ECA

ECONOMIC
CONSULTING
ASSOCIATES

The Potential of Regional Power Sector Integration

Greater Mekong Subregion (GMS) | Transmission & Trading Case Study

Submitted to ESMAP by:

Economic Consulting Associates

January 2010

Economic Consulting Associates Limited
41 Lonsdale Road, London NW6 6RA, UK
tel: +44 20 7604 4545, fax: +44 20 7604 4547
email: peter.robinson@eca-uk.com

Contents

Contents i

Tables, Figures and Boxes iv

Abbreviations and Acronyms vi

Preface ix

1 Executive summary 1

1.1 Motivations/objectives for trade 1

1.2 The trade solution put in place (or attempted) 2

1.3 Progress against targets 3

2 Context for trade 4

2.1 Economic and political context 4

2.1.1 Members of the Greater Mekong Subregion 4

2.1.2 Economic context 5

2.1.3 National power markets 5

2.2 Supply options 8

2.3 Demand 11

2.4 Energy tariffs 14

2.4.1 Retail tariffs 14

2.4.2 Marginal cost comparisons 15

2.4.3 Prices of other fuels 16

3 History of scheme 18

3.1 Overview including timeline/chronology 18

3.1.1 The GMS Program 18

3.1.2 The power market's stages 21

3.1.3 Other regional power market initiatives 22

3.2 Project concept, objectives, and development 23

3.2.1	Concept and objectives	23
3.2.2	Development	24
3.2.3	"Omitted" areas	25
3.3	**Feasibility studies done**	**25**
3.4	**Assets built and planned resulting from the scheme**	**26**
3.5	**Interconnections and electricity trade**	**29**
3.6	**Environmental and social issues**	**30**
3.6.1	Environmental and social impacts	30
3.6.2	Carbon emissions savings	32
4	**Institutional arrangements**	**34**
4.1	**Organizations to govern and coordinate the scheme**	**34**
4.1.1	Electric Power Forum	34
4.1.2	Regional Power Trade Coordinating Committee	35
4.1.3	Focal Group	36
4.1.4	Planning Working Group	36
4.1.5	Proposed institutions	37
4.2	**Role of national governments and regional institutions**	**37**
4.3	**Regulatory agencies**	**38**
4.4	**Role of outside agencies**	**38**
5	**Contractual, financial and pricing arrangements**	**41**
5.1	**Contracts**	**41**
5.2	**Ownership and finance**	**44**
5.3	**Pricing arrangements**	**45**
6	**Future plans**	**46**
6.1	**Vientiane Plan of Action**	**46**
6.2	**Regional Cross Border Trade Road Map**	**47**
6.3	**Physical interconnections**	**49**
6.4	**Major issues**	**50**

Bibliography **52**

A1 National power markets **58**

A1.1 Cambodia **58**

A1.2 China (Yunnan and Guangxi) **60**

A1.3 Lao PDR **62**

A1.4 Myanmar **64**

A1.5 Thailand **66**

A1.6 Vietnam **71**

A2 Electricity supply **75**

A3 Electricity demand **86**

A4 Contracts **89**

Tables, Figures and Boxes

Tables

Table 1 GMS Member Country Economic Data (2007) 5

Table 2 Energy Resources in the GMS 10

Table 3 Summary of Actual, Planned and Proposed GMS Export Projects 27

Table 4 Major Existing Cross-Border GMS Trade Contracts 43

Table 5 Vientiane Plan of Action - Power Market Institutional Activities 46

Table 6 Regional Cross Border Trade Road Map, 2008-12 47

Table 7 Proposed ADB and World Bank-Funded Interconnection Projects 51

Table 8 Thailand Power Generation by Licensee Type 66

Table 9 GMS Current and Planned Installed Capacity 75

Table 10 Existing and Planned GMS Trade Projects 77

Table 11 Electricity Peak Demand in GMS Member Countries 86

Figures

Figure 1 The Greater Mekong Subregion 4

Figure 2 GMS Current and Planned Installed Capacity 8

Figure 3 Generation Fuel Mix (2007) 11

Figure 4 GMS Demand Growth 12

Figure 5 Daily Load Curves - Thailand and Vietnam 13

Figure 6 GMS Electricity Tariffs 15

Figure 7 GMS Program Institutional Structure 19

Figure 8 ASEAN Power Grid Interconnections - GMS 23

Figure 9 Export Flows in the GMS – Known Projects 28

Figure 10 Cambodia Transmission Grid 60

Figure 11 Lao PDR Transmission Grid 63

Figure 12 Myanmar Transmission Grid 65

Figure 13 Thailand Transmission Grid 68

Figure 14 Vietnam Transmission Grid 73

Figure 15 Lower Mekong Basin hydro projects 84

Figure 16 Myanmar Hydro Projects 85

Boxes

Box 1 Thailand's Power Import MOUs 70

Abbreviations and Acronyms

ADB	Asian Development Bank
AfD	Agence Française de Développement
AMBDC	ASEAN – Mekong Basin Development Cooperation
AIMS	ASEAN Interconnection Master Plan Study
ASEAN	Association of South-East Asian Nations
BCI	GMS Biodiversity Conservation Corridors Initiative
BOT	Build-Operate-Transfer
CA	Concession Agreement
CBP	Cost-Based Pool
CDM	Clean Development Mechanism
CEIA	Cumulative Environmental Impact Assessment
CEP	GMS Core Environment Program
CfD	Contract for Differences
CGM	Competitive Generation Market
CLMV	Cambodia, Lao PDR, Myanmar and Vietnam
CSG	China Southern Power Grid
EAC	Electricity Authority of Cambodia
ECA	Economic Consulting Associates
EDC	Electricité du Cambodge
EDL	Electricité du Laos
EGAT	Electricity Generating Authority of Thailand
EGP	Expert Group on Power Interconnection and Trade
EMP	Environmental Management Plan
EOC	GMS Environment Operation Center
EPF	Subregional Electric Power Forum
ERAV	Electricity Regulatory Authority of Vietnam
ERC	Energy Regulatory Commission (*Thailand*)
EVN	Electricity of Vietnam
FG	Focal Group
FS	Feasibility Study
GMS	Greater Mekong Subregion
HAPUA	Heads of ASEAN Power Utilities / Authorities
HPP	Hydro Power Plant
IAI	Initiative for ASEAN Integration
IGA	Inter-Governmental Agreement on Regional Power Trade in the

	Greater Mekong Subregion (*signed November 2002*)
IPP	Independent Power Project
ITCC	Inter-TSO Compensation Charge
Lao PDR	Lao Peoples Democratic Republic
LRMC	Long-Run Marginal Cost
MC	Management Committee
MEA	Metropolitan Electricity Authority (*Thailand*)
MEP	Ministry of Electric Power (*Myanmar*)
MIME	Ministry of Industry, Mines and Energy (*Cambodia*)
MOIT	Ministry of Industry and Trade (*Vietnam*)
MOU	Memorandum of Understanding
MOU #1	Memorandum of Understanding on the Conditions for the Implementation of the RPTOA—Stage 1 (*signed July 2005*)
MOU #2	Memorandum of Understanding on the Road Map for Implementing the Greater Mekong Subregion Cross-Border Power Trading (*signed March 2008*)
MP	Master Plan
MRC	Mekong River Commission
n.a.	Not available
n.k.	Not known
NDRC	National Development and Reform Commission (*China*)
NLDC	National Load Dispatch Center (*Vietnam*)
NPTC	National Power Transmission Corporation (*Vietnam*)
NRA	National Regulatory Agency
PC	Power Company (*Vietnam*)
PDA	Project Development Agreement
PDD	Project Design Document
PDP	Power Development Plan
PEA	Provincial Electricity Authority (*Thailand*)
Plan of Action	Plan of Action for the Energy Sector (*signed March 2008*)
PNPCA	Procedures for Notification, Consultation and Agreement
Policy Statement	Policy Statement on Regional Power Trade in the Greater Mekong Subregion (*approved January 2000*)
PPA	Power Purchase Agreement
PSO	Public Service Obligation
RMO	Regional Market Operator
Road Map	Road Map for Implementing the Greater Mekong Subregion Cross-Border Power Trading (*approved under MOU #2*)
RPTCC	Regional Power Trade Coordination Committee

RPTOA	Regional Power Trade Operating Agreement
PWG	Planning Working Group
REE	Rural Electricity Enterprise (*Cambodia*)
RRA	Regional Regulatory Agency
RRB	Regional Regulatory Board
RTC	Regional Transaction Coordinator
SEA	Strategic Environment Assessment
SERC	State Electricity Regulatory Commission (*China*)
SIDA	Swedish International Cooperation Development Agency
SPC	State Power Corporation (*China*)
TA	Technical Assistance
TBD	To be determined
TOR	Terms of Reference
TSO	Transmission System Operator
UNFCCC	United Nations Framework Convention on Climate Change
Vientiane Plan of Action	*See* Plan of Action
WGE	GMS Working Group on Environment

Preface

This case study is part of an Energy Sector Management Assistance Program (ESMAP) project on Regional Power System Integration (RPSI). The objective of the project is to facilitate and accelerate RPSI projects in developing countries around the world. The project will draw on international experience and theoretical analysis in this area to provide a framework to assess:

- the economic, financial and environmental benefits that can accrue to regional power trading;
- the institutional and regulatory arrangements needed to sustain and optimize regional projects; and
- the ways in which obstacles to integration have been successfully overcome.

The final output of the project will be an umbrella report, *Regional Power Sector Integration – Lessons from Global Case Studies and a Literature Review*. This review will summarize the 12 case studies and literature review undertaken and analyze common themes on barriers to RPSI and solutions to overcome them.

Economic Consulting Associates was contracted to execute the project. In doing so, we are working closely with ESMAP and World Bank staff, as well as government officials, utility, power pool, and regional economic community personnel, and others directly involved in implementing regional power schemes.

This and other 11 Case Studies are prepared as clear, factual presentations of the selected projects. The intent is to provide a direct, easily digestible description of each of the selected projects without imposing an analytic framework or making judgments about the degree of success. Such analysis will be undertaken at the global level, considering the entirety of experiences from the Case Studies, in the aforementioned umbrella report.

All 12 Case Studies follow a uniform structure to facilitate ease of comparison and reference from one Study to the next. Some sections are longer than others, depending on the specifics of the Study. Additionally, there is some cross-referencing within each Study.

1 Executive summary

1.1 Motivations/objectives for trade

The Greater Mekong Subregion (GMS) comprises Cambodia, Lao PDR, Myanmar, Thailand, Vietnam and the Yunnan Province and Guangxi Zhuang Autonomous Region of China. Since 1992, the countries have been linked through the GMS Economic Cooperation Program.

The GMS Program has provided a framework under which the countries have been able to cooperate, with the support of external partners such as the Asian Development Bank (ADB), in developing regional initiatives such as power trade. However, it is not the only such regional initiative. The various countries involved in the GMS Program also cooperate through a range of other institutions, notably the Association of South-East Asian Nations (ASEAN), which includes all the GMS members excepting China, as well as Brunei, Indonesia, the Philippines and Singapore. ASEAN is itself driving various programs of regional integration including, through the ASEAN + 1 format, integration with China.

The potential for power trade within the region has been discussed for many years. The rapid economic growth of Thailand during the 1980s and early 1990s, together with the ending of various regional conflicts, led to renewed interest in making use of the abundant hydro potential of Lao PDR and Myanmar as a means of meeting growing electricity demand at low cost and allowing diversification of the generation mix. More recently, Vietnam has emerged as a potential importer to meet demand growth which, in recent years, has averaged 12% annually.

Since 1993, Thailand has entered into a series of Memoranda of Understanding (MOUs) with Lao PDR, Myanmar and China for power imports. Currently, under these MOUs, Thailand is committed to importing 10,000 MW from Lao PDR by 2017 and to the development of five major hydro projects in Myanmar (the first two of which would have a combined capacity of 8,200 MW). Two export hydro projects in Lao PDR are already in operation, the 210 MW Theun Hinboun plant—which commissioned in 1998, although development started in 1991, preceding the GMS Program—and the 150 MW Houay Ho plant, which commissioned in 1999. The 1,088 MW Nam Theun 2 plant is due to commission in late 2009. Vietnam has also entered into MOUs with Lao PDR, and imports from the 250 MW Xekaman 3 hydro plant are due to start in 2010.

Of the other GMS member countries, Cambodia's interest in power trade is that it offers a way to reduce current reliance on expensive oil-fired generation. Imports of up to 200 MW from Vietnam over a new interconnector are due to begin shortly, and there are existing imports from Thailand. In the longer term, Cambodia may become an exporter of power from hydro schemes.

China is currently a significant exporter of power to Vietnam but may also become an importer in future from Lao PDR and Myanmar in order to meet its own rapid demand growth. Chinese firms are also active in the development of many export projects in the region.

1.2 The trade solution put in place (or attempted)

The objectives for the GMS regional market are established in a Policy Statement issued in 2000. In summary, these are to:

- Promote the efficient development of the regional power sector and regional power trade in order to aid economic growth.
- Promote extended cooperation between GMS members in the field of energy.
- Protect and improve the environment through the use of appropriate technologies and plans.

