 in the Lao PDR, with ADB assistance, is also expected to be online by 2017.

Various other power generation and associated transmission projects in the GMS have also been developed with assistance from other development partners and by the private sector. Among these are the generation and associated interconnection projects in the Lao PDR and Myanmar that are intended for regional power trade, including the ongoing construction of the coal-fired Hongsa plant (1,800 MW) and various new hydropower capacity in the Lao PDR as well as the recently completed Shewli-1 (600 MW) and Dapein-1 (240 MW) hydropower plants in Myanmar now dispatching power to Yunnan Province in the PRC. Appendix 8 provides details of projects falling within the scope of GMS regional power trade.

Existing power interconnections in the GMS serve either to transmit electricity generated from export-oriented power plants or to dispatch power to cross-border areas experiencing domestic supply deficiencies and areas distant from national networks.[26]

component involved the construction of a diversion dam across the Nam Song River to divert water to the Nam Ngum reservoir with the intention of increasing Nam Ngum power generation for exports to Thailand. The diversion dam was completed in 1996, but, due to substantial increase in local demand, the additional power generation went to meeting this demand.

[25] These hydro plants are Theun–Hinboun completed in 1998, Nam Leuk in 2000, and Nam Theun 2 in 2010.

[26] There is also an interconnection between neighbors Malaysia and Thailand for power importation to Thailand and significant power export and transmission capacity from Yunnan Province and the Guangxi Zhuang Autonomous Region, PRC to the rest of the PRC.

The following are the major high voltage (220 kV and above) power interconnections in the subregion:

(i)	Lao PDR to Thailand	– Theun Hinboun hydropower plant (HPP) to Sakhonnakhon, 230 kV, 176 km [1998] – Houayho HPP to Ubon 2, 230 kV, 230 km [1999] Nam Theun 2 HPP to Roi Et 2 substation, 500 kV, 304 km [2009]
(ii)	Myanmar to Yunnan Province, PRC	– Shewli-1 HPP to Dehong, 220 kV DC, 2x120 km [2008] Dapein-1 HPP to Yunnan Province near Dehong, 500 kV SC, 120 km [2011]
(iii)	Viet Nam to Cambodia	– Chau Doc to Phnom Penh, 220 kV/230 kV, 111 km, 100 MW in 2009 and 200 MW from 2010 onward [2009][27]
(iv)	Yunnan Province, PRC to Viet Nam	– Xinqiao to Lao Cai, 220 kV, 56 km [2006] – Maguan to Ha Giang, 220 kV, 51 km [2007]

Lao People's Democratic Republic–Thailand transmission lines

Various medium- and low-voltage (from 115 kV and below) interconnections also exist between (i) the Lao PDR and Cambodia for 10 MW export to Cambodia through a 22 kV connection in the Steung Treng area; (ii) the Lao PDR and Thailand for power supply to five locations in Lao PDR border areas and exchange of power via 115 kV transmission lines in another five locations; (iii) the Lao PDR and Yunnan Province in the PRC for exchange of power on a 115 kV line and low-voltage import of power to Yunnan Province in the PRC in three locations; (iv) the Lao PDR and Viet Nam for low-voltage connections in six locations; (v) Yunnan Province in the PRC and Viet Nam for power supply to Viet Nam through four 110 kV links; (vi) Thailand and Cambodia for up to 80 MW exports to Cambodia via a 115 kV transmission line serving western Cambodia and for another 40 MW export capacity to Cambodia via 22 kV connections to deliver power to seven border communities; and (vii) Viet Nam and Cambodia via 22 kV connections in 12 locations.

As a result, the following electricity trade flows now exist in the GMS:

- Cambodia has been importing from the Lao PDR (south) since 2010, Thailand since 2009, and Viet Nam (south) since 2008.
- The Lao PDR (north) has been importing from Thailand since the late 1990s and Yunnan Province, PRC since 2009.
- Thailand has been importing from the Lao PDR (hydropower) since 1971.
- Viet Nam (north) has been importing from Yunnan Province, PRC since 2004.
- Yunnan Province, PRC has been importing from Myanmar (hydropower) since 2008.

In 2010, the total trade in electricity in the GMS was approximated at 34,139 GWh, with the Lao PDR, Myanmar, and the PRC serving as the subregion's net exporters (Table 1). The Lao PDR exports the largest volume of electricity in the subregion and offers the most

[27] Due to the demand in Viet Nam, only 130 MW is exported to Cambodia.

competitive supply price. Regional power trade has so far helped Thailand and Viet Nam meet their large and rapidly growing demand through competitively priced electricity from the Lao PDR and the PRC. It has also allowed Cambodia to access more affordable electric power from neighboring GMS members, compared to its own power production cost (Table 2). The remote border regions of the Lao PDR, Cambodia, and Viet Nam have also benefited from access to power supply from neighboring countries.

Table 1: Greater Mekong Subregion Power Trade and Net Imports, 2010 (GWh)

	Imports	Exports	Total Trade	Net Imports
Cambodia	1,546	–	1,546	1,546
Lao PDR	1,265	6,944	8,210	(5,679)
Myanmar	–	1,720	1,720	(1,720)
Thailand	6,938	1,427	8,366	5,511
Viet Nam	5,599	1,318	6,917	4,281
PRC	1,720	5,659	7,379	(3,939)
Total	**17,069**	**17,069**	**34,139**	–

( ) = negative, – = nil, GWh = gigawatt-hour, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.

Note: The table refers to trade within the Greater Mekong Subregion only and does not consider power flows from the Guangxi Zhuang Autonomous Region and Yunnan Province to the rest of the PRC, and Thailand's power imports from Malaysia.

Source: Calculated from Table 2, Appendix 2.

Table 2: Greater Mekong Subregion Power Import/Export Tariffs, 2010/Latest (US cents/kWh)

	Average Import Tariff	Average Export Tariff
Cambodia	71.70	–
Lao PDR	6.17–6.33	4.81
Myanmar	–	n.a.
Thailand	4.80	7.30
Viet Nam	5.10	6.12
PRC	n.a.	5.11–5.15

– = nil, kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Note: The table refers to average import and export price for power trade within the Greater Mekong Subregion only, weighted by the volume of power trade.

Source: Calculated from Tables 2 and 3, Appendix 2.

Coordination with Development Partners

In addition to that of ADB, energy cooperation in the GMS benefits from the assistance of various international agencies and bilateral donors, including the World Bank, the Swedish International Development Agency (Sida), the Australian Agency for International Development (AusAID), and the Agence Française de Développement (AFD) (Appendix 9). The World Bank has been instrumental in providing support and expertise in undertaking the 1999 Regional Study on Power Trade Strategy and in preparing the 2002 IGA on Regional Power Trade. The World Bank also participates in various financing of power generation and transmission projects in the subregion with a view to developing the infrastructure for regional power trade as well as providing support and expertise in undertaking important analytical studies,[28] followed with technical assistance and capacity building. Sida and AFD have sponsored technical assistance to further regional power trade in the context of a phased approach to the creation of a regional power market, the need for regional institutions, regulations and technical standards to support this process, and the need to integrate environmental impacts of power trading into project design and implementation.[29]

In particular, Sida financed a series of studies to further the regional power trade road map, including the 2008 update of the regional master plan for interconnection, as well as capacity development in the management of environmental programs at the project level.[30] AFD financed technical assistance that facilitated the creation of the RPTCC's sub–working groups as well as capacity building and human resource development relating to regional power trade operations and management.[31] AFD is also sponsoring the conduct of a strategic environmental assessment (SEA) of the GMS power transmission master plan and the formulation of alternative scenarios considering among others renewable energy, and alternative energy security scenarios, with the additional objective of strengthening the capacity of GMS agencies to develop SEAs.

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28 Such as World Bank. 1999. *Power Trade Strategy for the Greater Mekong Subregion.* Washington, DC; 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, DC.

29 ADB. 2003. *Technical Assistance for Study for a Regional Power Trade Operating Agreement.* Manila. (TA6100-REG, $850,000, approved on 21 April 2003, financed by the TA Special Fund).

30 ADB. 2007. *Technical Assistance for Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the GMS.* Manila. (TA6440-REG, $5 million, approved on 19 December 2007, financed by the Government of Sweden).

31 ADB. 2006. *Technical Assistance for the GMS Power Trade Coordination and Development.* Manila (TA 6304-REG, $5.00 million, approved on 16 January 2006, financed by the AFD); ADB. 2010. *Technical Assistance for Ensuring Sustainability of GMS Regional Power Development.* Manila. (TA7764-REG, $1.35 million, approved on 12 November 2010, financed by the Government of France through the AFD).

Working Toward a GMS Power Market

Night view of Greater Mekong Subregion

The varying levels of development of the energy sectors of the six GMS countries, including the differing sophistication of national physical networks and institutional and regulatory capacities, will continue to pose challenges in bringing the subregion to a fully functioning regional power market. This is similarly true for the task of marshaling the resources necessary to build the major transmission backbone and grid interconnections that will allow regional power trade to happen. Moreover, while the benefits of regional power trade are clearly desirable for the subregion as a whole, energy security in the context of social and environmental sustainability as well as the fair and equitable sharing of benefits will continue to challenge policy making and planning, especially in the ongoing work of crafting institutional, commercial, and regulatory rules, including the preparation of the Regional Performance Standards, the GMS Technical Grid Code, and transmission regulation.

In the immediate time ahead, the development of the future GMS regional power market is expected to continue exploiting three natural complementarities in the power systems of countries across the subregion:

(i) Through *natural cross-border interconnections,* which are interconnections of adjacent border regions due to the cost effectiveness of deriving power from nearby generating plants across the border rather than to source and transmit electricity from nationally owned but remote power supply centers. This was early on demonstrated by the low-voltage cross-border interconnections that have helped certain GMS members pursue remote rural electrification through interconnections at the border regions. Also owing to the long-span transmission lines that are necessary to connect in-country transmission systems, it is far cheaper to transmit power from nearby power centers, such as from the Lao PDR (south) to Viet Nam (south) than to supply Viet Nam (south) from Viet Nam's own coal or hydropower generation from the north.

(ii) Through *interconnections arising from differences in natural resource endowments,* evident in the economic evacuation of power from hydro-resource-rich countries to GMS members with high power demand, such as the Lao PDR hydropower exports to Thailand and Myanmar's to Yunnan Province in the PRC, or the short-term replacement of expensive diesel-fired power in Cambodia with lower-cost electric power from other GMS members, or eventual exports of hydropower from the Lao PDR/Cambodia to Thailand/Viet Nam.

(iii) Through *interconnections arising from differences in peak load profile*, through synchronous operation of power systems potentially between Viet Nam/Thailand/Myanmar and Yunnan Province in the PRC, and/or seasonal peak load variations, such as those possible between Thailand and Viet Nam, with Viet Nam experiencing sharper winter peak loads relative to Thailand. Power trade between areas with different load timings would allow generation capacities to be shared to meet differing peak loads in different load centers and would help delay the need to build new generation capacity.