The objectives are supported by a set of guiding principles, including that each GMS member recognizes:

- International power trade as an integral part of its energy policies.
- The importance of technical harmonization of transmission standards to facilities interconnection.
- The desirability of foreign direct investment and private participation in the power sector.

A four-stage development of the regional power market has been set out:

- In the first stage, trade will primarily take the form of bilateral export projects, as at present. The focus during this stage is establishing common minimum standards for bilateral agreements and national codes that will allow harmonization under future regional power trade agreements, and on identifying priority interconnection projects to support expanded power trade.
- During the second stage, it is expected that links between the interconnectors constructed for export projects will allow trade between any pair of GMS member countries. However, trade will be limited to use of the surplus capacity of export project lines. During these two stages, trade will be conducted by national utilities (single buyers).
- The third and fourth stages are less well defined and are seen as being some way off. Under the third stage, interconnectors will be developed expressly for power trade, and third parties will be allowed to trade over them. The fourth stage will see the creation of an integrated competitive regional power market. Implementation of these stages is dependent on the restructuring of national power markets to allow competition in these.

The GMS Program is managed at the highest level by summits of heads of government. Three such summits have been held to date. Ministerial meetings and meetings of senior officials in the sectors of activity are held about once a year. The development of the regional power market was initially led by the Subregional Electric Power Forum (EPF), established in 1995, located under this overall GMS Program governance structure. In 2002, a Regional

Power Trade Coordination Committee (RPTCC) was established with responsibility for preparing a Regional Power Trade Operating Agreement (RPTOA) and establishing actions required to achieve the objectives for power trade. In 2005, guidelines for implementation of the RPTOA during Stage 1 of the power market were approved, and two institutions under the RPTCC were established—the Focal Group (FG), which coordinates implementation activities, and the Planning Working Group (PWG), whose responsibilities include identifying priority interconnection projects and establishing common regional performance standards.

The RPTCC, FG and PWG are comprised of representatives of national governments and utilities. They have no permanent office or budget. The secretariat is provided by the host country for each meeting and the Asian Development Bank (ADB). The ADB has and continues to manage a number of consultancy projects providing support to the RPTCC, FG and PWG in their work.

1.3 Progress against targets

Power trade in the GMS region is expected to rapidly expand in the form of bilateral export projects—almost 60 export generation projects are under construction, planned, or proposed. With regard to regional power trading, in 2008, a Road Map for implementation of power trading was approved at the Vientiane GMS Summit. This identifies a number of actions to complete Stage 1 of the regional market (focused on establishing common minimum standards), which are to be completed by 2010, and a set of actions to be undertaken in preparation for implementation of Stage 2 (focused on regulatory issues related to interconnector access and use), which are to be completed by 2012.

At this time, there appears to be no trade resulting from the regional power market itself, but this is understandable given the stage of development and given that even bilateral trade is very limited at present. The concept of the regional market appears to be supported by all participating members and embedded in their own policymaking and planning. But it is only when the market moves to Stage 2, with rules for cross-border power trading and, possibly, the establishment of permanent dedicated institutions, that the market might be expected to begin to have significant impacts on the regional power sector.

2 Context for trade

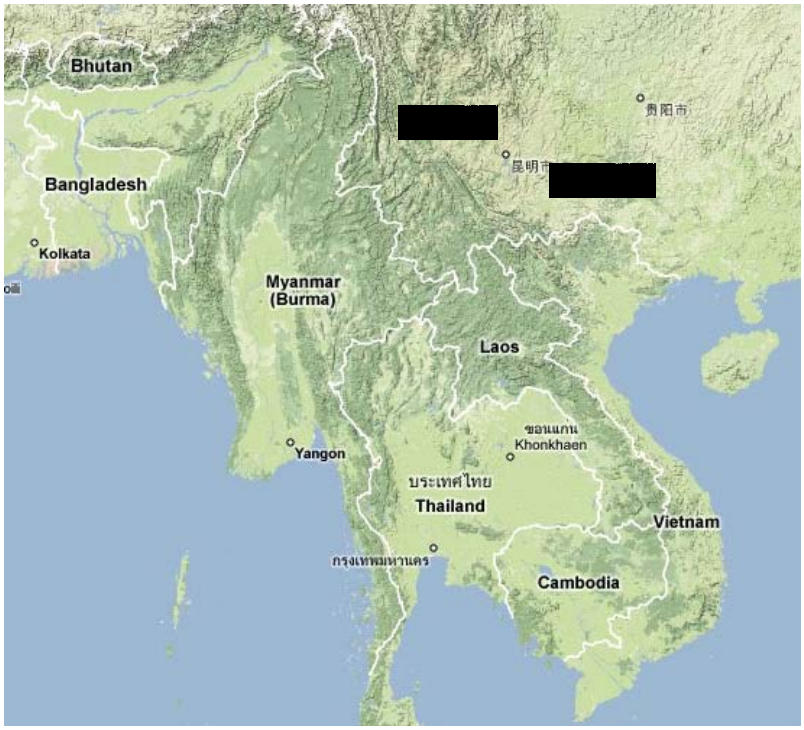
2.1 Economic and political context

2.1.1 Members of the Greater Mekong Subregion

The Greater Mekong Subregion (GMS) is comprised of the following countries and regions of China:

- Kingdom of Cambodia
- Guangxi Zhuang Autonomous Region and Yunnan Province of the People's Republic of China
- Lao People's Democratic Republic (Lao PDR)
- Union of Myanmar
- Kingdom of Thailand
- Socialist Republic of Vietnam

Figure 1 The Greater Mekong Subregion



Source: Google Maps

This section provides an overview of the context within which the GMS power market is being developed. Brief comparative economic data and a summary of major regional relations are provided first. This is followed by a short outline of the power sector in each member country. More detail on demand, supply, and tariffs within each GMS member are provided in subsequent subsections.

2.1.2 Economic context

Basic economic data on the GMS countries is provided in Table 1. Noticeable are the high economic growth rates across the region. Although the ongoing global recession has inevitably reduced these, the region as a whole appears generally well-placed for recovery according to the latest IMF forecasts (contained in the April 2009 *World Economic Outlook*). The notable exception to this pattern is Thailand, whose growth rates have declined very substantially since the Asian financial crisis of 1997 and which also appeared to face a severe economic downturn in 2009.

Table 1 GMS Member Country Economic Data (2007)

	GDP	GDP Per Capita	Population	Average Real GDP Growth	
	US$ bn	*US$*	*millions*	*1987-97*	*1997-07*
Cambodia	9	649	13	5.8%	9.3%
China	3,382	3,426	1,321	9.9%	9.6%
Lao PDR	4	675	6	6.0%	6.4%
Myanmar	20	340	58	3.5%	12.0%
Thailand	246	3,743	66	8.4%	3.3%
Vietnam	71	835	85	7.6%	7.2%

Source: IMF (2009)[1]

2.1.3 National power markets

The national power markets across the GMS member countries differ greatly in size, with the markets of China and Thailand dominating, followed by Vietnam and then the much smaller markets in Cambodia, Lao PDR and Myanmar. The markets are also characterized by their different fuel mixes with hydro and coal dominating in the Yunnan and Guangxi provinces of China, gas in Thailand, coal, gas and hydro in Vietnam, oil in Cambodia, and

[1] Sources used are identified in the main text by author and date. Full references are provided in the Bibliography at the end of this report.

hydro in Lao PDR and Myanmar. More detail on the level and mix of generating capacity in the various markets is provided in later subsections.

The various markets remain dominated by state-owned utilities, although there is large-scale penetration by independent power producers (IPPs) in all countries except Vietnam (in some cases these IPPs have been developed by entities which themselves are state-owned). Generation, transmission and distribution are vertically integrated in Cambodia, Lao PDR and Vietnam (although substantial IPP capacity also exists in all three countries). In Thailand, generation and transmission are vertically integrated while in Myanmar, transmission and distribution are integrated.

None of the countries has introduced competitive power markets, either at the wholesale or retail level. Various concepts for wholesale power market competition have been explored in China, while Vietnam has issued and is implementing a road map to introduce a competitive generation market in 2010, eventually leading to full retail competition by 2024. Thailand considered the potential for introducing a competitive power market during the late 1990s, but has subsequently settled for a single-buyer market model. Cambodia, Lao PDR and Myanmar are too small for competitive power markets to be realistic.

National regulatory agencies (NRAs) have been established in Cambodia, China, Thailand and Vietnam. The independence and powers of these regulators varies significantly. That in Cambodia is probably the most independent, with the greatest powers over pricing and planning. The agencies in Thailand and Vietnam oversee planning and have a major role in setting prices but operate within frameworks where final decisions are generally taken by government. The agency in China has largely advisory powers with key decisions being taken by central government.

More details on the individual national market structures and governance are provided in Annex A1.

The original motivation at the national level for the development of power trade within the GMS region was Thailand's rapid demand growth in the 1990s alongside its economic growth. During this period, Thailand was concerned about securing access to low-cost energy supplies. Environmental opposition effectively ruled out further large-scale hydro expansion within Thailand,[2] making imports of power from hydro projects located in Laos, Myanmar and Yunnan especially attractive. Since 1993, Thailand has entered into a series of intergovernmental memoranda of understanding (MOUs) for power imports from GMS countries:

- ***Lao PDR***: Thailand signed its first MOU with Lao PDR in 1993 for the import of 1,500 MW of power by 2000. In 1996 a second MOU was signed for the import of a total of 3,000 MW by 2006. A third MOU was signed in 2006, which increased the purchase amount to 5,000 MW by 2015. In December 2007, the quantity to be

[2] The last major dam built in Thailand was the 136 MW Pak Mun project completed by EGAT in 1994. This project has been widely criticized as having severe negative impacts on local fisheries and requiring large-scale resettlement for little benefit in terms of electricity generated (output has averaged only around 290 GWh, although EGAT has argued the plant was always supposed to operate as peaking capacity). Protests by affected villagers spread to Bangkok and have led to interventions at the cabinet level both to order EGAT to open the dam gates to restore fisheries and to close them as governments have changed.

purchased was further increased to 7,000 MW by 2020. Further amendments to these MOUs mean that currently Thailand is committed to purchasing 1,500 MW by 2010, 7,000 MW by 2015 and 10,000 MW by 2017.

- ***Myanmar***: An initial MOU was signed in July 1997 for the purchase of 1,500 MW of hydro capacity by 2010. In May 2005, a new MOU was signed for the development of five hydro power projects on the Salween[3] river for which the Myanmar government proposed two initial projects with a combined capacity of 8,200 MW.

- ***China***: In 1998, Thailand signed an MOU with China for the import of 3,000 MW by 2017. Imports would be by interconnectors passing through Lao PDR, making it necessary to agree to transit payments to be made to Lao PDR. At present, no agreement has been reached on these payments, and progress on developing export projects under the MOU remains stalled.

Following the Asian financial crisis of 1997, Thailand's economic growth and energy demand growth have slowed markedly. Despite this, Thailand has continued to remain committed to large-scale future imports. This appears to be partly due to the cost advantages of hydro imports and partly due to a desire to diversify away from the current dependence on natural gas for power generation. Domestic opportunities for such diversification are very limited—further large-scale hydro development is not an option, and attempts to increase coal-fired generation have run into heavy opposition on environmental grounds. Nuclear generation is now being planned but also seems likely to face strong opposition domestically.

This demand has provided opportunities for Lao PDR and Myanmar to develop export-oriented hydro projects in the form of IPPs as a means of earning revenues and, through the allocation of part of the resulting capacity to domestic needs, to support electrification. The first export IPP, the 210 MW Theun Hinboun hydro plant in Lao PDR, was commissioned in 1998, followed by the 150 MW Houay Ho hydro plant in 1999. The 1,088 MW Nam Theun 2 hydro plant is due to commission in 2009 and further potential export projects have been identified. Myanmar is less advanced in implementing export projects but also has ambitious plans.

Meanwhile, Vietnam's rapid economic growth since the introduction of the Doi Moi reforms in 1986 has seen the country's electricity demand expand at double-digit rates. This has driven increasing interest in electricity imports—both to relieve short-term supply constraints, as with current imports from China, and as a means of providing access to long-term, low-cost power supplies, as in the various hydro projects under development in Laos. Vietnam signed an intergovernmental MOU with Laos in 1998 for the import of 2,000 MW of power. A number of project-specific MOUs have been signed.

Cambodia's primary interest at present in increased power trade is the potential this offers to import lower-cost power supplies to replace its existing reliance on expensive diesel generation and to allow expansion of grid electricity services. Cambodia has ambitious plans for the development of a national transmission grid around the various interconnectors

[3] The Salween is known as the Nu in China and Thanlwin in Myanmar.