In furthering regional power trade, the GMS members, since their 1999 Policy Statement on Regional Power Trade, have thus consistently affirmed the principles of cooperation, gradualism, and respect for the environment. All of them recognize that regional power trade will develop in phases and that a regional market will need to evolve through institutional strengthening and reforms, and infrastructure development, which is conscious of energy security and sustainable environmental and social impact. So far, the framework for developing the GMS power market has taken a phased approach that has built on cross-border interconnections associated with power exports and bilateral PPAs.

The gradualist approach is expected to continue even while agreement on the establishment of the Regional Power Coordination Center (RPCC), the permanent dedicated center envisioned to coordinate power trade in the GMS, reached an advanced stage of discussions by early-2012. Cognizant of the need for an RPCC owned and operated by the GMS members in coordinating complex regional processes, the GMS members are currently threshing out an inter-governmental MOU for the RPCC's establishment. The draft MOU is expected to soon undergo internal clearance processes in each of the GMS members for eventual signing at the next GMS Ministerial Meeting in 2012. The host country of the RPCC will be decided by the GMS members.

Besides the establishment of the RPCC, to facilitate implementation of the milestones and activities prescribed in the MOU-2, the GMS members agreed at the 11th meeting of the RPTCC in November 2011 to create two working groups—the Working Group on Performance Standards and Grid Code, and the Working Group on Regulatory Issues—for moving forward to development of the GMS regional power market. The terms of reference of the two working groups were adopted at the 12th meeting of the RPTCC in May 2012.

Significant progress has been made for GMS regional power trade since the beginning of GMS regional energy cooperation through a two-pronged approach to develop the GMS power market—the policy and institutional framework for promoting power trade and physical interconnections to facilitate cross-border power. However, to move toward a GMS power market, more efforts should be made by the GMS members themselves to realize the full benefits of synchronous operations in the GMS. ADB will continue to support GMS members' efforts in coordination with other development partners.

APPENDIX 1

Key Energy Indicators of the GMS and Selected Countries

Table A1.1: GMS Energy Resources (2009/latest)

Energy Resource	GMS	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	Guangxi Zhuang Autonomous Region, PRC	Yunnan Province, PRC
Hydro (MW[a])	229,031	9,703	17,979	39,669	4,566	35,103	17,640	104,370
Coal (MT)	28,065	10	503	2	1,239	150	2,167	23,994
Natural gas (BCM)	1,179	n.a.	–	590	340	217	n.a.	n.a.
Crude oil and natural gas liquids (MT)	819	n.a.	–	7	50	626	173	n.a.

BCM = billion cubic meter, GMS = Greater Mekong Subregion, Lao PDR = Lao People's Democratic Republic, MT = million ton, MW = megawatt, n.a. = not available, PRC = People's Republic of China.

[a] Refers to technically exploitable capability. The World Energy Council data for hydropower has been converted from terawatt-hours per year to megawatts, using the World Energy Council assumption of 0.40 capacity factor.

Sources: World Energy Council. 2010. *2010 Survey of Energy Resources,* London; for PRC data, country sources.

Table A1.2: Energy Use (kilotons of oil equivalent)

	1990	1995	2000	2005	2009
Cambodia	n.a.	3,373	3,978	4,779	5,182
Lao PDR	1,150	1,322	1,454	1,733	n.a.
Myanmar	10,656	11,768	12,500	15,996	15,062
Thailand	42,028	62,442	72,228	97,226	103,316
Viet Nam	24,325	30,052	37,066	51,188	64,048
Guangxi Zhuang Autonomous Region, PRC	9,157	15,796	18,685	34,080	49,525
Yunnan Province, PRC	13,679	18,484	24,278	42,168	52,576
Indonesia	103,923	133,650	155,444	179,444	201,999
Malaysia	21,988	37,112	47,271	62,070	66,826
Singapore	11,456	18,851	18,068	23,896	18,476

Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Sources: ADB. 2011. *Key Indicators for Asia and the Pacific 2011;* [People's Republic of] *China Energy Statistical Yearbook 2011*; World Bank 2011. *World Development Indicators Online; Guangxi Statistical Yearbook 2011; Yunnan Statistical Yearbook 2010.*

Table A1.3: Energy Production (kilotons of oil equivalent)

	1990	1995	2000	2005	2009
Cambodia	n.a.	2,901	3,203	3,501	3,668
Lao PDR	1,085	1,244	1,652	1,843	n.a.
Myanmar	10,654	10,999	15,405	23,276	22,357
Thailand	26,547	33,212	43,836	54,316	61,705
Viet Nam	24,711	34,529	48,106	69,698	76,642
Guangxi Zhuang Autonomous Region, PRC	4,932	7,724	5,833	8,547	12,742
Yunnan Province, PRC	11,162	16,196	17,302	37,474	53,167
Indonesia	172,166	217,058	240,527	282,550	351,841
Malaysia	48,763	64,548	76,137	91,495	89,693
Singapore	–	–	–	–	–

– = nil, Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Sources: ADB. 2011. *Key Indicators for Asia and the Pacific 2011;* [People's Republic of] *China Energy Statistical Yearbook 2011;* World Bank 2011. *World Development Indicators Online; Guangxi Statistical Yearbook 2011; Yunnan Statistical Yearbook 2010.*

Table A1.4: Energy Imports (net, % of energy consumption)

	1990	1995	2000	2005	2009/ Latest
Cambodia	n.a.	14	19	27	29
Lao PDR	6	6	(14)	(6)	n.a.
Myanmar	0	7	(23)	(46)	(48)
Thailand	37	47	39	44	40
Viet Nam	(2)	(15)	(30)	(36)	(20)
Guangxi Zhuang Autonomous Region, PRC	46	51	69	75	74
Yunnan Province, PRC	18	12	29	11	(1)
Indonesia	(66)	(62)	(55)	(57)	(74)
Malaysia	(122)	(74)	(61)	(47)	(34)
Singapore	100	100	100	100	100

( ) = negative, Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Sources: ADB. 2011. *Key Indicators for Asia and the Pacific 2011;* World Bank. 2011. *World Development Indicators Online;* Calculated values.

Table A1.5: Energy Use Per Capita (kilogram of oil equivalent per capita)

	1990	1995	2000	2005	2009/ Latest
Cambodia	n.a.	321	318	359	368
Lao PDR	280	287	285	309	n.a.
Myanmar	261	263	250	289	255
Thailand	753	1,051	1,161	1,493	1,544
Viet Nam	369	421	481	625	748
Guangxi Zhuang Autonomous Region, PRC	217	348	393	731	1,020
Yunnan Province, PRC	370	463	572	948	1,150
Indonesia	579	686	755	816	873
Malaysia	1,215	1,793	2,012	2,342	2,395
Singapore	3,819	5,386	4,517	5,557	3,695
Asia	282	329	328	437	695
World	1,050	1,006	1,008	1,072	1,235

Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Sources: Calculated values; for population figures: ADB. 2011. *Key Indicators for Asia and the Pacific 2011;* International Energy Agency. Various years. *Key World Energy Statistics*.

Table A1.6: Electric Power Consumption (gigawatt-hour)

	1990	1995	2000	2005	2009/10
Cambodia	101	119	366	764	1,828
Lao PDR	183	n.a.	n.a.	n.a.	n.a.
Myanmar	1,674	2,510	3,516	3,916	4,936
Thailand	36,604	74,535	91,160	125,260	140,492
Viet Nam	6,185	11,469	22,904	47,593	78,934
Guangxi Zhuang Autonomous Region, PRC	12,558	22,077	32,202	51,015	85,629
Yunnan Province, PRC	12,455	22,371	31,725	55,725	89,119

Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Sources: ADB. 1997. *Electric Utilities Data Book;* [People's Republic of] *China Energy Statistical Yearbook 2010;* World Bank. 2011. *World Development Indicators Online.*

Table A1.7: Electricity Production (gigawatt-hour)

	1990	1995	2000	2005	2009/10
Cambodia	n.a.	198	451	880	1,206
Lao PDR	821	1,128	3,438	3,509	n.a.
Myanmar	2,478	4,055	5,118	6,015	5,850
Thailand	44,175	80,060	95,977	132,195	148,389
Viet Nam	8,679	14,648	26,561	53,462	83,191
Guangxi Zhuang Autonomous Region, PRC	n.a.	21,729	28,909	44,604	94,445
Yunnan Province, PRC	n.a.	22,842	29,784	62,420	117,086

Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Sources: ADB. 2009. *Energy Statistics in Asia and the Pacific (1990–2006);* [People's Republic of] *China Energy Statistical Yearbook 2010;* World Bank. 2011. *World Development Indicators Online.*

Table A1.8: Electric Power Per Capita (kilowatt-hour per capita)

	1990	1995	2000	2005	2009/10
Cambodia	11	11	29	57	131
Lao PDR	44	n.a.	n.a.	n.a.	450 (ADB, 2011)
Myanmar	43	60	78	85	104
Thailand	641	1,250	1,443	1,878	2,045
Viet Nam	94	159	295	578	918
Guangxi Zhuang Autonomous Region, PRC	297	486	678	1,095	1,763
Yunnan Province, PRC	337	561	748	1,252	1,950
Indonesia	160	260	387	494	590
Malaysia	1,171	2,004	2,726	3,121	3,614
Singapore	4,983	6,069	7,575	8,507	7,949
Asia	n.a.	n.a.	634	1,093	1,461
World	2,073	2,150	2,334	2,603	2,733

Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Sources: World Bank. 2011. *World Development Indicators Online; Guangxi [Zhuang Autonomous Region] Statistical Yearbook 2010; Yunnan [Province] Statistical Yearbook 2010;* for Lao PDR data: ADB. 2009. *Energy Statistics in Asia and the Pacific (1990–2006);* International Energy Agency. Various years. *Key World Energy Statistics.*

Table A1.9: Access to Electricity (% of households with access)

	1994/1995	2000	2005	2009
Cambodia	10	15.8	20.1	24.0
Lao PDR	16	36.0	49.0	69.0
Myanmar	10	n.a.	16.0	26.0
Thailand	87	82.1	99.0	99.3
Viet Nam	15	75.8	84.2	97.6
Guangxi Zhuang Autonomous Region, PRC	90	n.a.	n.a.	100.0
Yunnan Province, PRC	76	n.a.	n.a.	99.3
Developing Asia	n.a.	67.3	72.8	81.0
World	n.a.	72.8	75.6	80.5

Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Source: ADB. 1997. *Electric Utilities Data Book;* International Energy Agency. Various years. *World Energy Outlook;* for Lao PDR: Electricite du Laos Statistics 2009, as quoted in World Bank. 2012. *Power to the People;* for Myanmar and PRC data: country sources.

APPENDIX 2

GMS Peak Power Demand, Power Flows, and Tariffs

Table A2.1: GMS Peak Load Demand Profile (megawatt)

Year	GMS	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	Guangxi Zhuang Autonomous Region, PRC	Yunnan Province, PRC
2000	26,126	114	167	780	14,918	4,890	n.a.	5,257
2010	83,259	467	618	1,573	23,936	16,165	16,300	16,400
2015	148,371	1,008	1,911	2,533	31,734	30,084	31,600	30,100
2020	212,005	1,610	2,665	3,898	42,024	47,608	41,800	39,000
2025	277,220	2,401	2,696	5,596	54,588	71,280	50,290	47,970

GMS = Greater Mekong Subregion, Lao PDR = Lao People's Democratic Republic, n.a. = not applicable, PRC = People's Republic of China.

Note: GMS total includes projected export to rest of PRC from the GMS provinces of PRC.

Sources: ADB. 2002. *Indicative Master Plan on Power Interconnection in GMS Countries*. Manila; ADB. 2010. *Update of the GMS Regional Master Plan*. Manila.

Table A2.2: GMS Power Flows, 2010[a] (gigawatt-hour)

	To					
From	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	PRC[b]
Cambodia		–	–	–	–	–
Lao PDR	6.6[c]		–	6,938[d]	–	–
Myanmar	–	–		–	–	1,720[e]
Thailand	385[c]	1,042[a, d]	–		–	–
Viet Nam	1,155[c]	163[a, f]	–	–		–
PRC[a]	–	112.5[a, e]	–	–	5,599[g]	

– = nil, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.

Note: The table refers to net power flows as recorded by the receiving country.

[a] Electricité du Laos Statistics 2011.
[b] Refers to power dispatched to and from interconnection in Yunnan Province, PRC.
[c] Electricity Authority of Cambodia (EAC). 2011. *Report on Power Sector of the Kingdom of Cambodia 2010*.
[d] Electricity Generating Authority of Thailand (EGAT). 2011. *EGAT Annual Report 2010*.
[e] China Southern Power Grid Co. Ltd. (CSPG). http://eng.csg.cn/
[f] 2009 data. Electricity Regulating Authority of Viet Nam (ERAV). www.erav.vn/
[g] Electricity Vietnam Center of the National Power System (EVN-NLDC). *Annual Report 2010*. www.nldc.evn.vn/

Sources: CSPG (2011); EAC (2011); EGAT (2011); ERAV (2011); EVN (2011).

Table A2.3: GMS Average Power Trade Tariffs, 2010/latest
(United States cents per kilowatt-hour)[a]

From	To					
	Cambodia	Lao PDR	Myanmar	Thailand	Viet Nam	PRC
Cambodia		–	–	–	–	–
Lao PDR	7.02[b]		–	4.80[c] (1.45 baht)	–	–
Myanmar	–	–		–	–	n.a.
Thailand	10.29[b] (3.10 baht)	6.20[d]	–		–	–
Viet Nam	6.14[b]	6.00[e]	–	–		–
PRC	–	6.21–9.39[e] (0.41–0.62 yuan)	–	–	5.10[f]	

– = nil, Lao PDR = Lao People's Democratic Republic, n.a. = not available, PRC = People's Republic of China.

Note: The table indicates the average import and export price for intra-Greater Mekong Subregion power trade, weighted by the volume of power trade. The specific prices for bilateral cross-border trade vary by project, either set under power purchase agreements (PPAs) or according to the supply price applicable per customer category by the power utilities and suppliers. The table is indicative and does not consider future application of escalation factors as may be provided for in PPAs.

[a] ADB reference rates, 31 Dec 2010: $1.00 = 30.13 baht; $1.00 = 6.60 yuan.
[b] Electricity Authority of Cambodia. 2011. *Report on Power Sector of the Kingdom of Cambodia 2010.* Average tariffs calculated by weighting tariff rates by 2010 import volumes.
[c] Electricity Generating Authority of Thailand (EGAT). 2011. *EGAT Annual Report 2010.* Average tariff calculated from total baht and gigawatt-hour purchases from the Lao PDR.
[d] ADB. 2005. *Loan to the Lao PDR for Nam Theun 2 Hydroelectric Project.* Manila. Cites weighted average cost of the Lao PDR's imported electricity, including EGAT sales to the Lao PDR grid and Provincial Electricity Authority cross-border sales.
[e] Electricite du Laos. 2010. *EDL Annual Report 2010.*
[f] Viet Nam Net. [People's Republic of] China attempts to raise electricity price, Vietnam under hard pressure. 6 March 2011. http://english.vietnamnet.vn/en/business/

APPENDIX 3

Key Studies Relevant to the GMS Energy Program

A. Subregional Energy Sector Study for the Greater Mekong Subregion, 1995. Prepared by Norconsult, under ADB RETA 5535.

This first energy sector study for the Greater Mekong Subregion (GMS) with region-wide focus includes the following salient findings:

(i) Rapid growth in energy demand in the subregion, with electricity demand projected to increase from about 90 terawatt-hours (14.5 gigawatts) in 1993 to 600 terawatt-hours (92 gigawatts) in year 2000.
(ii) Ample amounts of unevenly distributed energy resources in the subregion providing opportunities for extended economic as well as professional cooperation. Further development of hydropower and natural gas is of great interest across the subregion as well as options for electricity supply to local communities across borders.
(iii) Thailand is the main energy importer in the GMS, and will need to increase its import of energy, either in the form of coal or oil from the international market, hydropower from the Lao People's Democratic Republic (Lao PDR), Myanmar, or Yunnan Province in the People's Republic of China (PRC), or natural gas from Myanmar, and possibly Viet Nam and Cambodia.
(iv) Subregional cooperation based on a system approach will allow for an optimum utilization of energy resources. Most hydropower projects need to be reviewed and more extensive basin studies need to be carried out for better use of GMS water resources.
(v) Environmental and socioeconomic concerns need to be integrated from the very beginning into the planning of hydropower projects, as well as other energy system projects.
(vi) A shift from a self-sufficiency approach to a more integrated energy development program would bring important benefits, particularly in the electric power and natural gas subsectors, through transmission and pipeline grid interconnection. Based on reduction of peak load, due to load diversity and lower combined reserve requirements, immediate investment reductions in new generating facilities could amount to about $400 million, accumulating to more than $600 million in the year 2000, to about $1,800 million around 2020.
(vii) Regional power trade will result in reduced carbon emissions. The national self-reliance development scenario will increase emissions by about eight times versus a GMS power exchange scenario that would bring carbon emissions down by 17%.
(viii) Virtually all countries in the GMS, apart from Thailand, operate with electricity prices far below the actual cost of supply. The tariffs will need to be increased to the level of the long-run marginal cost of supply to expand electricity supply, provide electricity to new areas, and dramatically improve the prospects for attracting private capital.

(ix) A substantial degree of private participation in the power supply will need to be encouraged to meet the rapid growth in financing need.
(x) Each country in the subregion needs to adopt a policy which will encourage subregional cooperation in the energy field and have this policy reflected in the national regulatory framework and instructions to national administrations and in licensing procedures.
(xi) Implementation of cooperation forums within GMS is required to follow up and to maintain momentum toward increased cooperation in the fields of electric power and natural gas.

In addition, 20 project concepts appropriate for extended economic or institutional cooperation within the subregion were identified by the study, with comprehensive project and concept profiles. A number of these proposals were discussed and accorded high priority at the Third Conference on Subregional Economic Cooperation held in Ha Noi in April 1994. A revised list of projects was presented and reconfirmed at the Fourth Conference in Chiang Mai in September 1994.

B. Power Trade Strategy Study, World Bank, 1999.

This study identified the crucial policy, technical, institutional, and commercial and financial barriers to developing a regional power market in the GMS. The overall strategy to address these barriers is seen as "a process" to achieve a fully developed and competitive power market rather than a prescription for a specific long-term model to follow. The following strategies are recommended:

- In the **policy** area, that (i) each country should recognize and endorse international trading in electricity to be an integral part of its policies; (ii) an ad hoc group with no formal structure should assume responsibility for developing the regional protocols and early planning for regional integration; (iii) a formal regional cooperation agreement and permanent organization to coordinate the planning, development, operation, and regulation of a future interconnected system should be established; (iv) countries should examine the compatibility of legislation, regulations, and contracts to ensure that they permit the required flexibility for the regional market to expand; (v) each government in the region should establish a clear policy as to which entity will own and operate the transmission assets within its boundaries; (vi) that policies of open access to the transmission network for wholesale competition should be established by each government; and (vii) environmental issues should be addressed through a regional approach to resolve conflicts between regions and countries, coordinate regulation, and incorporate environment issues into overall planning.
- In the **technical** area of transmission operations, that (i) a master plan should be established to provide information on least-cost plant locations and transmission development; (ii) each of the governments in the region should commit to the construction of specific low-risk, least-cost transmission lines; and (iii) operators of transmission systems should develop an operations protocol to establish procedures to maintain reliable operations and facilitate trading.
- In the **institutional** area, that (i) leadership needs to be assumed by a regional coordination group; (ii) each of the countries should consider establishing an independent regulator in order to reduce financial uncertainties; and (iii) the development community needs to provide technical assistance to strengthen institutions on power trade issues.
- In the **commercial and financial** area, that (i) all generation tariffs and power purchase agreements should be constructed on the basis of a two-part tariff—

a capacity or availability payment related to fixed costs, and an energy payment function of the actual production and variable energy costs; (ii) each country should develop a system of transparent transmission tariffs which will provide a firm basis for expansion and operation of the network; (iii) government and agencies should take all necessary steps to reduce the uncertainty of the future of generation; (iv) governments and utilities in the region should take measures to reduce the risks associated with transmission planning and construction; (v) governments need to decide their policy on taxation and royalties on exports of electricity and communicate it clearly to all interested parties; and (vi) official donors need to provide adequate financial instruments to support transmission development and power trade in the region.

C. Regional Indicative Master Plan on Power Interconnection, 2002. Prepared by Norconsult, under ADB RETA 5920.

This was the first indicative master plan developed for regional power interconnection in the GMS. The master plan compared two main power development scenarios: Scenario 1—Limited Power Cooperation and Scenario 2—Extended Power Cooperation, with a few alternative scenarios (2A, 2B, and 2C) based on varying degrees of power cooperation. It concluded that significant cost savings result from extended power cooperation relating to Scenarios 2B and 2B-rg (scenarios that exclude the most expensive generation projects). Scenario 2B was thus recommended as the indicative master plan on power interconnection in GMS countries. The main sources of power were identified to be hydropower from the Lao PDR, Yunnan Province in the PRC, and Myanmar for export to Thailand and Viet Nam. The recommended scenario was seen to offer promising advantages with regard to fuel diversity, power supply robustness for the participating countries, and substantial reduction of air pollution from thermal plants. The scenario will also require mitigation of local environmental effects arising from some of the hydropower project development and dealing with the acceptability of transmission lines in certain areas.

Two interconnection projects for bulk supply of loads in Cambodia—one from Viet Nam (south) and one from Thailand—are recommended for immediate implementation: the 230-kilovolt (kV) double-circuit line between Chau Doc and Phnom Penh and the 115 kV single-circuit line between Thailand and Cambodia (west). These are anticipated to be in service by 2004.