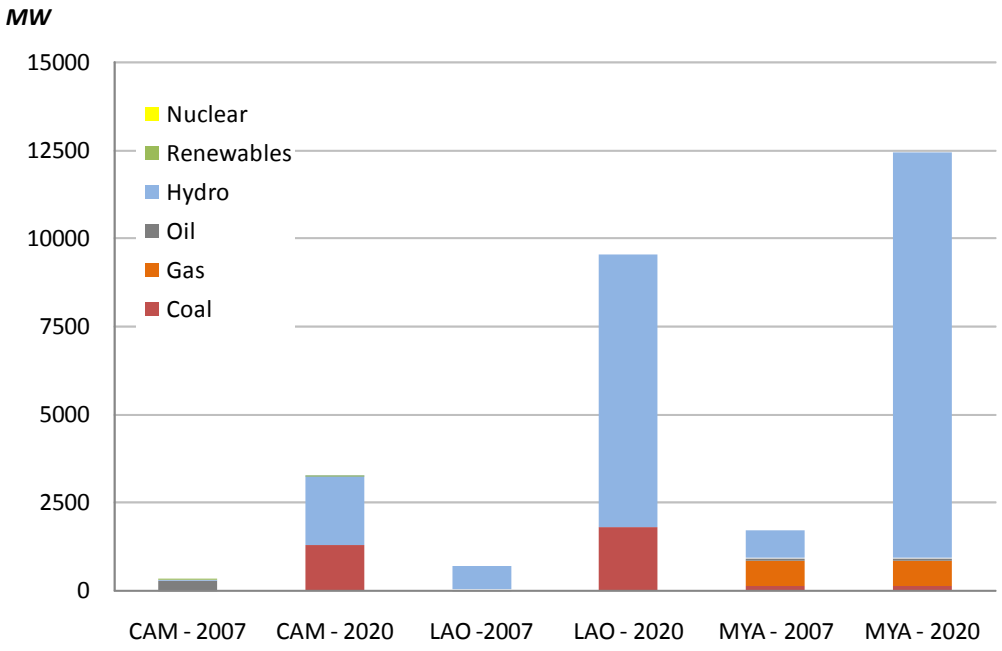
currently being constructed, which will greatly increase the coverage of grid electricity. In the longer term, Cambodia may become a power exporter from its hydro and gas resources and, potentially, through the development of power plants using imported coal and exporting power to Thailand.

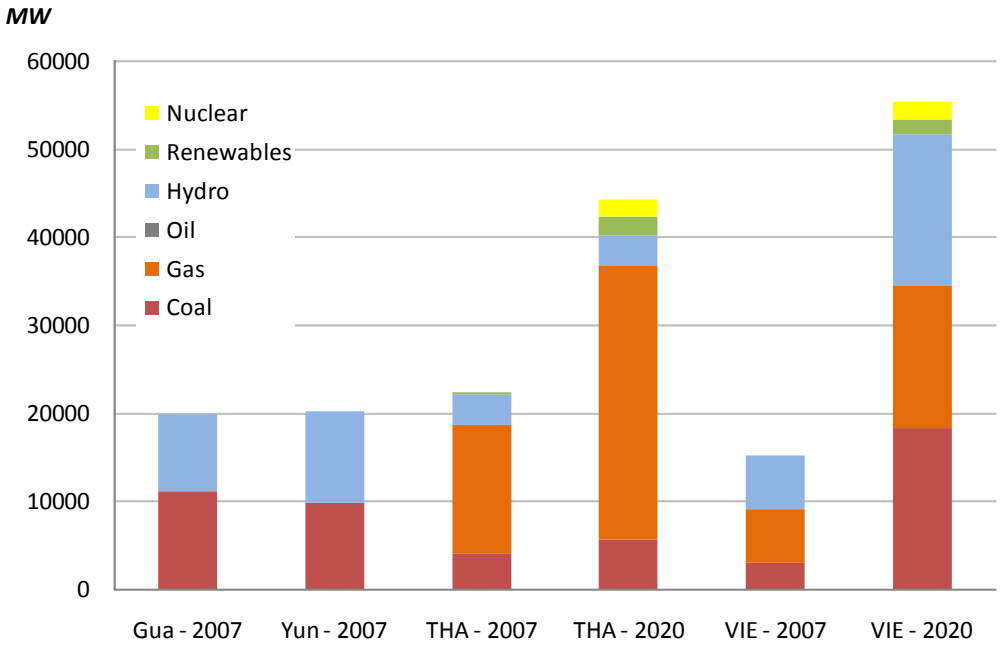
China's interest in energy trade appears to derive from a combination of import and export opportunities, including the potential for Chinese firms to develop projects in GMS countries for the regional market. Chinese firms are active in project development in Cambodia, Laos, Myanmar and Vietnam—although not all of these are directed at exports to the regional market.

2.2 Supply options

Figure 2 provides a summary of existing installed capacity for GMS members and planned expansion to 2020 according to country master plans. A tabular listing together with source notes is provided in Table 9 in Annex A2. The expansion plans shown include projects developed for export purposes—which explains the large-capacity expansion in Lao PDR and Myanmar, which greatly exceeds expected growth in demand (see following section).

Figure 2 GMS Current and Planned Installed Capacity





CAM	Cambodia	Gua	Guangxi Zhuang Autonomous Region (China)	LAO	Lao PDR
MYA	Myanmar	THA	Thailand	VIE	Vietnam
Yun	Yunnan Province (China)				

Different scales are used for Cambodia, Lao PDR, and Myanmar than for China, Thailand, and Vietnam, given the very large differences in size between the electricity industries in these two country groups.

Planned capacity for 2020 is not available for China.

Sources: See Table 9 in Annex A2.

Noticeable is the massive increase in capacity planned in Vietnam, driven by the very rapid expected growth in demand included in the most recent master plan. Installed capacity is planned to increase by over six times in 10 years at an average of almost 8 GW of additions in each year. Even larger proportional increases are projected for Cambodia, Lao PDR and Myanmar, but these represent much smaller absolute capacity additions, due to their very small starting points. Expansion in these three countries is driven by export projects rather than to meet domestic demand. Thailand is planning to add almost 2 GW of domestic generating capacity annually over the period (as well as projects developed in neighboring countries).

Available energy resources are shown in Table 2. For hydro and wind power the theoretical potential is shown. The economic potential will be significantly lower than this.

Table 2 Energy Resources in the GMS

	Coal (Mt)	Gas (BCM)	Oil (Mt)	Hydro (GW)	Wind (GW)
Cambodia	n.k.	43-99	7-14	15	26
China					
Yunnan	23,580	32	226	150	n/a
Guangxi	n/a	n/a	n/a	n/a	n/a
Lao PDR	910	-	-	26	182
Myanmar	200-300	160	32	100	n/a
Thailand	2,400	943	124	13	152
Vietnam	>40,000	144	82	30	513

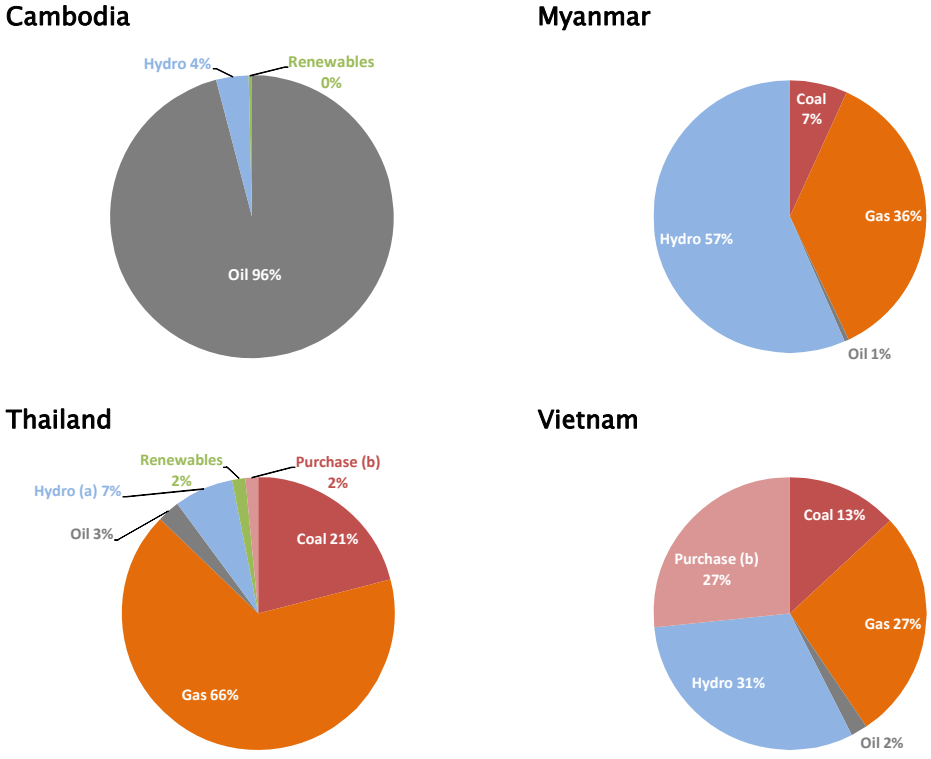
Source: Baardsen (2008)

Unsurprisingly, the two countries with the greatest interest in importing power in the GMS market are those that have the greatest need for new capacity and have most exploited their existing low-cost hydro resources. Thailand's current installed hydro capacity represents 26% of its theoretical potential, and Vietnam's is 18%. By contrast, Lao PDR has exploited just 3% of its hydro capacity to date and Myanmar 1%. This difference in available resources is a major driver of the developing regional market

The current fuel mix in each country's generation is shown in Figure 3 (where available). Of particular note is the dependence of Thailand on gas for power generation. Concern over this reliance combined with the levelling-off of gas production from Thailand's existing fields has been one of the drivers of Thailand's interest in importing energy, either in the form of coal to be used in Thailand or electricity imports from hydro plants located in Lao PDR and Myanmar.

Over the period to 2020, Thailand is likely to remain dependent to a large extent on gas under planned capacity additions. The role of hydro will greatly increase in Cambodia and Myanmar, in large part due to export projects. The biggest shift in fuel mix will take place in Vietnam, where coal will become increasingly dominant in the generation mix under current expansion plans.

Figure 3 Generation Fuel Mix (2007)



a Includes hydro imports from Lao PDR

b Imports and purchases from IPPs for which no fuel breakdown is given

Sources:

Cambodia	Electricity Authority of Cambodia (2008)
Myanmar	Presentation at PWG-5 (2008)
Thailand	EGAT (2008)
Vietnam	Trung (2008)

2.3 Demand

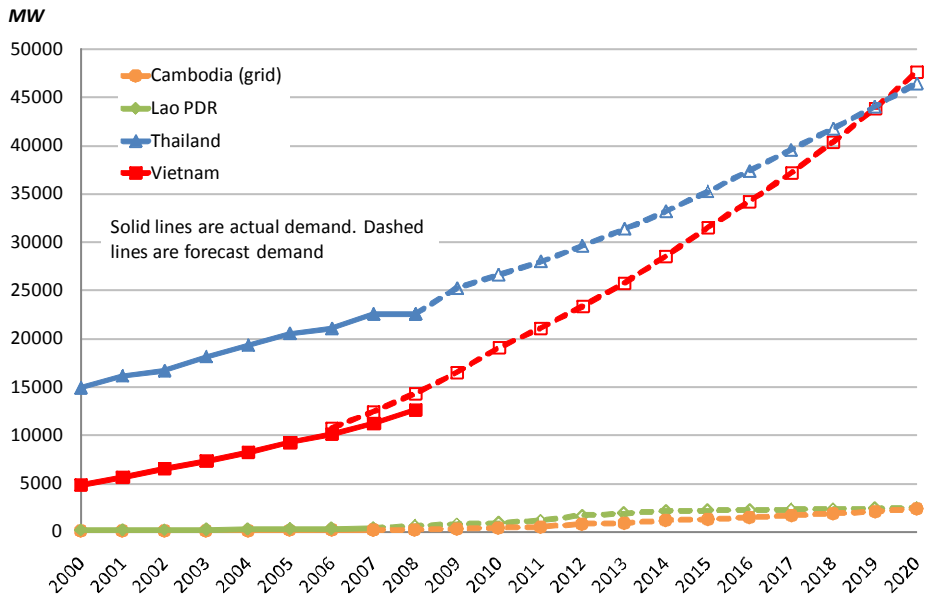
Figure 4 shows actual demand since 2000 and projected demand to 2020 for the GMS member countries, to the extent this can be determined from published documents. A tabular listing together with source notes is provided in Table 11 in Annex A3.

Of particular note is the rapid growth in demand across the region. Since 2000, Cambodia, the Guangxi and Yunnan regions of China, Lao PDR and Vietnam have all recorded double-digit growth in demand. Demand in Thailand has grown around 6% annually on average over this period.

Looking ahead, this rapid growth is expected to continue. Cambodia and Lao PDR both project very high growth rates, but from a very low starting base. Demand growth in

Thailand is expected to slow (and more so following recent revisions to forecasts as a result of the economic recession), but will increase by over 20 GW over the period to 2020.

Figure 4 GMS Demand Growth



Annual actual and forecast demand growth data is not available for China and Myanmar. Vietnamese projections are available for 2010, 2015 and 2020 and interpolated for other years.

Demand growth rates

	Cambodia	China (CSG)	Lao PDR	Myanmar	Thailand	Vietnam
2000-07	16.3%	12.6%	13.3%	4.9%	6.1%	12.0%
2007-20	20.9%	n.a.	14.8%	n.a.	5.7%	11.7%

Sources: See Table 11 in Annex A3.

Dominating demand growth in the GMS, though, are southern China and Vietnam. Long-run projections of demand for China are not available. However, if a 10% rate of electricity demand growth was maintained in the Guangxi and Yunnan regions, a rate consistent with historic growth, then the combined peak demand of these regions would grow from 23 GW in 2007 to around 80 GW by 2020 or an increase of 57 GW. Demand in Vietnam is projected to grow by 35 GW by 2020 from its 2007 levels.

Together, the Guangxi and Yunnan regions of China, Thailand and Vietnam would, therefore, account for a combined demand increase of around 110 GW to 2020 or 8 to 9 GW annually. While China is likely to be largely self-sufficient, both Thailand and Vietnam will be dependent on imports to meet a large part of this demand (see preceding section).

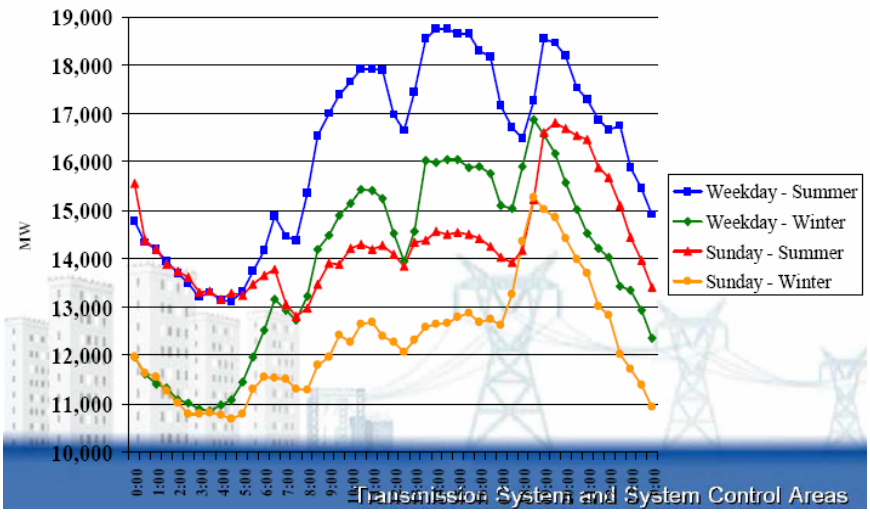
The massive discrepancies in demand levels across the GMS countries are very noticeable. In 2007, demand in the Guangxi and Yunnan regions of China and in Thailand was 110 times

greater than that in Cambodia and in Vietnam was 50 times greater. Vietnam is projected to become increasingly dominant in the region's demand. Using the growth rates in the current Master Plan, its demand will exceed that of Thailand by 2020.

At present, there appears to be limited potential for opportunity trades even if the necessary interconnectors were in place. The systems in Cambodia, Lao PDR and Myanmar are too small for such trading to be significant. For Thailand and Vietnam, demand peaks at similar times during the day. However, it is possible to envisage seasonal trade developing, with Thailand taking advantage of its lower winter demand relative to summer demand and greater share of thermal capacity to export power to Vietnam, where winter demand tends to be similar to summer demand and reliance on seasonal hydro generation is greater (Figure 5).

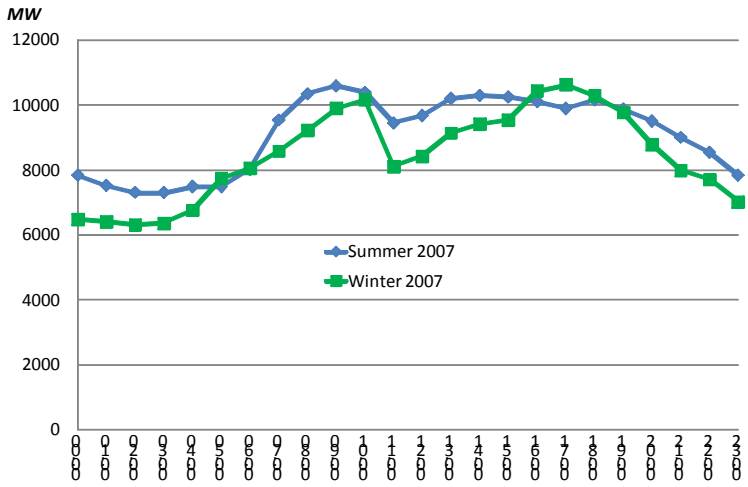
Figure 5 Daily Load Curves - Thailand and Vietnam

Thailand



Source: EGAT (2007a)

Vietnam



Source: Trung (2008)

2.4 Energy tariffs

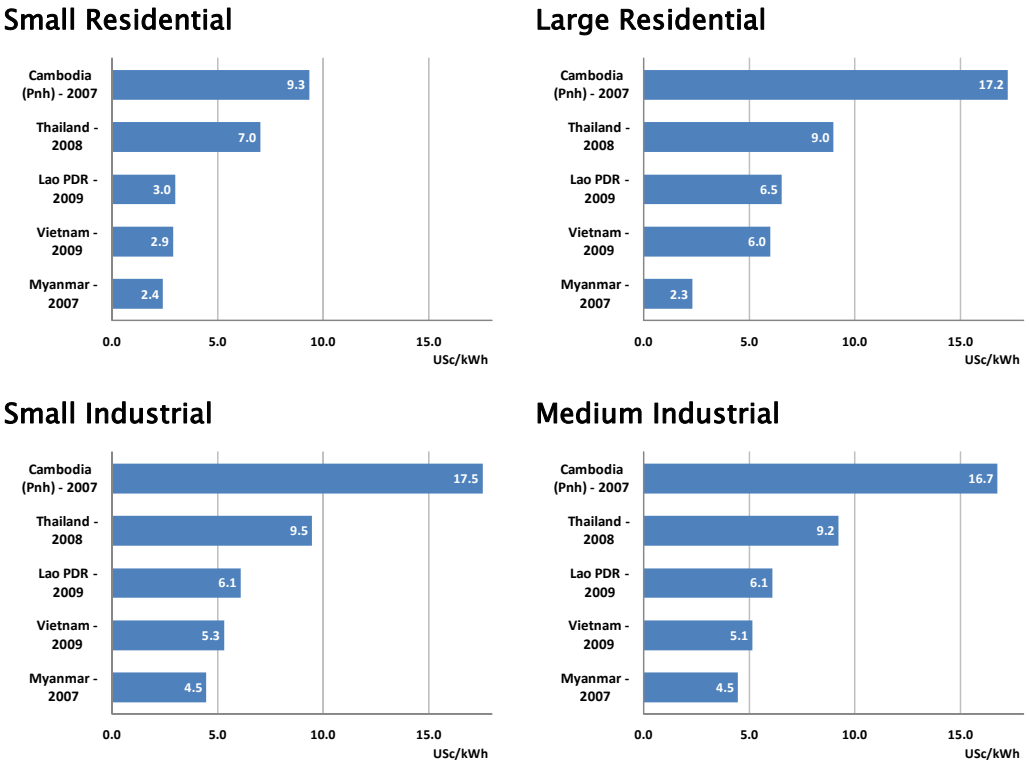
2.4.1 Retail tariffs

Figure 6 shows average tariffs across the GMS member countries for different customer types. Data on tariffs for China was not available.

The extremely high tariffs in Cambodia are due to the dependence on oil-fired generation. The potential benefits for Cambodia from access to lower-cost imports are clear. Thailand's relatively high tariffs, which in part result from its dependence on gas-fired generation, also suggest potential benefits from trade with countries with lower-cost hydro resources. It is not clear how cost-reflective the tariffs for Lao PDR, Vietnam and Myanmar are and, therefore, the extent to which the differences between these tariffs and those for other countries reflect differences in the costs of supply.[4]

[4] A tariff study for EDL, released in May 2009, identified a need for a 50% increase in average tariffs between 2009 and 2011, suggesting that current tariffs are significantly below costs. See: "Householders to pay more for electricity from 2009 to 2015," *Electricité du Laos*, 18 June 2009 (http://www.edl-laos.com/edl_update2.php).

Figure 6 GMS Electricity Tariffs



A small residential customer is assumed to use 50 kWh/month and a large residential customer 300 kWh/month. A small industrial customer is assumed to be connected at 6 kV to 12 kV (depending on voltage levels in use) and to use 10,000 kWh/month with a peak demand of 40 kW. A large industrial customer is assumed to be connected at 35 kV or 69 kV and to use 100,000 kWh/month with a peak demand of 220 kW.

Sources:

Cambodia	Electricity Authority of Cambodia (2008)
Lao PDR	Electricitè du Laos website
Myanmar	Presentation at Franco-ASEAN Seminar (2007)
Vietnam	Prime Minister Decision No. 21/2009/Q Đ-TTG
Thailand	Energy Regulatory Commission (2009) and Provincial Electricity Authority website
	Conversions are made at current market exchange rates (as reported by the *Financial Times* for 31 July 2009) excepting Myanmar, where the unofficial market exchange rate is used.

2.4.2 Marginal cost comparisons

Only limited recent evidence on long-run marginal costs (LRMCs) for GMS countries is available. A 2006 study for Vietnam by Economic Consulting Associates using data from 2002–2003 estimated the LRMC for industrial customers as approximately USc4.6/kWh (using then-current exchange rates) and for residential customers as approximately USc7.9/kWh.

Marginal costs were estimated for Thailand as part of a tariff study conducted in 1999–2000 by PricewaterhouseCoopers. The marginal cost of supply for all customers averaged

USc6.1/kWh, while for residential customers it was USc6.8/kWh and for medium-sized industrial customers it was USc5.7/kWh. However, these estimates were prepared at a time of very low fuel prices compared to recent levels and of a significant level of overcapacity following the 1997 financial crisis.

Analysis as part of the preparation of the World Bank and Asian Development Bank – supported Rural Electrification and Transmission Project for Cambodia estimated the LRMC of supply to customers in Phnom Penh at USc12.3/kWh in the absence of electricity imports and significantly lower with imports.

In general, LRMC estimates appear to be below current tariff levels, but this does not necessarily imply current tariffs are excessive relative to the costs of utilities in the region. Given the large increases in fuel prices in recent years and rising investment costs, comparisons of current tariffs with the LRMC estimates must be made with caution.

2.4.3 Prices of other fuels

In China and Thailand, prices of (nontransport) fuels are largely liberalized, although some limited government intervention remains.[5] Rather than direct control, governments influence prices through, for example, limits on entry into or exit from fuel supply industries, encouragement or discouragement of exports, and so forth.

Prices in other GMS countries largely remain regulated. The impacts are probably most significant in Vietnam,[6] where coal prices for power generation have been consistently maintained below world levels. Currently, the sales price from the state minerals corporation, Vinacomin, to the state electricity corporation, EVN, is set through negotiations overseen by the Ministry of Industry and Trade and the Ministry of Finance. Based on data reported by the National Load Dispatch Centre (NLDC), the average domestic coal price for power generation in 2008 was $126/t compared to $157/t for imported coal.[7] Media reports suggest that the price difference may be much greater, with imported coal prices being given as "twofold" those of domestic coal.[8] The government has committed to gradually increasing coal prices for electricity generation toward export parity levels in line with planned increases in retail electricity tariffs—in early 2009, coal prices rose by 27%.

The Vietnamese government has pursued a policy of pricing gas at the cost of production on a field-by-field basis (and below for some users such as fertilizer plants). For earlier gas fields, particularly the associated gas produced from the Nam Con Son basin, this has

[5] For example, the Thai government helped the majority state-owned oil and gas company, PTT, which holds a monopoly over sales to the power sector, reach an agreement with the state generation utility, EGAT, whereby the full increase in gas prices during 2008 resulting from their oil indexation was not passed through. In return, gas prices to EGAT have not been lowered as much during 2009 as the fall in world oil prices would require, with the government permitting the higher price to be included in electricity tariffs.

[6] Insufficient information is available on fuel price regulation in Myanmar to determine whether these are more or less heavily regulated than Vietnam.

[7] Assumes a coal calorific value of 6,500 kcal/t. Prices reported in PB Associates (2009).

[8] See, for example: "Power investors turn back on Vietnamese coal importers," *LookatVietnam*, July 2009 (http://www.lookatvietnam.com/2009/07/power-investors-turn-backs-on-vietnamese-coal-importers.html)

resulted in gas prices of around $3.8/mmbtu in 2008. The more recent Ca Mau project has, however, faced much higher gas prices reported by NLDC as around $9.2/mmbtu.

3 History of scheme

3.1 Overview including timeline/chronology

3.1.1 The GMS Program

Regional power trade in the GMS began in 1971 with exports from the Nam Ngum hydropower plant (HPP) in Lao PDR to northeast Thailand. Subsequently, the Theun Hinboun and Houay Ho HPPs have been developed in Lao PDR, exporting to Thailand, along with the soon-to-commission Nam Theun 2 HPP,[9] which will also export to Thailand, and the Xekanman 3 HPP exporting to Vietnam. A large number of other hydro power plants are under development or planned for Lao PDR and Myanmar, for export to China, Thailand and Vietnam. A number of high-voltage interconnectors are planned or being developed alongside these exports which, it is hoped, will form the nucleus for both a future Lao national grid and for trade between GMS countries via Lao PDR.