The establishment of a meshed 500 kV grid for Thailand, the Lao PDR, and Viet Nam by 2008 is likewise recommended. This grid should satisfy the minimum transmission needs of competitive hydropower projects in the area and an (N-1) planning criterion. The meshed grid will involve

- 500 kV double-circuit transmission lines and associated 500/230, 115 kV substations that are needed at an early stage: Tha Tako–Chaiyaphum in 2006, Chaiyaphum–Udon Thani in 2007, and Chaiyaphum–Roi Et in 2007;
- Grid Scenario 2B: a two-step decision procedure resulting in the implementation of (i) a 500 kV double-circuit line Roi Et–Savannakhet–Nam Theun 2–Ha Tinh in 2008, and (ii) a 500 kV single-circuit line Savannakhet–Ban Sok–Pleiku in 2010; or
- Grid Scenario 2B-rg alternative: if financed and implemented with early commissioning in 2008, the following also satisfy the transmission requirements and the (N-1) criterion: (i) 500 kV double-circuit line Roi Et–Savannakhet; (ii) 500 kV single-circuit line Savannakhet–Nam Theun 2–Ha Tinh; and (iii) 500 kV single-circuit line Savannakhet–Ban Sok–Pleiku.

The 500 kV transmission lines above will be part of a subregional meshed main grid. In addition, the study identified some radial interconnection projects that are extensions to this grid: (i) 2008: Grid Connection of Nam Mo hydropower plant (HPP), Lao PDR; (ii) 2009: Interconnection at Vientiane, Lao PDR; (iii) 2009: Grid Connection of Hongsa TPP; (iv) 2012: Grid Connection of Tasang HPP, Myanmar; (v) 2013: 500 kV Interconnection Scheme of Jinghong HPP, Yunnan Province, PRC to Thailand; (vi) 2019: Grid Connection of Malutang HPP, Yunnan Province, PRC; and (vii) 2018/19: 230 kV Interconnection Sambor HPP, Cambodia to Tan Dinh, Viet Nam.

D. Building a Sustainable Energy Future: the Greater Mekong Subregion, ADB, 2009.

The purpose of this study was to help develop a regional strategy for the energy sector to help expand cooperation among GMS countries in meeting rising energy needs and developing a robust regional energy market.

The study results highlighted regional integration as one of the most important opportunities for the GMS to meet a sustainable energy future. Using the energy planning model MESSAGE (Model of Energy Supply Systems Alternative and Their General Environmental Impacts) to undertake optimization exercises, the study results indicated that integration reduces overall energy costs in the next 2 decades by over 19%, or nearly $200 billion lower than the base case with business as usual. The model estimates that the subregion needs to invest $585 billion in power and other energy sectors to ensure that energy will not become a constraint to rapid growth in the GMS. It also predicts that nearly 238 gigawatts (GW) of new capacity will have to be created in the power sector alone. Integration is expected to increase regional energy security by reducing overall energy dependence to the rest of the world by as much as 5.5% of total energy consumption. Accordingly, integrating environmental and social costs also improves overall outcomes in terms of 40% lower coal-based power generation capacity and greater reliance on renewable energy sources and other off-grid solutions by as much as 11 GW.

The study maintains that removing policy and institutional barriers to regional energy trade will yield high returns. Such barriers include overall resource availability, energy policy asymmetries, widely varying levels and speed of energy sector development across GMS economies, a complex regulatory environment arising from lack of a consistent legal framework, limited human and institutional capacity, and market structure limitations.

To meet various emerging challenges and to realize the opportunities of a shared energy future for the GMS, the study recommended priority actions and identified corresponding regional, country, and donor initiatives for seven priority actions:

(i) Mobilize political will for cooperation in all energy sectors, not limited to and beyond the power sector into natural gas and refining, energy efficiency, and energy for all.
(ii) Improve energy efficiency—investing in energy productivity now will help to increase energy security in the era of high and rising energy prices.
(iii) Pursue a time-bound program of sector reform on a GMS-wide basis.
(iv) Reduce oil dependency and review existing approaches to backstop technological options such as coal liquefaction and biofuels.
(v) Review the transport modal mix, given the subregion's high oil dependence and rapid transport sector growth.
(vi) Promote regional private sector participation and innovative solutions, given the large resource requirement.
(vii) Create institutional capital and matching human capability to effectively meet a cleaner, brighter energy future.

E. Update of the Regional Indicative Master Plan on Power Interconnection, 2010. Prepared by RTE International et al., under ADB RETA 6440.

This study updates the regional indicative master plan for power interconnection in the GMS. It covers the period 2010–2025 and used the OPTGEN planning and operation software to run its simulations. The study pictures the GMS interconnection backbone in 2025 to have the largest power exchanges with the PRC, Thailand, and Viet Nam importing power from Myanmar, the Lao PDR, and Cambodia. It concludes that the future GMS regional grid will develop around three main poles:

(i) **North–West pole to connect Myanmar to the PRC and Thailand** to take advantage of a 28 GW hydro potential in Myanmar as a substitute for more expensive thermal coal-fired generation in the PRC and gas-fired generation in Thailand. Large power interconnections (up to 20 GW by 2028) between Myanmar and the PRC will be developed, as well as between Myanmar and Thailand (> 5.5 GW by 2028).
(ii) **East–West Northern link to connect Thailand, the Lao PDR (north), Viet Nam (north), and possibly the PRC** to take advantage of the 10 GW hydro potential in the Lao PDR (north) as a substitute for thermal generation in Thailand, Viet Nam (north), and possibly the PRC. This link will also open the opportunity for exchanges between Thailand and Viet Nam if any surplus situation were to occur in one of these countries, as well as exchanges between the Lao PDR and Thailand or Viet Nam in case of very dry hydrological conditions in the Lao PDR.
(iii) **Southern pole to connect Cambodia, the Lao PDR (south), Viet Nam (center), and Viet Nam (south)** to take advantage of the 5 GW hydro potential in Cambodia and the Lao PDR (south).

Below is the base case schedule of committed and planned interconnection projects under this plan update, expressed in megawatt carrying capacity.

Interconnection	Committed 2011–2015	Planned 2016–2028
PRC – Myanmar	1,680	20,000
Thailand – Myanmar	–	5,800
Thailand – Lao PDR (north)	2,320	2,100
Thailand – Cambodia	60	–
Viet Nam (north) – Lao PDR (north)	–	2,400
Viet Nam (central) – Lao PDR (south)	1,225	900
Viet Nam (south) – Cambodia	220	200
Lao PDR (south) – Cambodia	40	–

The analysis validated the general economic justification of the various interconnections on the basis of generation and transmission costs (levelized cost of transmission $7–$11 MWh vs. price gap of $30/MWh for coal- and $50/MWh for gas-dominated generation mixes). The study confirmed that the financial viability of the prioritized interconnection projects will likely remain resilient to negative shocks from fuel prices and interconnection or hydropower construction costs. Finally, the study estimated benefits due to the expansion of interconnection (compared to a "no expansion" case, where only the interconnection projects committed up to 2015 are developed) to result in global cost savings for the GMS of $14.3 billion (discounted value over the 2010–2030 period) and a reduction of carbon emissions of 14.2 metric tons per year in 2020.

APPENDIX 4

Key Milestones in GMS Regional Power Trade and Cooperation

1992	• Greater Mekong Subregion (GMS) Economic Cooperation Program is initiated.
1994	• The Subregional Energy Sector Study is completed and published in the subsequent year.
	• The 3rd and 4th Ministerial Meetings in Ha Noi and Chiang Mai endorse subregional priority projects, which include eight hydro and transmission line projects, two oil and natural gas projects, and one institutional project, as recommended by the subregional energy sector study.
1995	• The subregional Electric Power Forum (EPF) is established in April 1995.
1998	• The Experts Group on Power Interconnection and Trade (EGP) is established by the EPF, drawn from utilities and GMS member governments.
1999	• The Policy Statement on Regional Power Trade in the GMS is adopted at the 6th EPF in December 1999.
2000	• The Policy Statement on Regional Power Trade in the GMS of 1999 is endorsed by the 9th GMS Ministers' Meeting.
2002	• The regional indicative master plan on power interconnection is completed and endorsed in May 2002.
	• The intergovernmental agreement (IGA) on regional power trade in the GMS is signed at the First GMS Summit in November 2002.
	• The Regional Power Trade Coordination Committee (RPTCC) is established to coordinate the implementation of regional power trade pursuant to the IGA.
2004	• The IGA on regional power trade is ratified by all six GMS countries.
	• The Guidelines for the RPTCC is adopted at the 1st meeting of the RPTCC in July 2004.
2005	• The Memorandum of Understanding on the Guidelines for the Implementation of Stage 1 of the Regional Power Trade Operating Agreement (MOU-1) is signed.
2008	• The MOU on the Road Map for Implementing the GMS Cross- Border Power Trading (MOU-2) is signed.
	• The update of the regional master plan on power interconnection is completed.

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2009	• The study on building a sustainable energy future in the GMS is published [RETA 6301].
2010	• The second update of the GMS regional master plan is completed by RTE International [RETA 6440].
2011	• Discussions on the establishment of the Regional Power Coordination Center (RPCC), the dedicated coordination center for regional power trade, are initiated.
2012	• Two working groups are set up: (i) performance standard and grid code, and (ii) regulatory issues.
	• Intergovernmental MOU is initialed by all members.

APPENDIX 5
Summary of the Meeting Proceedings of the GMS Regional Power Trade and Cooperation

A. Subregional Electric Power Forum (EPF)

Meeting	Discussion/Agreements
EPF 1 Apr 1995, Yangon	The meeting objective was to maintain the momentum of cooperation in the power sector in the GMS, advance subregional initiatives, and reinforce and focus the subregional consultative process. The specific objective was to strengthen institutional cooperation among key units in the power sector to facilitate future undertakings and discuss the terms of reference (TOR) of the EPF, initial work program, implementation, and financing arrangements of the EPF, and next steps. EPF 1 agreed to recommend a revised TOR to the ministerial conference and emphasized that the EPF is an advisory and not a decision-making body. Also discussed were organizational matters and agreement reached on rotating the chairperson among member countries and for ADB to act as co-chairperson providing the necessary technical support and, together with other donors, financial assistance for EPF activities. It was agreed that the EPF 2 meeting agenda will include discussion of certain priority projects agreed to at the 3rd and 4th ministerial conferences, training and human resource development needs in the power sector, and organizational and procedural matters.
EPF 2 Dec 1995, Vientiane	The meeting aimed to strengthen the subregional consultative process with a view to facilitating preparation and implementation of priority power projects. The specific objective was to discuss (i) TORs for Project A1 (Xe Kong and Se San basin hydropower development studies in Cambodia, the Lao People's Democratic Republic [Lao PDR], and Viet Nam, including transmission interconnection among these countries and Thailand) and Project A4 (Nam Theun basin hydropower development study in the Lao PDR, including transmission interconnection between the Lao PDR and Thailand); (ii) arrangements for Project A5 (Thanlwin basin hydropower development study in Myanmar and Thailand, including transmission interconnection between Myanmar and Thailand); (iii) the implementation of Project A3 (feasibility study of transmission interconnection of the Jinghong hydropower project in Yunnan Province in the People's Republic of China [PRC] and Thailand); (iv) training in the power sector; (v) organizational, administrative, and procedural matters related to the operations of the EPF; and (vi) the next steps to be taken. The meeting agreed to consolidate the river basin studies of projects A1 and A4 and discussed the implementation arrangements and details of the regional technical assistance through which the river basin study will be implemented. The meeting also discussed the implementation status of the Project A3 feasibility study of transmission interconnection of the Jinghong

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Meeting	Discussion/Agreements
	hydropower project in Yunnan Province in the PRC and Thailand, with the Lao PDR agreeing in principle to the routing of the transmission line through its northern territory. The feasibility study would in turn take into account the interests of the Lao PDR, including the power situation in the north, as well as the project's impact on flow fluctuations in the downstream countries. It was furthermore recommended that an assessment of priority training requirements in the GMS countries be carried out and that the training in the power sector for neighboring power utilities available in Thailand through the Electricity Generating Authority of Thailand be utilized to the maximum extent possible.
EPF 3 Dec 1996, Kunming	The meeting objectives were to (i) review the progress of implementation of subregional projects and initiatives; (ii) consider ways of enhancing effectiveness of subregional cooperation; (iii) coordinate with activities of other international organizations involved with energy cooperation in the GMS; and (iv) discuss the environmental and social issues in subregional hydropower projects. The meeting (i) discussed implementation updates on various priority projects; (ii) discussed individual member country presentations on the status of their energy sectors and the need to improve the compatibility of the regulatory frameworks covering the power sector in the GMS countries; (iii) agreed to begin with the exchange of information on existing regulatory frameworks and planned modifications; (iv) discussed the Mekong River Commission–sponsored Mekong Integrated Transmission Study, whereupon ADB indicated its readiness to consider technical assistance to support the identification and assessment of options for an appropriate institutional framework for the development and management of the GMS interconnection network; (v) endorsed the World Bank–proposed subregional power market study that would look into the power market, assess the potentials and impediments to power trade and the possible establishment of an electric power pool, and present options for structuring the power market in the subregion; (vi) discussed and considered presentations on social issues in subregional hydropower development; (vii) agreed to include presentations by the private sector, including private financial institutions, involved in power development; and (viii) requested ADB to develop an appropriate information system to monitor developments in the sector, and to disseminate this information to the participating countries and for each country to designate a national focal point to coordinate with ADB.
EPF 4 Oct 1997, Ha Noi	The meeting objectives were to (i) review the progress of implementation of subregional projects and initiatives in the energy sector; (ii) consider ways of advancing the framework for subregional cooperation in energy development and resource sharing; (iii) engage the private sector in a dialogue on issues concerning their participation in energy projects; and (iv) discuss the environmental and social issues in subregional hydropower projects. The meeting (i) reviewed developments in the energy sector, including an overview of the sector developments in the GMS and country-specific status and future directions; (ii) discussed the status of implementation of subregional energy projects; (iii) discussed and agreed in principle to the establishment of an experts group (Experts Grou p on Power Interconnection and Trade, or EGP) within the EPF that would now focus on promoting cross-border trade in electricity and the attendant requirement of developing a regional power grid; (iv) provided the forum for bringing about a better understanding of environmental and social issues; and (v) highlighted the important role of the private sector in energy development during the panel discussion with private sector representatives and recognized that governments will need to play a key role in creating the enabling environment for promoting private sector participation.

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Meeting	Discussion/Agreements
EPF 5 Dec 1998, Bangkok	The meeting objectives were to (i) provide an assessment of the energy sector in the context of the economic crisis; (ii) review the progress of implementation of priority subregional projects in the energy sector; (iii) discuss the energy sector components in the GMS Indicative Work Program for 1998–2000; and (iv) consider the preparation of a policy statement on regional power trade. The meeting (i) covered a review of energy sector developments in the context of the economic crisis, including a review of the energy supply and demand in the GMS and country-specific developments; (ii) discussed and updated on the status of implementation of ongoing priority subregional projects, as well as ADB's GMS Indicative Work Program; (iii) acknowledged the holding of the First and Second EGP in June and December 1998, respectively, and for which the Second EGP covered (a) the generation and transmission system master plans, (b) the planning and design criteria for generation and transmission systems, (c) the policy statement on regional power trade and regional protocol, and (d) the adoption of the work plan of the EGP for 1999–2001; (iv) discussed the findings of the World Bank study "Power Trade Strategy for the Greater Mekong Subregion" and the World Bank's program to support the GMS efforts toward power systems integration and development of power trade, highlighting the three key objectives of the forthcoming activities of the EGP up to 2001: development of a regional master plan; study of a viable organizational structure and regulation for the future regional pool; and, finally, development of regional protocols at both the government and utilities levels. The meeting also held a discussion series on integrating area development in hydropower projects, with ADB staff and representatives from E7 and the Tennessee Valley Authority invited as resource persons for the session.
EPF 6 Oct 1999, Phnom Penh	The meeting covered (i) the review of country-specific developments in the energy sector and country presentations on the power situation in Thailand and Viet Nam; (ii) large dams and recommended practices and lessons learned from the implementation of the Nam Leuk hydropower project in the Lao PDR; (iii) regional cooperation in building power utility capabilities; and (iv) consideration of the summary of proceedings and recommendations made by EGP 3, especially the Policy Statement on Power Trade. The meeting also held a discussion series on the changing role of independent power producers (IPPs), including the development context in the Thailand power market, the power sector reform experience in the Philippines and Australia, and legal issues of IPPs in competitive markets and inter-state exchange.
EPF 7 Dec 2000, Vientiane	The meeting objectives were to discuss important developments that will significantly impact future directions of GMS cooperation in the energy sector, especially the power sector restructuring in Thailand and Malaysia, and the final report of the World Commission on Dams (WCD). The meeting covered presentations and discussions on (i) the energy sector liberalization and privatization policy in Thailand; (ii) experience, lessons, and future directions for power sector restructuring in Malaysia; (iii) final report by the WCD on Development, which finds that while dams have made significant contributions to development, there have been many cases of unnecessary social costs and large inequities in the distribution of costs and benefits, which need to be addressed through several strategic priorities recommended by the WCD; and (iv) the work plan of the EGP up to 2003 and consideration of the report of the EGP-4.

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Meeting	Discussion/Agreements
EPF 8 Dec 2001, Ha Noi	The meeting (i) undertook country presentations on power sector policy developments, including generation and transmission plans; (ii) discussed the adoption of the Inter-Governmental Agreement (IGA) on Power Trade by the EPF, which would be the prerequisite to the IGA's signing, and adopted the revised draft, which would be endorsed for signing at the 11th GMS Ministerial Conference in 2002; and (iii) noted the report of the EGP-6, wherein the draft report of the Indicative Master Plan on Power Interconnection in the GMS was extensively discussed and for which a second draft report was to be circulated.
EPF 9 Oct 2002, Yangon	The meeting discussed (i) the progress toward the signing of the IGA on Regional Power Trade in the GMS; (ii) latest developments in the power sector reforms in the PRC and in the power sector of Yunnan Province, PRC relevant to the GMS power market; (iii) and the structural, institutional, and regulatory options for the future GMS regional power market, as well as examples worldwide; and (iv) approval/adoption of guidelines for the establishment of the Regional Power Trade Coordination Committee (RPTCC) pursuant to the IGA, for which on the issue of representation the members agreed that, given the policy issues and need to commit resources, representatives to be appointed to the RPTCC need to be of a very high level with responsibility for policy decision-making within their own organizations.
EPF 10 Nov 2003, Guangzhou	The meeting (i) discussed the road map for accelerating the implementation of the IGA, during which a session on the RPTCC was held to facilitate ratification of the IGA and follow-up nomination of RPTCC members, as well as to agree on immediate steps to set up the RPTCC; (ii) discussed the work plan for the study on the regional power trade operating agreement (RPTOA); (iii) discussed the findings of the World Bank–assisted study of options for the structure of the GMS power market; and (iv) was provided with an update of the proposed assistance programs by the PRC and Thailand within the power sector of other GMS countries.
EPF 11 Dec 2004, Bangkok	The meeting discussed (i) the report of the study to update the energy sector strategy, recommendations on the possible extension of scope of the EPF to the whole energy sector, and country positions on priority areas for GMS cooperation; (ii) the energy components of the development matrix, particularly those in the flagship program for regional power interconnection and trade, and the flagship programs for the three priority GMS corridors; and (iii) the proposed roles of development partners in energy and power trade cooperation in the GMS. EPF 11 was the last meeting of the EPF, before its functions were subsumed under the new Subregional Energy Forum (SEF).

B. Expert Group on Regional Power Trade and Interconnection (EGP)

Meeting	Discussion/Agreements
EGP 1 Jun 1998, Bangkok	The first EGP meeting was very brief and concluded with an agreement on the agenda for the second EGP meeting.
EGP 2 Dec 1998, Bangkok	The meeting objectives were to (i) review the updates of the countries' transmission and generation master plans; (ii) review the existing planning criteria for generation and transmission systems; (iii) discuss preparation of a draft policy statement for regional power trade in the GMS; and (iv) develop a work plan to promote regional power trade. The meeting was presented with and discussed (i) specific country updates of generation and transmission system master plans; (ii) the planning and design criteria for generation and transmission systems for each GMS country; (iii) a draft policy statement on regional power trade and regional protocol; and (iv) the adoption of the EGP work plan for 1999–2001.
EGP 3 Oct 1999, Phnom Penh	The meeting objectives were to review the findings on the EGP work program consisting of (i) updates on each country's transmission and generation master plans; (ii) a draft of the Policy Statement on Regional Power Trade; (iii) a draft of the Regional Protocol on Power Trade; (iv) the TOR for the formulation of the Regional Indicative Master Plan; and (v) preparation of workshop no. 1 on the coordination of technical issues. The meeting discussions covered (i) country presentations updating on transmission and generation master plans; (ii) details of the draft policy statement on regional power trade; (iii) regional protocol on power trade proposed by the World Bank, noting that there are two types of agreements that will be needed to promote trade in the region—the Inter-Governmental Memorandum of Understanding and the Market Operating Agreement; (iv) the draft TOR for the regional indicative master plan to be supported by ADB; and (v) the pre-workshop questionnaire to serve as background toward better understanding coordination issues in the transmission and telecommunication between national transmission networks.
EGP 4 Dec 2000, Vientiane	The meeting objectives were to (i) provide a report of activities since the last meeting; (ii) exchange information on power sector policy developments and generation/transmission plans; and (iii) discuss the future agenda of the group. The focus of the meeting was on the country reports on power sector developments, as well as the Inception Report of the Regional Indicative Master Plan on Power Interconnection in the GMS. The meeting highlights included (i) country presentations on power sector policy developments and plans, which found that power demand had risen since the crisis, and power reforms had been broadly pursued in the GMS; (ii) the long-term power generation and transmission plan of Malaysia showing rapid power demand growth with huge potential for cooperation with the GMS; (iii) substantial progress made toward the development of a regional power market in the GMS and the technical assistance by the World Bank to the EGP to continue, with additional reference to be provided by the E7 report on pooling of resources and interconnection of power systems; and (iv) the inception report on the Regional Indicative Master Plan for Power Interconnection in the GMS.