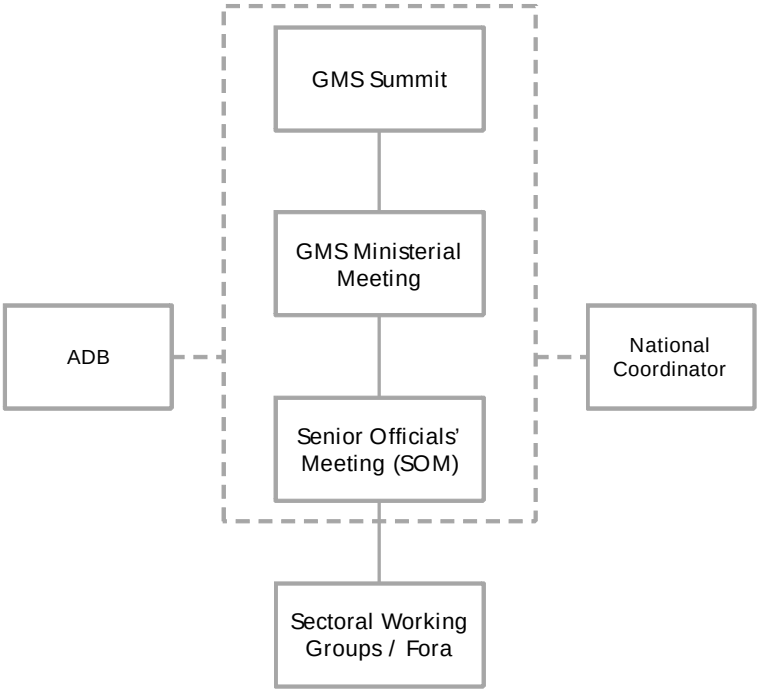
While these various projects are gradually leading to the de facto establishment of an interconnected regional electricity grid, the impetus behind the development of a more formal GMS market is the GMS Economic Cooperation Program. The program was initiated in 1992 to implement high-priority subregional projects in transport, energy, telecommunications, environment, human resource development, tourism, trade, private-sector development and agriculture. The ADB has been a major driving force behind the program, although other donors also provide support.

A formal institutional structure for the program was agreed upon in 1995. Under this, the highest coordinating body is the GMS Summit attended by prime ministers of participating countries. Policy direction and coordination is generally provided by Ministerial Meetings and, under these, Senior Officials Meetings. A number of Sectoral Working Groups and Fora are responsible for operational matters relating to the implementation of the program. The structure is illustrated in Figure 7. As of mid-2008, there had been three GMS Summits (in 2002, 2005 and 2008) and 14 Ministerial Meetings (or approximately one per year). The Senior Officials Meeting takes place once or twice per year.

The GMS Program does not have a formal secretariat. Instead, the ADB acts as a de facto secretariat, facilitates and coordinates meetings and activities, and provides technical, financial, administrative and logistical support to the GMS institutions.

[9] This is the subject of a separate case study.

Figure 7 GMS Program Institutional Structure



Source: ADB (http://www.adb.org/Documents/Others/GMS/Program/institutional-arrangements.pdf, accessed 6 May 2009)

The concept of a GMS power market has existed for many years. During the 1950s, Thailand and the newly independent states of French Indochina and Myanmar (then known as Burma) were cooperating on initiatives to develop the Mekong River. The first regional power project, the Nam Ngum plant in Lao PDR, began operations in 1971. However, the various wars and border tensions that followed during the 1970s and 1980s prevented any significant progress until the 1990s. At the time of the formation of the GMS Program in 1992, regional power integration was identified as one of the areas of cooperation between members. Export projects were already being explored by this date—the Lao PDR government had begun studies on potential projects during 1991, of which the first result was the Theun Hinboun HPP.[10]

Major dates in the development of the GMS electricity market under the GMS Program are:

- ***April 1995***: The **Subregional Electric Power Forum (EPF)** was formally inaugurated at a meeting in Yangon, Myanmar. Establishment of the EPF was agreed at the Fourth Conference on Subregional Economic Cooperation (Ministerial Meeting) held in Chiang Mai, Thailand, in September 1994.

- ***January 1998***: The **Expert's Group on Power Interconnection and Trade (EGP)** was established to provide recommendations on regional power issues in the GMS.

[10] http://www.adb.org/Projects/Theunhinboun/Pcr/project_description.asp

- ***January 2000***: At the Ninth GMS Ministerial Meeting in Manila, ministers endorsed the *Policy Statement on Regional Power Trade in the Greater Mekong Subregion* (the **Policy Statement**). This establishes the objectives and principles for power trade among the GMS member countries. It also provided for an intergovernmental agreement on regional power trade to be prepared, which would provide the framework to implement the policy statement.

- ***November 2002***: The *Inter-Governmental Agreement on Regional Power Trade in the Greater Mekong Subregion* (the **Inter-Governmental Agreement, IGA**) was signed in Phnom Penh. The IGA provided for the establishment of a **Regional Power Trade Coordination Committee (RPTCC)** and required the RPTCC to establish a plan for:

  - Preparing a draft **Regional Power Trade Operating Agreement (RPTOA)** specifying the rules for regional power trade.

  - Recommending the arrangements for policymaking and day-to-day management of regional power trade, including the necessary coordination bodies.

  - Establishing the short, medium and long-term actions required to achieve the objectives for regional power trade.

  - Identifying the necessary implementation steps, including financing arrangements.

- ***July 2005***: A *Memorandum of Understanding on the Guidelines for the Implementation of the RPTOA – Stage #1* (**MOU #1**) was signed in Kunming. This approved the draft RPTOA[11] issued by the third RPTCC meeting (April 2005) as guidelines for Stage 1 of the regional power market. It also established two new institutions to support the work of the RPTCC:

  - The **Focal Group** (FG) was established to coordinate implementation activities in each GMS country. MOU 1 provides that this may subsequently evolve into a technical secretariat.

  - The **Planning Working Group** (PWG) was established to fulfil the functions of the operational and system planning working groups identified in the draft RPTOA. These include preparing a regional interconnection plan, participating in developing regional performance standards, and creating a regional database.

- ***March 2008*: *A Memorandum of Understanding on the Road Map for Implementing the Greater Mekong Subregion Cross-Border Power Trading* (**MOU 2**) was signed in Vientiane. The Road Map contains actions and an indicative timeline up to 2012 required to implement Stage 1 of regional power trading and prepare for Stage 2. Activities identified are:

[11] Formally, MOU #2 approved guidelines for implementation of the RPTOA during Stage 1. For conciseness, in this report we refer to these guidelines as the approved RPTOA.

- Completion of the studies on performance standards, transmission regulations, a priority interconnection plan, standard metering and communications arrangements and power trade rules by 2009–2010 for implementation of Stage 1.

- Completion of studies on a GMS grid code, expanded transmission regulations and identification of regulatory barriers to the development of power trade by 2012 in readiness for Stage 2.

This second MOU was signed alongside the most recent GMS Summit (prime ministerial level) which was held in Vientiane 30–31 March 2008. The summit endorsed a Plan of Action for GMS Development, including the Road Map for the energy sector set out in MOU #2.

The various agreements and the role, composition and administration of the institutions created under these are discussed later in this case study as part of the descriptions of institutional arrangements and contracts.

3.1.2 The power market's stages

The regional power market is planned to evolve through a number of stages. Stage 1 is defined in the RPTOA approved under MOU #1 in July 2005. Stage 2 is briefly defined in MOU #2 signed in March 2008. The definitions of each stage as used in these agreements are provided below:

> ***Stage 1*** corresponds to 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 neighbouring 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*** corresponds to the moment when trading will be 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.

In effect, Stage 1 represents the existing situation where power trade is almost entirely conducted under bilateral contracts, although the definition also provides scope for opportunity trades between national utilities, using any spare interconnection capacity developed for bilateral exchanges. Under Stage 2, it is expected that some transit trade will develop, but this will continue to largely use interconnector capacity constructed under bilateral arrangements.

Two further stages have been outlined. Under Stage 3, interconnectors will be developed expressly for cross-border power trading, and third parties (other than national utilities) will be permitted to begin trading over these. Under Stage 4, a competitive regional power market would be established. A precondition for this would be the establishment of multi-seller, multi-buyer power markets in member countries. The timing of Stages 3 and 4 is

uncertain, and different countries may move to these stages at different times, depending on the extent of liberalization of their national electricity market.

3.1.3 Other regional power market initiatives

Most of the GMS members, with the exception of the Yunnan Province and Guangxi Zhuang Autonomous Region of China, are also members of the Association of South-East Asian Nations (ASEAN). ASEAN has its own set of regional initiatives promoting economic cooperation and linkages in a number of sectors, including energy.

In June 1996, ASEAN members and China signed the Basic Framework of ASEAN-Mekong Basin Development Cooperation (AMBDC) in Kuala Lumpur.[12] The Framework's objectives include strengthening interconnections between ASEAN and Mekong riparian countries, including in energy. However, there do not appear to have been substantial actions in the energy sector emerging out of this Framework. The minutes of the most recent Ministerial Meeting, held in Singapore on 29 August 2008, identified only the Singapore-Kunming Rail Link Project as a significant infrastructure project under the AMBDC framework.[13]

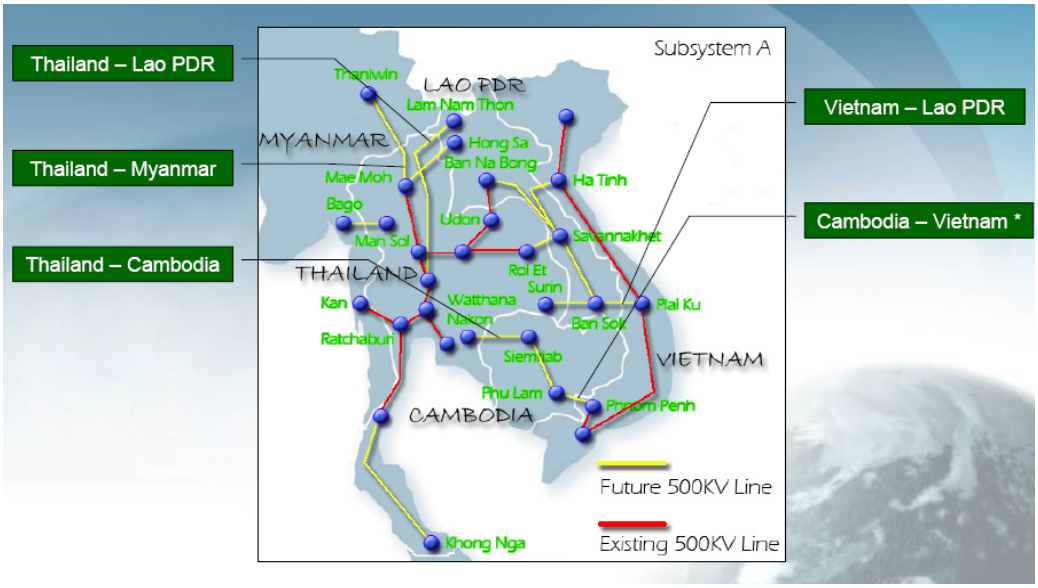
ASEAN has also established the Initiative for ASEAN Integration (IAI), which is intended to assist the economic development of the poorer ASEAN members, Cambodia, Lao PDR, Myanmar and Vietnam (collectively referred to as CLMV). The most recent workplan under the IAI, covering 2009–2012, includes support for projects building CLMV capacity to participate in the ASEAN Power Grid.[14] The Power Grid concept is derived from an ASEAN Interconnection Master Plan Study (AIMS) completed in March 2003, which identified 11 priority interconnection projects for ASEAN for implementation between 2007 and 2020. Of these, a number fall within the GMS as illustrated in Figure 8. It appears to have been agreed that further action on those interconnections planned for the GMS will be undertaken in the context of the GMS Program.

[12] http://www.aseansec.org/6353.htm. At the time the Framework was signed, Cambodia, Lao PDR and Myanmar were not members of ASEAN, but all subsequently joined, leaving China as the only non-ASEAN signatory to the Framework.

[13] http://www.aseansec.org/22363.htm

[14] http://www.aseansec.org/22325.pdf

Figure 8 ASEAN Power Grid Interconnections - GMS



Project	Type	Capacity (MW)	Year
Thailand – Lao PDR	HVAC	1578 / 2015	2008 / 2010
Thailand – Myanmar	HVAC	1500	2013
Thailand – Cambodia	HVAC	80 / 300	2004 / 2016
Vietnam – Lao PDR	HVAC	1887	2007-2016
Cambodia - Vietnam	HVAC	80 / 120	2003-2006

Source: HAPUA (2008)

3.2 Project concept, objectives, and development

3.2.1 Concept and objectives

The objectives for the regional power market, as identified by the GMS Program countries participating countries, are set out in the Policy Statement issued in January 2000:

(a) To promote the efficient development of the electric power sector in the GMS with the objective of aiding economic growth;

(b) To promote opportunities for extended economic cooperation between Members in the field of energy;

(c) To facilitate the implementation of priority electric power projects;

(d) To address technical, economic, financial and institutional issues relevant to GMS electric power development;

(e) To promote electric power trade, where economic, to further these objectives; and

(f) To protect and improve the environment through the adoption of appropriate technologies and plans.

These objectives are supported by a set of guiding principles, also contained in the Policy Statement:

(a) Each Member recognises and endorses international trading in electric power to be an integral part of its policies to strengthen its electricity sector;

(b) Each Member recognises the importance of technical harmonisation of electric power transmission parameters and practices with eventual interconnection in mind;

(c) Each Member recognises the desirability of foreign direct investment on reasonable terms in its electric power sector in order to speed economic development in the GMS;

(d) Each Member recognises that, for private-sector participation in the electric power sector on reasonable terms, certain "best practice" guiding principles should be recognised as generally indicated in Annex 1 hereto [see the full Policy Statement for this Annex];

(e) Each Member recognises the importance of open communication and the sharing of information in order to promote the efficient development and supply of electric power; and

(f) Each Member recognises the need to protect and improve the environment through the adoption of appropriate technologies and plans.

3.2.2 Development

Regional power trade has become part of the long-term power development planning of all GMS member countries. The initial impetus appears to have come from Thailand with its signing of MOUs for imports with Lao PDR and Myanmar. This has led all three countries to include projects for export from Lao PDR and Myanmar to Thailand in their own national power development plans. More recently, both Cambodia and Vietnam have included regional projects in their national power planning.

The main driver for the development of regional power trade appears to continue to be Thailand's desire for imports of power, which Lao PDR, Myanmar and now Cambodia are all enthusiastic to supply. Trade is being largely driven by the benefits offered in the form of lower-cost power for Thailand and revenue-generating opportunities for exporting countries. Vietnam's increasing interest in imports may lead to some shifts in the future. Meanwhile, China's involvement to a great extent appears to be in participating in export projects in regional countries—Chinese developers are promoting projects in Cambodia, Lao PDR and Myanmar.

The ongoing development of a regional market framework has been more in response to these developing power trades than in leading them. The framework builds on the cross-border interconnections being developed to support export projects and the bilateral power purchase agreements (PPAs) underlying these, as is clear from the description of Stage 1 of the market. At no time do possible alternatives such as moving rapidly to a regional power pool appear to have been seriously considered given the massive political, legal and technical barriers to such a market.

The creation of a separate institutional, legal and regulatory framework for the regional market seems in large part to be due to its inclusion in the general move to greater

integration of regional activities under the GMS Program to which ministers in the participating countries have committed themselves. The actual design of the power trading framework has largely been handled by utility experts working through the various groups set up for this purpose, with very extensive support from IFIs and their consultants. In many cases, it seems IFIs and their consultants have taken the lead in developing draft documentation to provide a basis around which representatives of the member countries can build consensus.

Separate from the arrangements for the regional power market, the GMS Program is now pursuing a similar strategy to the development of a regional action plan for energy integration covering nonpower energy trade and renewable energy sources in particular. A Subregional Energy Forum (SEF) has been established and has held two meetings to date to agree upon a draft Energy Action Plan for presentation to the GMS Ministerial Meeting.

3.2.3 "Omitted" areas

The regional market's focus is currently on facilitating trade using transmission facilities already being developed, particularly for bilateral export projects. While priority interconnection projects are being identified through a regional planning process, at present the market institutions do not seem to be directly involved in the structuring, financing or implementation of these.

In general, the regional market is being developed in very much a gradualist manner. The scope of activities reflect this, with initial focus being on establishing a minimal set of rules and standards which can be used by national system operators in trading power over spare interconnector capacity and in developing national-level documents which are consistent with those in other GMS countries. Initial work on the design of regional transmission tariffs and regulatory arrangements is beginning, but introduction of these is some way off.

3.3 Feasibility studies done

While feasibility studies have been undertaken for specific power projects being developed for export purposes within the GMS, we are not aware of any feasibility studies of the GMS power market itself.

External agencies, notably the Asian Development Bank (ADB), World Bank and ESMAP, have supported a number of studies looking at the potential gains from increased regional power trade and major barriers to achieving this. Most recent of these is the ADB-supported strategy, *Building a Sustainable Energy Future: The Greater Mekong Subregion*, issued in June 2009. This estimates that the present value of electricity costs across the GMS over the period 2005–2025 would be some US$213 billion lower if the regional energy market was to be fully integrated, representing a reduction of around 15% in costs.

The ADB and other financing institutions and donors have also been active in funding consultancies to support the various studies being undertaken to implement the GMS Regional Power Market (as identified in the IGA, MOU #1 and MOU #2). This support is described further in Section 4.4. These studies include an indicative regional master plan which, while not a feasibility study, does identify priority projects for development to support regional power trade. The initial version of this master plan issued in 2004 provided

estimates of total generation and transmission costs for GMS countries if only existing and committed interconnections were developed and under an extended cooperation scenario under which all economic projects identified in existing MOUs were completed. Total cost savings to 2020 from extended cooperation in power trade were estimated at US$914 million (present value in 2001, discounted at 12%) or around 2% of total costs.[15]

3.4 Assets built and planned resulting from the scheme

Table 10 in Annex A1 provides a list of generation projects and international interconnectors currently in place or under development among GMS countries. A summary of the identified projects is provided in Table 3.

Projects are organized by the host country rather than by importing country. The status of many of these projects is difficult to ascertain, and this list should not, therefore, be regarded as definitive. The list of interconnectors ignores trades conducted at medium voltages (there are a number of cross-border purchases by isolated areas in Cambodia and Lao PDR from the neighboring Thai and Vietnamese systems at medium voltage). It also does not include interconnectors constructed for the purposes of transmitting power from export projects and which are owned by the associated project companies and national utilities.

[15] Table 6-16 in Norconsult (2004), *Indicative Master Plan on Power Interconnection in GMS Countries*. Reported in Garrett (2004).

Table 3 Summary of Actual, Planned and Proposed GMS Export Projects

Exporter	Generation Projects		Interconnector Projects	
	No	Capacity (MW)	No	Capacity (MW)
Cambodia	8	8,630	0	0
China (Guangxi and Yunnan)	1	n.k.	7	2,610
Lao PDR	38	19,582	3	n.k.
Myanmar	12	29,070	1	n.k.
Thailand	0	0	2	n.k.
Vietnam	0	0	2	240

Sources: See Table 10 in Annex A2.

Figure 9 provides a summary of current and imports and exports between GMS member countries, the possible level by 2020, and the total potential level based on identified projects. Decisions on project status used in preparing this summary are inevitably somewhat arbitrary but, in general, only projects included in both the importing and exporting countries' current power master plans are assumed to proceed by 2020. The main potential power flows are from Cambodia and Lao PDR to Vietnam, from Lao PDR and Myanmar to Thailand, and from Myanmar to China. The major flows which appear most likely to be in place by 2020 are from Lao PDR to Thailand and Vietnam and from China to Vietnam. There will also be small-scale exports and imports involving Cambodia.

The various planned projects are not the result of any comprehensive regional planning exercise. Instead, they have been identified at a national level, although in some cases the impetus has been agreements for exports to neighboring countries which have incorporated planned projects into their own national master plans.

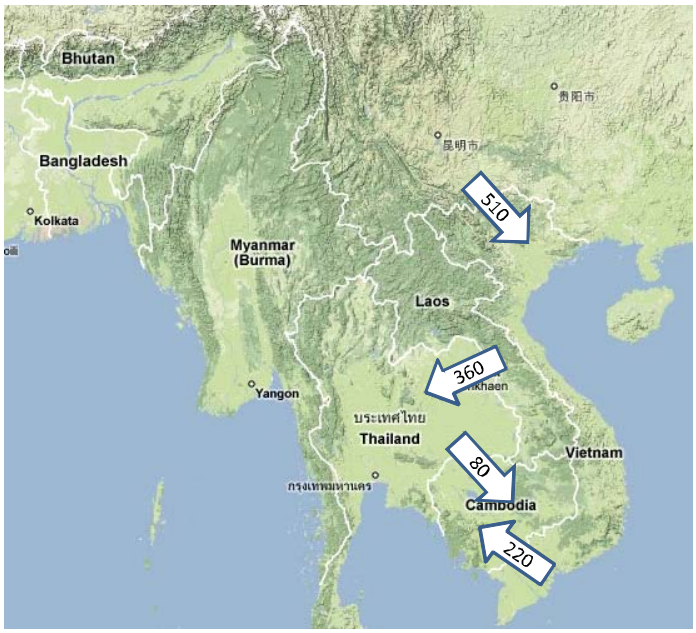
The indicative regional master plan prepared under ADB funding also provides a set of projections of future energy trade between GMS member countries, based on optimizing flows within the region. These show a rather different pattern of expansion from that under the existing national plans. By 2021, the indicative plan projects the major export flows as being from China to Thailand via Lao PDR, from Cambodia, Lao PDR and Myanmar to Thailand, and from Vietnam to China and Thailand. By 2028, it projects Lao PDR and Myanmar to be major exporters to Thailand, reduced flows from China to Thailand, much reduced flows from Cambodia to Thailand, and relatively small flows from Myanmar to China, Cambodia to Vietnam and China to Vietnam. Most noticeable compared to national plans is the expectation from the regional plan that Vietnam will be an exporter, not importer, for at least part of the period,[16] and that exports from Myanmar to Thailand will start more rapidly than is reflected in Thailand's own national planning.

[16] From examination of the report, it appears that this may be due to an assumption that domestic coal and gas prices in Vietnam will remain below export parity levels for an extended period, making it economic to develop thermal generating capacity in Vietnam's North region to export to China.

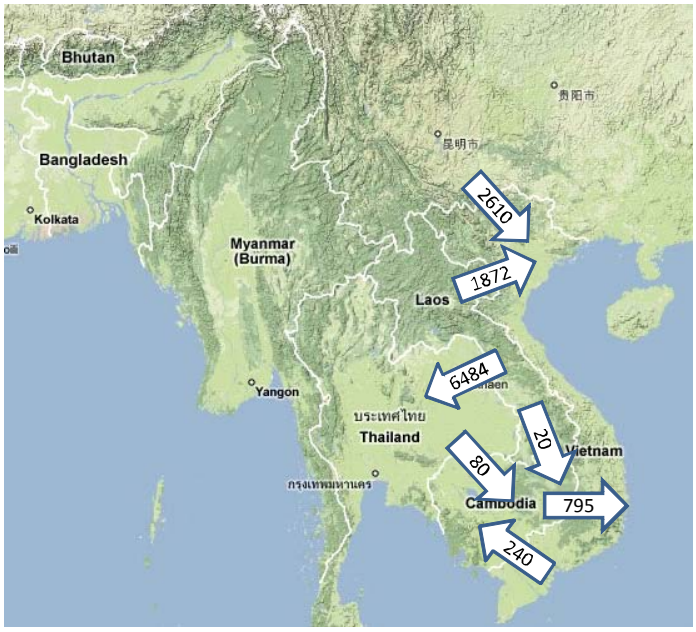
The analysis in the ADB's regional strategy, *Building a Sustainable Energy Future*, shows the largest projected trade as being from Myanmar to Thailand with significant trade also from Lao PDR and Cambodia to Thailand, Vietnam and China. Thailand would be the largest importing country.

Figure 9 Export Flows in the GMS – Known Projects

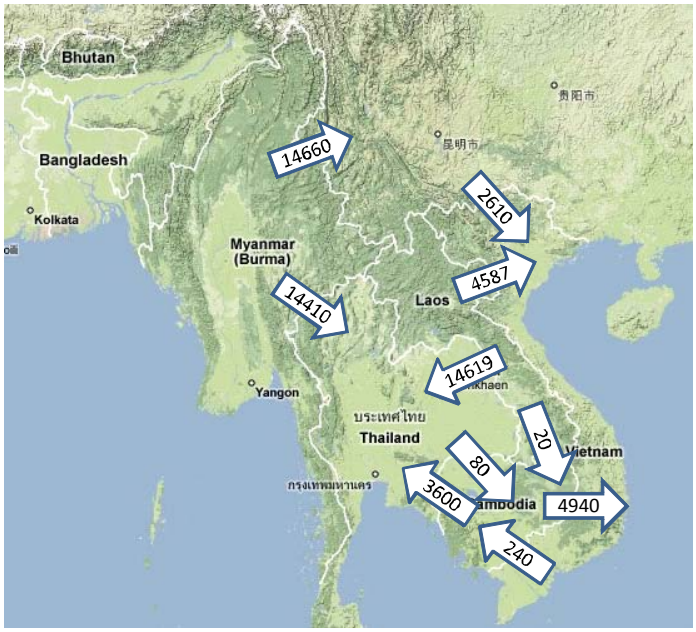
Current (mid-2009)



Possible (to 2020)



Potential (all identified projects)



Numerical values represent maximum potential flows in MW

Sources: As for Table 3.