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Meeting	Discussion/Agreements
EGP 5 Jun 2001, Kunming	The meeting was divided into three major daily sessions as follows: (i) consideration of the Interim Report for the Study on the Regional Indicative Master Plan on Power Interconnection in the GMS, including sections covering long-term power demand and supply options, by country and GMS-wide; (ii) discussion of the interconnection candidates for study and the institutional and regulatory arrangements of the master plan study and presentations by GMS countries of their proposed work plans (2002–2004) for the energy sector; and (iii) review of the latest draft of the IGA. SEACTED also presented on Human Resource Management and Development for Power Utilities in the GMS.
EGP 6 Dec 2001, Ha Noi	The meeting objectives were to discuss Norconsult's draft final report for the Study on the Regional Indicative Master Plan on Power Interconnection in the GMS and to be followed by discussion of the EGP work plan. The meeting was devoted largely to the presentation and review of the master plan, covering sections on (i) long-term power demand forecast; (ii) compatibility of transmission systems and technical coordination; (iii) generation expansion scenarios; (iv) transmission development scenarios; (v) economic comparison of scenarios; (vi) summary of 13 prioritized indicative power transmission projects and project profiles for proposed interconnections; (vii) availability of financial resources for power investments; and (viii) institutional and regulatory arrangements. The draft work plan of the EGP, as submitted by EGP members, was also discussed.
EGP 7 May 2002, Chiang Mai	The meeting aimed to discuss, among others, the EGP activities after the IGA signing, especially the guidelines for the establishment of the RPTCC and preparation of the RPTOA, and to review the second draft of the master plan study. The meeting (i) discussed the contents of the draft guidelines for the RPTCC and held initial discussion on the processes of the RPTCC; (ii) discussed the progress of signing of the IGA and commented on the implementation arrangements for the study on the RPTOA; (iii) reviewed the second draft of the master plan study and tackled follow-up actions for the master plan; and (iv) was provided with a presentation of the results of the Japan Bank for International Cooperation study on "Regional Cooperation Strategy in Interconnected Power Networks in IndoChina."
EGP 8 Oct 2002, Yangon	The meeting (i) discussed further the establishment of the RPTCC and reviewed the draft RPTCC guidelines; (ii) discussed and noted progress of power sector development in the GMS countries; and (iii) considered and adopted the completed study on the Indicative Master Plan on Power Interconnection in the GMS, and the proceedings of the EGP 7 and EGP 8 meetings. Specifically on the establishment of the RPTCC and its draft guidelines, the meeting agreed that (i) the RPTCC would be formally constituted upon entry into force of the IGA (i.e., when the IGA is ratified by at least three countries); (ii) upon IGA signing, the EPF and EGP could act as a base to form the RPTCC and working groups (tasked to determine first steps for establishing power trade arrangements); (iii) country representation in the RPTCC will comprise three individuals—one from the ministry responsible for power, one from the power utility, and a third at the discretion of government; (iv) flexibility will be exercised in naming the power trade coordinator, who would coordinate activities and serve as a link between the RPTCC, RPTOA working groups, and governments; (v) the RPTCC chair would be rotated annually; (vi) the vice-chairperson would likewise serve as RPTOA project manager and would not be rotated until the draft RPTOA has been agreed upon; and (vii) the home institution of the RPTOA project manager would provide administrative support for drafting the RPTCC guidelines during drafting of the RPTOA.

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Meeting	Discussion/Agreements
EGP 9 Nov 2003, Guangzhou	The meeting objectives were to discuss (i) progress and future plans for power restructuring in the PRC; (ii) latest developments and policy changes in the power sector of GMS countries; (iii) international experiences on cross-border trade; and (iv) a briefing on the GMS Power Interconnection Phase I project. The meeting (i) discussed the latest developments and policy changes in the power sector in the GMS countries, particularly the long-term investment plans, financing sources, gaps, and the tariff structure; (ii) discussed the progress of power sector restructuring in the PRC, as well as the international experiences in cross-border power transactions; (iii) discussed the status of the project preparatory technical assistance for the GMS Power Interconnection Project Phase I; and (iv) also apprised that with ratification of the IGA by three members, there would be election of officers of the RPTCC on the second day. EGP 9 was the last EGP meeting, following the constitution of the RPTCC and its taking over of EGP functions.

C. Regional Power Trade Coordination Committee (RPTCC)

Meeting	Discussion/Agreements
RPTCC 1, Jul 2004, Guilin	The meeting objectives were to hold discussions on (i) an overview of GMS energy cooperation; (ii) review and adoption of RPTCC guidelines; (iii) proposals on the RPTCC work plan by GMS members, the World Bank, and ADB; and (iv) review of the RPTOA interim report including international experiences, simulations in cross-border transactions, and PTOA general design. The meeting (i) elected its first RPTCC chairperson; (ii) affirmed the GMS commitment to the IGA, with the sixth country Cambodia expecting to ratify the IGA; (iii) adopted the Guidelines for the RPTCC; (iv) reached agreement on the draft RPTCC work plan; and (v) discussed the priorities reflected in the GMS development matrix.
RPTCC 2, Dec 2004, Bangkok	The meeting purpose was to hold discussions to (i) review the draft final report on the study for the Regional Power Trade Operating Agreement (RPTOA); (ii) review the draft PTOA agreement; (iii) review the inception report for the preparation of phase 1 of the GMS power interconnection project; and (iv) finalize the work plan of the RPTCC (based on discussions held at RPTCC 1).
RPTCC 3, Apr 2005, Vientiane	The meeting discussed the (i) second draft of the final report of the study for the RPTOA, including (a) general design, key revisions, and changes in recommended actions, (b) draft text of the initial agreement to install Stage 1 of the RPTOA, with timeframe and plan for approval and signing, and (c) proposed institutional arrangements of the RPTOA; (ii) interim report for the preparation of Phase I of the GMS Power Interconnection project; (iii) country presentations on proposed framework for the RPTOA; (iv) GMS energy cooperation projects and institution building for the RPTCC; (v) consultants' feedback on discussions on RPTOA and RPTCC institutional development; (vi) update and revision of the work plan of the RPTCC; (vii) the proposed GMS power transmission line interconnecting the PRC, the Lao PDR, and Thailand; (viii) the proposed technical assistance paper for an energy sector strategy study; and (ix) development partners' perspectives on GMS energy cooperation.

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Meeting	Discussion/Agreements
RPTCC 4, Sep 2005, Yangon	The meeting objectives were to discuss (i) institutional arrangements and the action plan for implementing Stage 1 of the RPTOA, including establishment of the RPTCC-Focal Group (FG); (ii) case studies on regional power trade, including cross-border transmission pricing; (iii) RPTCC country programs and work plan, including updates; (iv) the proposed ADB regional technical assistance (RETA); and (v) the proposed GMS power interconnection projects.
RPTCC 5, Jun 2006, Siem Reap	The meeting objectives were to (i) discuss and decide on the recommendations of the FG for priority RPTCC activities, and confirm the work plans for both the RPTCC-FG and the RPTCC Planning Working Group; (ii) take stock of various ongoing and planned ADB assistance to the GMS energy sector, and (iii) discuss and derive lessons from recent experiences in developing regional energy markets.
RPTCC 6, May 2007, Sanya	The meeting aimed to (i) confirm the FG-4 agreements and recommendations on the next steps and timelines of priority RPTCC studies and activities; (ii) discuss updates on the ongoing and proposed technical assistance to the RPTCC; (iii) review, refine, and set the milestones for preparation of the proposed MOU on the power trade road map and action plan on energy; and (iv) brief GMS representatives on the experiences in developing other regional energy markets.
RPTCC 7, Nov 2008, Ho Chi Minh	The meeting reviewed the overall results of RETA 6304: Regional Power Trade Coordination and Development, in terms of the major RETA components on training, website/database development, studies on performance standards and transmission regulation, and master plan update. This review served as the basis for charting the way forward under the new RETA 6440: Facilitating Regional Power Trading and Environmentally Sustainable Electricity Infrastructure in the GMS.
RPTCC 8, Nov 2009, Luang Prabang	The meeting objectives were to (i) discuss ways to strengthen linkages between RETA 6440 and other subregional programs in promoting environmentally sustainable regional power trade development; (ii) firm up the objectives, scope, and components of proposed projects for advancing regional power trade under the GMS Energy Road Map; (iii) share knowledge and experience that would provide suitable generation and transmission technology options for GMS countries' power development programs; and (iv) share appropriate practices for promoting renewable energy and energy efficiency in the GMS, a continuation of the Subregional Energy Forum (SEF) knowledge sharing series.
RPTCC 9, Oct 2010, Shenzhen	The meeting (i) took stock of the final reports and recommendations of RETA 6440; (ii) discussed successor RETA on support for sustainable GMS power trade development and its implementation arrangements; (iii) reviewed the country progress reports on power development plans; and (iv) considered various institutional options for developing power trade.
RPTCC 9A, Dec 2010, Bangkok	The meeting objectives were to (i) undertake further discussions on the establishment of a proposed Regional Coordination Center (RCC) to oversee GMS power trade development, which was initiated at the RPTCC 9 meeting in Shenzhen on 26 October 2010; (ii) endorse the final results and recommendations of RETA 6440, such as priority interconnections identified in the master plan update, and other activities in relation to the milestones to fully achieve stage 1 of power trading; and (iii) take up SEF matters, such as the appointment of the SEF chair for 2 years and agreement on future topics for the knowledge-sharing sessions.

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Table continued

Meeting	Discussion/Agreements
RPTCC 10, May 2011, Siem Reap	The meeting objectives were to (i) discuss the requirements for setting up of an RCC for power trade in the GMS; (ii) look into a suitable governance structure of the RCC; (iii) discuss the selection criteria for RCC headquarters, headquarters agreement, staffing, and funding; and (iv) discuss the contents of an agreement to establish the RCC. In addition, the RPTCC 10 meeting discussed the latest draft of the new GMS Strategic Framework, the results framework for energy, and its implications on the GMS energy cooperation program, as well as the proposed complementary capacity-building program at the national level in the GMS.
RPTCC 11, Nov 2011, Ho Chi Minh	The meeting objectives were to (i) review the previous discussions/agreements on setting up the Regional Power Coordination Center (RPCC); (ii) discuss the draft agreement to establish the RPCC; and (iii) discuss updates on organizing the evaluation committee for the RPCC headquarters and the selection process. The RPTCC 11 meeting additionally took up (i) country updates on power development programs (PDPs) especially cross-border projects; (ii) knowledge sharing on smart metering and on the Association of Southeast Asian Nations Energy Regulators' Network (AERN); (iii) preliminary findings of the review of RETA 6440 and the GMS power trade program; (iv) introduction to RETA 7764 on ensuring sustainability of GMS power development; and (v) the RPTCC work plan (master plan disclosure, etc.).
RPTCC 12, May 2012, Vientiane	The meeting was held mainly to continue discussions on the inter-governmental MOU to establish the RPCC focused on further firming up the draft inter-governmental MOU based on proposed amendments received by ADB during and after the RPTCC meeting held in Bangkok in March 2012. The meeting also covered the (i) finalization of the RPCC headquarters selection criteria and process; (ii) presentation of the revised scope of work of the working groups on (a) regulatory issues and (b) performance standards and grid code, discussion of their work plans, and finalization of the chair, vice-chair, and GMS nominees to the working groups; and (iii) discussion of the progress of RETA 7764: Ensuring Sustainability of GMS Regional Power Development.

APPENDIX 6

Four Stages of Regional Power Trade Development

Given the differences in the regulatory frameworks and transmission networks in the Greater Mekong Subregion (GMS), the subregional power market is expected to evolve in stages. These broad stages of regional power development in the GMS were first introduced in a World Bank study on Options for the Structure of the GMS Power Trade Market published in 2006 and confirmed in the ADB-implemented Study on Regional Power Trade Operating Agreement released in 2004/2005. The following four stages were defined:

Stage 1 The initial period when only country-to-country power transactions are possible, before a regional transmission network is established to enable power trading between any pair of member countries. During this period, the existing cross-border transmission lines are mostly associated with power purchase agreements between the parties or an independent power producer located in any one party country selling power to a national power utility in a neighboring country. The cross-border trading in Stage 1 refers to opportunity exchange of power between national power utilities of the parties using the excess capacity of existing cross-border transmission lines over and above the transmission capacity required for power transfers associated with power purchase agreements.

Stage 2 The moment when trading is possible between any pair of GMS countries, eventually using transmission facilities of a third regional country. However, in this stage the available cross-border capacity is limited and based on surplus capacity of lines linked to power purchase agreements.

Stage 3 This stage occurs when interconnectors for cross-border trade are expressly developed and third parties other than national power utilities are allowed to begin trading over these.

Stage 4 This last stage corresponds to when a regional competitive market exists, whereby multi-buyer and multi-seller markets can execute trades within and across countries.

References:

Greater Mekong Subregion Memorandum of Understanding on the Guidelines for the Implementation of Stage 1 of the Regional Power Trade Operating Agreement (MOU-1);
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, DC.

APPENDIX 7
ADB Assistance to the GMS Energy Sector

Table A7.1: Lending and Technical Assistance, 1992–2011

A. Loans

Loan No.	Project Name	Objective/Project Description	Date Approved	Amount ($ million)
LAO-1214	Nam Song Hydropower Development	The project will result in (i) increased foreign exchange earnings from increased electricity exports to Thailand; (ii) foreign exchange savings from the substitution of imported fuels with electricity generated by the project; and (iii) at a later stage, local economic development resulting from an increased supply of electricity to the local market. The project has four components, the first of which is the construction of a 21- meter-high concrete weir on the Nam Song River to divert an average of about 65 cubic meters per second of water through natural valleys and a 2.5-kilometer-long canal into the existing Nam Ngum Reservoir. The project is expected to generate an additional 137 gigawatt-hours (GWh) of electricity per annum at the existing Nam Ngum Hydropower Station. The other three components are for the engineering design of the proposed Nam Leuk hydropower station, the feasibility study of Nam Hang 3 hydropower, and the procurement of electrical metering equipment for about 10,400 consumers to improve the accuracy of metering capacity in Vientiane.	21 Dec 1992	31.5
LAO-1329	Theun-Hinboun Hydropower	The project aims to support economic growth in the Lao People's Democratic Republic (Lao PDR) by enhancing foreign exchange earnings through the export of electric power to Thailand. It involves the construction of 210-megawatt (MW) run-of-river hydropower plant and its associated 230-kilovolt (kV) double-circuit transmission line, 86 kilometers from the project site in the Lao PDR to Thakhek on the Thai border. It is the first joint venture of the Government of the Lao PDR with the private sector for financing, constructing, and operating a power plant.	8 Nov 1994	60

continued on next page

Table A7.1: continued

Loan No.	Project Name	Objective/Project Description	Date Approved	Amount ($ million)
LAO-1456	Nam Leuk Hydropower	The project objective is to, among others, support the optimal development of the country's power subsector and provide generating capacity to meet domestic demand and increase exports of electricity to Thailand. It entails construction of 60 MW hydropower capacity, which will generate 215 GWh of hydropower annually both for the domestic market and for exports to Thailand. In addition, the project will increase the diverted water flow energy generation at the existing hydropower station downstream at Nam Ngum by 30 GWh.	10 Sep 1996	52
CAM-2052	Greater Mekong Subregion Transmission	The project objective is to stimulate trade and economic growth in the subregion by promoting the provision of sustainable and reliable electricity at affordable prices to consumers in Cambodia and to promote socioeconomic development and poverty reduction in Cambodia by enhancing accessibility to electricity on the part of the poor by continuing to reduce the high up-front connection costs. It will involve installation of a 200 MW capacity, 220 kV transmission line from the Vietnamese border to Phnom Penh, the first component of the GMS regional interconnection master plan to be implemented. A bulk supply distribution component will provide reliable medium-voltage supplies to villages along the transmission line route and encourage small private operators to invest in and operate connections to rural end-consumers.	15 Dec 2003	44.3
LAO-2161/2162/7210	GMS: Nam Theun 2 Hydroelectric	The project aims to promote economic growth in the region by developing hydroelectric power resources. Project revenues will support the government's priority poverty reduction and environmental conservation programs as outlined in the National Growth and Poverty Eradication Strategy. It involves a 1,070 MW trans-basin diversion power plant on the Nam Theun River, a tributary of the Mekong, in the central region of the Lao PDR. It will export 5,354 GWh of electricity to Thailand and will provide revenue to the Lao PDR through taxes, royalties, and dividends. The project provides 200–300 GWh of electricity for domestic use. The project will be developed by a private company, the Nam Theun 2 Power Company Limited, and is structured as a build–own–operate–transfer, with a concession period of 31 years, of which the operating period is 25 years.	4 Apr 2005	20/50/50

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Table A7.1: continued

Loan No.	Project Name	Objective/Project Description	Date Approved	Amount ($ million)
CAM-7256/2337	Cambodia Power Transmission Lines Co., Ltd.	The project is an integral part of Cambodia's Power Transmission Master Plan which seeks to reduce reliance on imported oil for generation and to achieve improved security, reliability, and efficiency (least cost) of energy supply. It will bring needed electricity to poorly served load centers at much reduced cost. The project comprises approximately 221 kilometers of a single-circuit 115 kV transmission line, three substations, and a switching station. The project will be the national transmission grid for northwest Cambodia and therefore part of Cambodia's national grid. It will connect to Thailand's 115 kV line at the Thai border—some 12 kilometers north of the present Poipet vehicular border crossing point—and, from there, will cross and deliver power to three provinces in northwest Cambodia—Banteay Meanchey, Battambang, and Siem Reap. The project will enable Électricité du Cambodge (EDC) to import reliable power from Thailand at competitive rates under a power purchase agreement between the Electricity Generating Authority of Thailand (EGAT) and EDC signed in 2002. The project will transmit about 23–80 MW of equivalent capacity over its 30-year life.	27 Jun 2007	8
LAO-2818/2819(SF)/7341/2799	Greater Mekong Subregion Nam Ngum 3 Hydropower Project	The project will (i) potentially provide revenue flows to the government in the form of taxes, royalties, and dividends currently estimated at $771 million over the 27-year concession period; (ii) increase regional cooperation in the GMS; (iii) promote economic growth in the Lao PDR through private sector investment, technology transfer, employment generation, and local infrastructure development; and (iv) ensure sustainable development in northeast Thailand by achieving energy security and reducing greenhouse gas emissions. The main features of the project include a 440 MW capacity hydropower plant and an associated 100-kilometer-long 500 kV transmission line connecting to an existing substation in Nabong where transmission lines from other power export projects will also be linked. The project is developed as a public–private partnership sponsored by the Nam Ngum 3 Power Company, which will sell an average of 2,072 GWh annually to EGAT.	3 Nov 2011	98.2/16.92/200/150

CAM = Cambodia, LAO = Lao People's Democratic Republic.

Source: Asian Development Bank.

B. Regional Technical Assistance (RETA): Advisory

RETA No.	Title	Total Amount	Date Approved
REG-5643	Subregional Electric Power Forum – GMS	78,000	20 Sep 1995
REG-5920	Regional Indicative Master Plan on Power Interconnection in the GMS	900,000	10 Jul 2000
REG-6100	Study for a Regional Power Trade Operating Agreement in the GMS	850,000	21 Apr 2003
REG-6301	Developing the GMS Energy Sector Strategy	900,000	3 Jan 2006
REG-6304	GMS Regional Power Trade Coordination and Development	1,200,000	16 Jan 2006
REG-6301	Developing the GMS Energy Sector Strategy (Supplementary)	150,000	13 Nov 2007
REG-6440	Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the GMS	5,000,000	19 Dec 2007
REG-7764	Ensuring Sustainability of GMS Regional Power Development	1,350,000	12 Nov 2010
	Total	**10,428,000**	

GMS = Greater Mekong Subregion, REG = regional.

Source: Asian Development Bank.

C. Technical Assistance (TA): Feasibility Study and Project Preparation

TA No.	Title	Total Amount	Date Approved
LAO-2054	Theun–Hinboun Power	100,000	4 Jan 1994
REG-5697	Se Kong–Se San and Nam Theun River Basins Hydropower Development Study	2,500,000	22 Aug 1996
LAO-2926	Nam Ngum 500 kV Power Transmission	580,000	28 Nov 1997
LAO-3225	Analyzing and Negotiating Financing Options for the Nam Leuk Hydropower Project Cost Overruns	140,000	
CAM-4078	Power Distribution and Greater Mekong Subregion Transmission	730,000	10 Jan 2003
LAO-4213	GMS: Nam Theun 2 Hydropower Development	700,000	9 Nov 2003
REG-6147	GMS Power Interconnection Project, Phase I	800,000	12 Dec 2003
LAO-4323	GMS: Nam Theun 2 Hydropower Development Phase II	1,000,000	29 Mar 2004
LAO-4816	Greater Mekong Subregion Northern Power Transmission	800,000	19 Jul 2006
LAO-4921	Cumulative Impact Assessment for the Nam Ngum 3 Hydropower Project	983,000	21 Feb 2007

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Table continued

TA No.	Title	Total Amount	Date Approved
LAO-7026	Na Bong–Udon Thani Power Transmission	760,000	12 Dec 2007
LAO-7094	GMS Nam Theun 2 Hydroelectric Project–Social Safeguards Monitoring	400,000	7 Jul 2008
REG-6481	Ban Sok–Pleiku Power Transmission Project in the GMS	1,000,000	26 Aug 2008
LAO-7094	GMS Nam Theun 2 Hydroelectric Project–Social Safeguards Monitoring (Supplementary)	225,000	29 Oct 2010
	Total	**10,718,000**	

CAM = Cambodia, GMS = Greater Mekong Subregion, kV = kilovolt, LAO = Lao People's Democratic Republic, REG = regional.