3.5 Interconnections and electricity trade

Current interconnections fall into two groups:

- Cross-border interconnections for electricity trade between China and Vietnam, Vietnam and Cambodia, and Thailand and Cambodia.
- Interconnectors dedicated to transporting output from export projects located in Lao PDR to Thailand and, in the near future, to Vietnam.

The major existing interconnectors that are not associated with export projects are:

- A 115 kV interconnector between Thailand and Cambodia commissioned in 2007 which exports power from Thailand's grid to the northwest region of Cambodia, serving the provincial capitals of Bantey Meanchay, Siem Reap and Battambang.
- A 220 kV interconnector between Vietnam and Cambodia which is due to commission imminently to serve the Phnom Penh region.
- A 110 kV interconnector between Vietnam and Cambodia and a 115 kV interconnector between southern Lao PDR and Cambodia which are both due to commission in 2010.
- Vietnam has imported significant quantities of power from China since 2004 in order to meet its rapidly growing demand. Initially imports were at 110 kV, but

new interconnectors at 220 kV were commissioned in 2007 and a 500 kV interconnector is planned.

There are also small-scale exports from Vietnam and Thailand to Cambodia, from Thailand to Lao PDR, and from Lao PDR to Vietnam to serve border communities which are distant from the national network. These exchanges are generally at medium voltage. While not a power trade as such, Thailand has also been importing gas from Myanmar since 1998 to supply the Ratchaburi CCGT plant.

The dedicated interconnectors associated with export projects are controlled by the dispatch centers of the importing country. Exports over the existing interconnector between Thailand and Cambodia are treated as any other high-voltage customer of PEA. Exports from Vietnam to Cambodia will be controlled by the respective system operators. Commissioning of this line will mark the start of interconnected grid operation for Cambodia. The Cambodia system will be operated synchronously with that of Vietnam. Exports from China to Vietnam are controlled by the respective dispatch centers. The Chinese system and that of Vietnam are not synchronized, and areas supplied from China are isolated as an electrical "island."

3.6 Environmental and social issues

3.6.1 Environmental and social impacts

The expectation is that the GMS will encourage and support the exploitation of lower-cost hydro resources across the region. There are obviously very significant environmental and social issues associated with the development of each individual hydro plant which are addressed through national environmental and social impact assessments, approvals and mitigation requirements. Rather than repeat the issues arising with respect to each individual project, the reader is referred to the separate case study on the Nam Theun 2 hydro project, which provides an example of how environmental and social issues arising from the development of hydro projects are being managed.

Cross-border interconnectors developed to facilitate power trade are subject to environmental and social impact assessments under national requirements and also the requirements of external funding agencies, such as the World Bank and the Asian Development Bank, where these are involved.

There are two main regional coordinating agencies for assessing and managing environmental impacts arising out of the development of the various hydro projects along the Mekong River in particular. These are:

- The Mekong River Commission (MRC), based in Vientiane, Lao PDR.
- The GMS Environment Operations Center (EOC), based in Bangkok.

Both agencies are engaged, in particular, in the assessment and awareness-raising of potential wider environmental impacts from regional projects in order to assist national governments in incorporating these into their own environmental impact assessments.

At present, there is no regional organization overseeing management and use of the Salween River. A joint technical committee was established in 1989 bringing together representatives of Myanmar and Thailand's power utilities. There is no direct coordination between the planning undertaken by this committee and China's own planned developments.

Mekong River Commission

The main coordinating mechanism among countries along the Mekong for the management of its resources is the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin, signed in April 1995. Signatories to the agreement are Cambodia, Lao PDR, Thailand and Vietnam. As well as the four signatories to the agreement, China and Myanmar are dialogue partners.

The agreement requires rules to be developed governing water utilization and requires that each country avoid creating substantial environmental damage to other countries from their use of the Mekong. A coordinating body, the MRC, is established under the agreement. This succeeded the Mekong Committee, which was set up in 1957 under UN auspices to help manage use of the Mekong.

The process of environmental and social impact assessment and approval continues to be conducted at the national level for individual projects located on the Mekong and its tributaries. However, the MRC has established Procedures for Notification, Prior Consultation and Agreement (PNPCA). These require the member countries to notify and consult in advance on the possible impacts of developments on the Mekong mainstream and its tributaries and, if necessary, to reach an agreement on managing or compensating impacts facilitated by the MRC. Under the Procedures for Maintenance of Flows on the Mainstream, member countries are obliged to maintain minimum monthly dry season flows at an acceptable level, to enable the reversal of flows on the Tonle Sap to take place during the wet season, and to prevent water releases leading to peak flows in the flood season in excess of natural levels.

Many of the planned hydro export projects are located on the major tributaries of the Mekong or on the Mekong itself. The MRC has identified eight existing or planned dams along the Upper Mekong in China, 11 planned dams along the Lower Mekong through Lao PDR and Cambodia, and 94 existing and planned dams on tributaries of the Mekong—although not all are export projects. Development on this scale can be expected to have very large bio-physical impacts throughout the Mekong basin as well as impacts on the livelihoods of many millions of people.

The MRC is currently conducting a Strategic Environmental Assessment (SEA) of *Proposed Hydropower Development on the Mekong Mainstream in the Lower Mekong Basin*. The SEA is intended to inform decision-making at the regional and national levels on the development of mainstream hydro projects, provide an initial baseline and framework for the assessment of the environmental impacts of individual projects, and provide inputs to the development of the Basin Development Plan by the MRC. It is one of two studies planned by the MRC. The second will consider the macroeconomic and fiscal impacts of the planned developments, including the regional distribution of costs and benefits and their impacts on social equity.

The SEA is not a legal requirement but is supported by the individual MRC member countries as a means of helping identify the environmental and social impacts of the planned developments. As the MRC has no legal authority in this area, it has publicly noted the need to ensure that the SEA does not appear to contradict decisions reached through national-level planning and environmental assessment processes.

Environment Operations Center

The EOC was established in April 2006 following on from the endorsement of the GMS Core Environment Program (CEP) at the second GMS Summit in July 2005. Its main tasks are:

- Managing GMS environmental information.
- Managing the GMS Core Environment Program, setting the framework of environmental safeguards and codes of practice for development sectors, preparing the GMS environment action plan, and managing the Biodiversity Conservation Corridors Initiative (BCI).
- Performing SEAs of sectors, contributing to the sustainability of development projects and carrying out environmental reviews of strategies and plans.
- Convening regular consultative meetings of development partners and stakeholders and nurturing the GMS environmental partnership.
- Serving as secretariat of the Working Group on Environment (WGE).

The WGE is one of the nine sector-based working groups under the GMS Program. It was originally established in 1995, and its 15th Annual Meeting was held in July 2009. The WGE facilitates the implementation of priority GMS environmental projects, ensures that environmental issues are properly addressed in other GMS sectors, particularly transport and energy, and helps harmonize national environmental legislation.

The EOC conducted an SEA in 2007–2008 on the hydropower aspects of the most recent national power development plan in Vietnam (Master Plan VI). A second SEA on eight dams located on the Mekong mainstream in Lao PDR is being undertaken.

3.6.2 Carbon emissions savings

The development of the regional power market should generally be expected to reduce emissions across the region—primarily through the substitution of gas-fired generation in Thailand and coal and gas-fired generation in Vietnam with hydro power generated in Cambodia, Lao PDR and Myanmar. Interconnection can also be expected to reduce emissions substantially in Cambodia in particular, given its current reliance on diesel generation which can be replaced by imported power, but the small size of the Cambodian system means that the impacts of this in regional terms will be minor. Although not currently envisaged, in the longer term it may allow for expanded development of the region's renewable energy resources—e.g., wind generation in Vietnam—relative to what individual countries could achieve.

However, there are also potentially offsetting effects. Large hydro power plants will release methane from the rotting vegetable matter submerged at the time of flooding the reservoir, and this can have substantial global warming impacts. At least two of the major proposed export projects to Thailand (the 3,600 MW Koh Kong project in Cambodia and the 1,800 MW Hong Sa project in Lao PDR) are coal-fired.

The ADB's analysis of regional market benefits (presented in *Building a Sustainable Energy Future*) estimates that emissions over the period to 2025 would be around 36 $MtCO_2e$ lower with a fully integrated regional energy market. This represents a saving of around 3% in emissions compared to the base case—suggesting that integration alone will deliver relatively small reductions in emissions without major actions to promote energy efficiency and the use of renewable energy technologies at national levels.

To date, only one project associated with the GMS market has applied for certification under the Clean Development Mechanism (CDM). This is the 220 kV interconnector between Vietnam and the Phnom Penh area in Cambodia. A Project Design Document (PDD) together with a proposed new methodology for the calculation of emissions savings resulting from a cross-border project of this type was submitted to the Methodology Panel of the United Nations Framework Convention on Climate Change (UNFCCC) in May 2008. As of the date of this case study, the Methodology Panel has not reached a decision on the validity of the proposed methodology, and the application is, therefore, still pending. The PDD estimates the annual savings in emissions resulting from the replacement of fuel oil and diesel generation in Cambodia with electricity generated using the Vietnamese capacity mix at an average of 53,616 tCO_2e annually over the requested 10-year crediting period.

4 Institutional arrangements

4.1 Organizations to govern and coordinate the scheme

The coordinating institutions for the regional power market sit underneath the GMS Program institutions, as described in Section 3.1.1 and illustrated in Figure 7. There are four institutions specific to the GMS power market:

- The Subregional Electric Power Forum inaugurated in April 1995.
- The Regional Power Trade Coordinating Committee established by the November 2002 Inter-Governmental Agreement.
- The Focal Group and Planning Working Group established under MOU #1, which are under the RPTCC.

The role, membership, powers and governance of each of these institutions is described in the sections that follow.

None of the institutions has a permanent base or secretariat. Instead, meetings rotate between member countries. The role of secretariat is fulfilled by government or utility staff in the host country for the meeting and the ADB. Minutes of meetings are generally posted on the website of the ADB.

4.1.1 Electric Power Forum

The EPF serves as an advisory body to the GMS Ministerial Meetings on subregional power issues. Its objectives, as set out in its Terms of Reference (TOR) are to:

- Act as a cooperative link among government agencies and related institutions directly involved in power supply and power system development in the subregion.
- Act as a promotional and advisory organization for the development of efficient power systems in the subregion.
- Identify and promote opportunities for mutually beneficial subregional cooperation projects in the power sector.
- Promote financing by government, utilities, donors and the private sector of priority projects related to the development of subregional power systems.
- Provide a forum for discussing software issues, such as planning tools and pricing principles, related to subregional cooperation in power projects.
- Provide and disseminate information to participating countries and cooperate with regional and international organizations.

- Facilitate training and other human resource activities to support the development of power systems.

Each GMS country is represented on the EPF by two members. One is a senior official from the ministry or other government agency responsible for power sector policy and planning and the other is a senior manager from the key power utility in the country.[17] The EPF has been supplanted by the establishment of the RPTCC, which has the same membership.

4.1.2 Regional Power Trade Coordinating Committee

The RPTCC was established under Article 4 of the IGA. Its role, as defined in the IGA, is to "…actively coordinate for successful implementation of regional trade and to represent the countries involved in regional power trade." The RPTCC reports to the GMS Ministerial Meeting.

The IGA defined the first task of the RPTCC as being to establish and implement regional trade arrangements for endorsement by member countries. The specific requirements were given as the preparation of a plan to:

- Provide to the parties a final draft of the RPTOA, which will specify the rules of regional power trade.
- Provide to the parties a recommendation for the overall policy and day-to-day management of regional power trade, including the necessary bodies for coordination.
- Establish the short-, medium- and longer-term initiatives which need to be pursued on a priority basis in order to achieve the objectives of regional power trade within a specified timetable.
- Identify necessary steps for implementation of regional trade, including means for financing.

The RPTCC is now responsible for the implementation of the Road Map agreed for implementation of Stage 1 and in preparation for Stage 2 under MOU #2 in March 2008.

The membership of the RPTCC is the same as that of the EPF.[18]

The first meeting of the RPTCC was held in June 2004. To date, seven meetings of the RPTCC have been held, with the latestbeing in Ho Chi Minh City in Vietnam in November 2008.

[17] China and Thailand have multiple major government-owned utilities. In each case, they are represented by the utility responsible for the operation and ownership of the transmission system—China Southern Power Grid (CSG) and EGAT, respectively.

[18] Other participants may attend meetings of the RPTCC, FG and PWG, including representatives of IFIs and donors and of government and utilities in member countries.

4.1.3 Focal Group

The FG is described in the RPTOA and was set up in January 2006 following agreement on its establishment in MOU #1, signed in July 2005. It is primarily responsible for implementation of the RPTOA.

The FG's membership comprises a group of middle managers from each country who are associated with the planning and operation of regional interconnections. As described in the RPTOA, its role is "…to implement the decisions of the RPTCC on a day-to-day basis in their respective countries and to act as the coordinating body of the RPTCC work program in each GMS member country." It reports to the RPTCC. The RPTOA envisages that the FG may evolve into a technical secretariat if the RPTCC decides this is required.