Source: Asian Development Bank.

Table A7.2: Details of ADB-Assisted Projects for GMS Power Trade and Interconnection

A. Completed

Project	Location	Market	Type	Capacity (MW)	Completion Date
Theun–Hinboun	Lao PDR	Thailand	Hydro	210	1998
Nam Leuk	Lao PDR	Lao PDR, Thailand	Hydro	60	2000
GMS Transmission	Cambodia to Viet Nam border	Cambodia	Transmission	200	2008
Nam Theun 2	Lao PDR	Thailand	Hydro	1,088	2010

GMS = Greater Mekong Subregion, Lao PDR = Lao People's Democratic Republic, MW = megawatt.

Source: Asian Development Bank.

B. Ongoing

Project	Location	Market	Type	Capacity	Expected Completion Date
Nam Ngum 3	LAO	Thailand	Hydro	440 MW	2017
GMS Northern Power Transmission	LAO to THA	Lao PDR, Thailand	Inter-connection	115 kV	2013
Transmission Line–Link between Kampot and Sihanoukville	VIE to CAM	Viet Nam	Inter-connection	220 kV	2013
Cambodia Power Transmission Lines Co., Ltd.	CAM	Cambodia	Transmission	115 kV	n.a.

CAM = Cambodia, kV = kilovolt, LAO/Lao PDR = Lao People's Democratic Republic, MW = megawatt, n.a. = not available, THA = Thailand, VIE = Viet Nam.

Source: Asian Development Bank.

C. Planned

Project	Location	Market	Type	Capacity	Target Completion Date
Nabong 500 kV Substation Transmission Facility Project	LAO		Transmission		(2012 Firm, RCBOP 2012–2014)
Lao PDR–Viet Nam Power Interconnection	LAO, VIE		Inter-connection		(2013 Firm, RCBOP 2012–2014)

kV= kilovolt, LAO/Lao PDR = Lao People's Democratic Republic, MW=megawatt, RCOBP= Regional Cooperation Operations Business Plan, VIE = Viet Nam.

Source: Asian Development Bank.

Table A7.3: ADB Assistance for Developing GMS Regional Power Systems

Loan		Technical Assistance
LOAN 1214-LAO: Nam Song Hydropower Development, $31.5 million	1992	• TA 5487-REG: Studies in Subregional Cooperation among Cambodia, the PRC, the Lao PDR, Myanmar, Thailand, and Viet Nam (Phase I), $270,000.
	1993	• TA 5535-REG: Promoting Subregional Cooperation among Cambodia, the PRC, the Lao PDR, Myanmar, Thailand, and Viet Nam (Phase II). JSF: $3 million, ADB: $1.5 million, Sida: $760,000.
LOAN 1329-LAO: Theun–Hinboun Hydropower Project, $60 million	1994	• TA 2054-LAO: Theun–Hinboun Power. ADB: $100,000.
	1995	• TA 5643-REG: Subregional Electric Power Forum–GMS. Norway: $78,000.
LOAN 1456-LAO: Nam Leuk Hydropower Project, $52 million	1996	• TA 5697-REG: Se Kong–Se San and Nam Theun River Basins Hydropower Development Study. ADB: $500,000, France: $2.0 million.
	1997	• TA 2926-LAO: Nam Ngum 500 kV Power Transmission. ADB: $580,000, Lao PDR: $25,000.
	1999	• TA 3225-LAO: Analyzing and Negotiating Financing Options for the Nam Leuk Hydropower Project Cost Overruns. ADB: $140,000.
	2000	• TA 5920-REG: Regional Indicative Master Plan on Power Interconnection in the GMS. ADB: $158,000, Norway: $742,000, GMS governments: $50,000.
LOAN 2052-CAM: GMS Transmission Project, $44.3 million	2003	• TA 4078-CAM: Preparing the Power Distribution and GMS Transmission Project. ADB: $730,000, Cambodia: $180,000.
		• TA 4213-LAO: Preparing the GMS Nam Theun 2 Hydropower Development Project. ADB: $700,000, Lao PDR: $60,000.
		• TA 6100-REG: Study for a Regional Power Trade Operating Agreement in the GMS. ADB: $850,000, GMS governments: $70,000.
		• TA 6147-REG: Preparing the GMS Power Interconnection Project, Phase I. ADB: $800,000, GMS governments: $160,000.
	2004	• TA 4323-LAO: GMS NT2 Hydropower Development Project, Phase II. ADB: $1 million, Lao PDR: $180,000.
LOAN 7210/2161/2162 LAO: Nam Theun 2 Hydroelectric Project, $70 million	2005	• None
	2006	• TA 6301-REG: Developing the GMS Energy Sector Strategy. AFD: $1.2 million, GMS governments: $100,000.
		• TA 6304-REG: GMS: Regional Power Trade Coordination and Development. ADB: $900,000, GMS governments: $100,000.
		• TA 4816-LAO: GMS Northern Power Transmission Project. ADB: $800,000, Lao PDR: $150,000.

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Figure A7.1: continued

Loan		Technical Assistance
LOAN 7256/2337-CAM. Cambodia Power Transmission Lines Co., $8 million	2007	• TA 4921-LAO: Cumulative Impact Assessment for the Nam Ngum 3 Hydropower Project. ADB: $983,000. • TA 6301-REG: Developing the GMS Energy Sector Strategy (Supplementary). ADB: $150,000. • TA 6440-REG: Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the GMS. Sweden: $5 million, GMS governments: $5 million. • TA 7026-LAO: Na Bong–Udon Thani Power Transmission. ADB: $760,000, Lao PDR: $150,000.
	2008	• TA 7094-LAO: GMS Nam Theun 2 Hydroelectric Project – Social Safeguards Monitoring. ADB: $400,000.
	2010	• TA 7094-LAO: GMS Nam Theun 2 Hydroelectric Project – Social Safeguards Monitoring (Supplementary). ADB: $225,000. • TA 7764-REG: Ensuring Sustainability of GMS Regional Power Development. AFD: $1.35 million.
LOAN 2818/2819(SF)/7341/2799-LAO: GMS Nam Ngum 3 Hydropower Project, $465 million	2011	• None

AFD = Agence Française de Développement, CAM = Cambodia, GMS = Greater Mekong Subregion, JSF = Japan Special Fund, kV = kilovolt, LAO = Lao People's Democratic Republic, PRC = People's Republic of China, REG = regional, TA = technical assistance.

Source: Asian Development Bank.

APPENDIX 8
Export-Oriented Power Plants in the GMS

1. Operational Plants

Project	Location	Market	Type	Capacity (MW)	Completion Date
Nam Ngum 1	Lao PDR	Lao PDR/ Thailand	Hydro	155	1971
Se Xet 1	Lao PDR	Lao PDR/ Thailand	Hydro	45	1990
Theun–Hinboun (IPP)	Lao PDR	Lao PDR/ Thailand	Hydro	210	1998
Houay Ho (IPP)	Lao PDR	Thailand	Hydro	152	1999
Nam Leuk	Lao PDR	Lao PDR/ Thailand	Hydro	60	2000
Nam Mang 3	Lao PDR	Lao PDR/ Thailand	Hydro	40	2004
Se Xet 2	Lao PDR	Lao PDR/ Thailand	Hydro	76	2009
Nam Theun 2 (IPP)	Lao PDR	Lao PDR/ Thailand	Hydro	1,075	2010
Nam Ngum 2 (IPP)	Lao PDR	Thailand	Hydro	615	2011
Shweli-1 (IPP)	Myanmar	Myanmar/ Yunnan Province, PRC	Hydro	600	2009
Dapein-1 (IPP)	Myanmar	Myanmar/ Yunnan Province, PRC	Hydro	240	2011

IPP = independent power producer, Lao PDR = Lao People's Democratic Republic, MW = megawatt, PRC = People's Republic of China.

Source: ADB staff estimates.

2. Ongoing (Committed or under construction)

Project	Location	Market	Type	Capacity (MW)	Completion Date
Xekaman 3 (IPP)	Lao PDR	Lao PDR/ Viet Nam	Hydro	250	2012
Theun–Hinboun Expansion (IPP)	Lao PDR	Lao PDR/ Thailand	Hydro	220 + 60	2012
Xekaman 1 (IPP)	Lao PDR	Lao PDR/ Viet Nam	Hydro	322	2014
Sekong 3	Lao PDR	Lao PDR/ Viet Nam	Hydro	205	2015
Xekaman 4	Lao PDR	Viet Nam	Hydro	80	2016
Hongsa Lignite (IPP)	Lao PDR	Lao PDR/ Thailand	Coal	1,878	2015
Nam Ngum 3 (IPP)	Lao PDR	Lao PDR/ Thailand	Hydro	460	2017

IPP = independent power producer, Lao PDR = Lao People's Democratic Republic, MW = megawatt.

Source: ADB staff estimates.

APPENDIX 9

Development Partners' Assistance to the GMS Energy Sector

Development Partner	Nature of Assistance
A. Bilateral partners	
Australia	Rural electrification and renewable energy in the Lao People's Democratic Republic (Lao PDR), Cambodia, and Viet Nam
PRC	Subregional power database and internet portal, power cooperation website, subregional power planning
Finland	Cooperation with the Mekong River Commission, including the Initiative on Sustainable Hydropower; Mekong Energy and Environment Program; Lao PDR renewable energy strategy development and capacity building; Cambodia energy balance construction and energy planning development
France/AFD	Hydropower, power transmission: Power Master Plan, energy regulation
Germany	Rural electrification program in Cambodia
Japan	
JBIC	Infrastructure projects
MOFA/JICA	Greater Mekong Power Network Development Project: Study on Power System Network Plan in the Mekong Region
Republic of Korea	Power transmission; solar power system
Sweden/Sida	Technical Assistance for Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the GMS
United States	Clean energy technologies/climate change mitigation
B. Multilateral partners	
EIB	Infrastructure projects
European Commission	National programs on energy
Nordic Development Fund	Energy (clean energy, energy efficiency, renewable energy, access to modern energy forms)
UNDP	Energy and environment for sustainable development
World Bank	Power trade: Power trade technical assistance and capacity building

AFD = Agence Française de Développement, EIB = European Investment Bank, JBIC = Japan Bank for International Cooperation, JICA = Japan International Cooperation Agency, MOFA = Ministry of Foreign Affairs, PRC = People's Republic of China, Sida = Swedish International Development Agency, UNDP = United Nations Development Programme.

Source: ADB. 2010. *GMS Development Partner Assistance Matrix.* Ha Noi.

Greater Mekong Subregion Power Trade and Interconnection
2 Decades of Cooperation

This publication is a historical summary of progress made in energy cooperation in the GMS since the beginning of the economic cooperation program in 1992. It highlights a two-pronged and phased approach to develop the GMS power market to realize the full benefits of synchronous operations—the policy and institutional framework to promote power trade and the physical interconnection to facilitate cross-border power transfers. This publication aims to help stakeholders understand GMS members' efforts in power cooperation and to draw attention to crucial issues on regional power trade.

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