Since its establishment, seven meetings of the FG have been held. These are generally held concurrently with meetings of the RPTCC, although separate meetings are held where required.

4.1.4 Planning Working Group

The PWG is also described in the RPTOA, and its establishment was approved in MOU #1. It was set up in June 2006 with responsibility for carrying out priority activities assigned to the RPTCC.

The PWG's membership comprises a senior level representative from each member country's transmission system operator with responsibility for national transmission planning. Its main objectives during Stage 1 of the regional power market are:

- Preparing a plan for developing a regional network with facilities that are dedicated to cross-border transactions but are not linked to specific PPAs.
- Planning and prioritizing the addition of new transmission capacity, including recommendations regarding ownership and financing.
- Defining excess transmission capacity that is available on a non-firm basis to support short-term opportunity exchanges of power.
- Preparing plans for augmenting the capacity of existing cross-border transmission facilities and reinforcements required in national transmission systems to facilitate cross-border power trading.
- Participate in developing performance standards regarding safety-security, reliability and quality of service.
- Create and maintain the regional database on power trading with due regard to the confidentiality aspects of PPAs with private parties.

The PWG's work is coordinated by the FG on a day-to-day basis.

Six meetings of the PWG have been held to date. These are generally held concurrently with RPTCC and FG meetings.

4.1.5 Proposed institutions

While only the previously mentioned institutions are currently in existence, a number of other proposed institutions have been identified in the consultant reports issued as part of the development of the draft RPTOA, but have not been established as yet. These proposed institutions would be located under the RPTCC and comprise the:

- ***Management Committee (MC)***. This would be established in Stage 2 and be an executive group within the RPTCC responsible for day-to-day interactions with other regional institutions. The MC would have a permanent office and staff and regular funding (either by budgetary contributions or a levy on cross-border energy flows).

- ***Regional Regulatory Board (RRB)***. According to the reports, this was to be established during Stage 1 but is not included in current agreements covering this stage. It would be responsible for promoting regional power trade, including encouraging consistency in regulation and removal of inhibiting national regulations, promoting common regional performance standards, approving tariffs and conducting market surveillance. From Stage 2, the RRB would have a permanent office and staff and regular funding (initially its membership would comprise national representatives who would cover their own costs). At Stage 3, the RRB would become a Regional Regulatory Agency (RRA).

- ***Regional Transaction Co-Ordinator (RTC)***. This would be established during Stage 2, at which time it would determine the availability of cross-border transmission capacity and match offers and bids for cross-border trade. It would also monitor the regional market's operations and develop maintenance programs and operating plans for regional transmission facilities (together with an operational planning group under the PWG). The RTC would have a permanent office and staff and regular funding. At Stage 3, the RTC would become a Regional Market Operator (RMO).

4.2 Role of national governments and regional institutions

The GMS power market has emerged from agreements among national governments in the region to cooperate in a range of sectors, one of which is energy. However, the form that the evolving market is taking is largely a response to developments in power trade on a bilateral basis. The existing regional energy sector institutions are building on bilateral arrangements as an initial step to a more integrated regional power market rather than designing or creating a market. The emphasis on the role of national government and agencies rather than regional institutions is shown in the absence of a formal regional secretariat and the composition of existing regional institutions—whose membership consists of representatives of national utilities and government agencies.

4.3 Regulatory agencies

National regulatory agencies (NRAs) exist in Cambodia, China, Thailand and Vietnam, although with varying levels of independence (see Annex A1 for more information). Regulatory agencies have not yet been established in Lao PDR and Myanmar, where regulatory responsibilities continue to be undertaken by ministries and utilities.

Currently, NRAs have no direct responsibility for regional electricity trade—their responsibilities end at national borders. However, representatives of at least some NRAs participate in regional activities—as an example, the Vietnamese regulator was co-organizer of the most recent meetings of the RPTCC, FG and PWG.

It is difficult to determine to what extent decisions on domestic regulatory matters by the NRAs are influenced by the regional power market. However, it does appear that the NRAs take account of requirements established or to-be-established under the various regional agreements. The NRAs in both Thailand and Vietnam have, for example, in personal communications, stated the need for ongoing revisions to their national Grid Codes to conform to the regional GMS performance standards that are under development.

4.4 Role of outside agencies

Outside agencies are playing a critical role in the development of the regional power market. Most significant is probably the contribution of the ADB, which is the main external agency supporting the GMS Program as a whole as well as the regional power market in particular.

The ADB has helped provide impetus to the establishment of the regional market through its own efforts and through the management of a number of technical assistance (TA) studies on the regional market (funded by the ADB and by bilateral donor agencies). These include the following:

- ***RETA 5920: Regional Indicative Master Plan on Power Interconnection in the Greater Mekong Subregion.***[19] This TA commenced in November 2000 and was completed in December 2003. It prepared the first version of the regional indicative master plan, which is used to identify priority interconnection projects to support regional power trade.
- ***RETA 6100: Study for a Regional Power Trade Operating Agreement in the Greater Mekong Subregion.***[20] This TA commenced in October 2003 and was completed in October 2007. Activities undertaken included:
  - Defining the stages for the development of the GMS market.
  - Drafting the RPTOA.

[19] The ADB website for this project is http://www.adb.org/Projects/project.asp?id=34092

[20] The ADB website for this project is http://www.adb.org/Projects/project.asp?id=36035

- Laying the basis for the signing of MOU #1.

- ***RETA 6304: GMS Regional Power Trade Coordination and Development.***[21] This TA commenced in April 2006 and is financed by Agence Fançaise de Développement (AfD). As of mid-2009, the TA is effectively completed. Activities undertaken include:
  - Preparing the action plan subsequently approved under MOU #2.
  - Supporting the FG and PWG.
  - Updating the regional indicative master plan.
  - Initiating work on a regional database and trading website.
  - Drafting regional performance standards.

- ***RETA 6440: Facilitating Regional Power Trading and Environmentally Sustainable Development of Electricity Infrastructure in the Greater Mekong Subregion.***[22] This TA commenced in late 2008 and is financed using funds from the Swedish International Cooperation Development Agency (SIDA). The purpose is to assist in completing the action plan activities identified for implementation of Stage 1 of the regional market as well as supporting preparation for Stage 2. Specific activities include:
  - Reviewing and, where necessary, assisting in preparing national power development plans in order to update the regional indicative master plan as well as identifying the need for additional studies for priority interconnection projects.
  - Estimating the costs and benefits of power trading and how these can be shared between participating countries.
  - Assessing measures required to prepare national regulatory frameworks for the introduction of competitive power markets as well as advising on the regulatory frameworks required at each stage of the regional market's development.
  - Providing capacity-building in the use of cumulative environmental impact assessments (CEIAs), SEAs and environmental management plans (EMPs), including undertaking pilot strategic and cumulative impact assessments for river basins in GMS countries. The project team is investigating opportunities to coordinate with EOC in this.

ESMAP has published two studies providing analyses and recommendations on the development of the GMS power market. An initial study published in December 2001

[21] The ADB website for this project is http://www.adb.org/Projects/project.asp?id=39594

[22] The ADB website for this project is http://www.adb.org/Projects/project.asp?id=41018. A project website has been established at http://www.gms-powertrade.net/. However, little material is publicly accessible.

identified constraints to the development of a regional power market. In December 2006, a further study was published providing an overview of market design options. This set out a phased market development program with the aim of achieving a unified regional market over a 15-year period.

The ADB and World Bank are also helping with the physical development of regional interconnectors through financial support and technical assistance. The ADB is planning support to interconnectors between southern Lao PDR, Cambodia, Thailand and Vietnam as well as the upgrading of existing MV interconnectors between northern Lao PDR and Thailand to 115 kV. Under the GMS Power Interconnection Project Phase 1, ADB had planned to develop a 500 kV interconnection between Thailand and Vietnam via the southern provinces of Lao PDR. Following concerns expressed by EGAT over the stability of an interconnection with the Vietnamese system at this time, separate interconnectors with Thailand and Vietnam are currently being developed.

The World Bank and ADB are jointly financing the interconnector between Vietnam and Phnom Penh in Cambodia. The World Bank is also planning to finance further 115 kV transmission lines within Cambodia and Lao PDR which will allow cross-border trade between these countries and southern Vietnam and allow future links between Thailand, Lao PDR and Cambodia. In addition, further support to the establishment of the GMS power market is being considered.

A listing of ADB and World Bank–supported interconnection projects is provided in Table 7 at the end of Section 6.

5 Contractual, financial and pricing arrangements

5.1 Contracts

Higher-level agreements on the regional power market include the IGA, MOU #1, and MOU #2, described in Section 3.1. The only regional operating contract or agreement currently in place is the RPTOA, approved as guidelines for implementation of bilateral projects under MOU #1.[23] Cross-border sales from export projects or across existing interconnectors are covered under bilateral agreements. Draft guidelines covering common regional performance standards have been developed by the PWG with consultant assistance (see Section 4.4). These are to be finalized by 2010 under the Road Map approved by MOU #2.

Regional Power Trade Operating Agreement

The RPTOA, in its current form, sets out guidelines for bilateral cross-border agreements, creating minimum common standards to facilitate future regional trade. The main features of these guidelines are as follows:

- Minimum communications and coordination protocols are established. However, details of scheduling and operation procedures and processes are left to bilateral agreements.
- The concerned transmission system operators (TSOs) are required to maintain a database of transactions suitable for future incorporation into a planned regional database.
- The contracting parties agree whether a transmission tariff (transit charge) should apply during Stage 1 of the regional market.
- Billing is to be monthly on the basis of energy sold.
- A phased dispute resolution process is established:
  - Initially, the general managers of the concerned control centers seek amicable agreement.
  - If this is not successful, then the dispute is referred to higher levels of the concerned TSOs. These initially appoint representatives for formal amicable discussions.
  - If the dispute relates to a technical matter, then the TSOs may agree on an independent expert to provide an opinion.
  - If an amicable resolution cannot be reached, the dispute is referred to arbitration. A three-member panel is appointed operating under

[23] Formally, MOU #1 approved guidelines for the implementation of the RPTOA.

UNCITRAL rules. Arbitration hearings are to be held in a neutral country and conducted in English. The decision of the panel is final and no appeal is allowed to the courts.

The RPTOA also defines the first two stages of the regional power market and the composition and roles of the FG and PWG.

Regional performance standards

The draft regional performance standards are developed from the draft regional grid code prepared as part of the consultant support to the drafting of the RPTOA. As well as the performance standards themselves they also comprise methodologies for interconnection studies, guidelines for the design of new transmission facilities associated with bilateral export projects, and guidelines on the design of transmission (transit) tariffs for application in Stage 1.

Major features of the draft guidelines for performance standards are as follows:

- The PWG will define and prepare and keep updated a model of the Regional Transmission Network used for cross-border transactions.
- Transmission systems should be designed to perform in accordance with the regional standards. The PWG is responsible for developing a Transmission Design Code with standards no less strict than those currently in force in GMS member countries. The PWG in consultation with TSOs can propose modifications to the standards while the RPTCC can order changes.
- TSOs are responsible for operating their national systems to meet regional standards. Initially, TSOs are responsible for providing their own reserves. Once the regional market is established, primary reserve requirements can be shared between all member countries.[24] The PWG is responsible for defining this reserve requirement and its allocation (based on energy generated) between countries.

The need for country-level studies to determine the current ability to comply with the regional performance standards is identified in the report containing the draft guidelines. The report also proposes interim standards to apply in the power systems of Cambodia, Lao PDR and Myanmar which do not currently have Grid Codes (a Grid Code for Cambodia has been almost finalized in anticipation of the interconnection of its 115 kV system to Vietnam).

The guidelines for the design of new export transmission facilities require that studies are undertaken to confirm that these comply with the regional performance standards and do not degrade the performance of the respective national transmission systems to which the facilities are connected.

The guidelines for transit tariffs note that there is currently no open access on national transmission systems and that any use of transmission lines owned by third parties for transit (e.g., from China to Thailand) is expected to be negotiated on a case-by-case basis.

[24] Primary reserve is set equal to the largest single generating unit plus a margin.

Therefore, an Inter-TSO Compensation Charges (ITCC) mechanism will only be required for Stage 2 onwards of the regional market. Given this, the guidelines only establish a few basic design principles for the ITCC, primarily that:

- Charges should be linked to the energy injected to and withdrawn from the regional transmission network. Charges will give access rights to the network as a whole.
- In Stage 2, charges should only recover the variable costs associated with incremental losses arising from transit flows. Optionally, a contribution to fixed costs might be included, but the assumption is that the regional network initially is comprised of networks built to serve national demand and paid for by national users.
- The exception to this is assets specifically constructed for regional trade, for which standard unit costs set by the RPTCC should be used to calculate costs to be recovered. These costs are allocated between users of the assets in proportion to their share in flows over those assets.

Bilateral contracts

Basic information on existing bilateral contracts is provided in Table 4. This excludes the soon-to-commission Nam Theun 2 hydro power project, which will export from Lao PDR to Thailand. That project is the subject of a separate case study to which readers are referred for more information.

Table 4 Major Existing Cross-Border GMS Trade Contracts

Project	Date Trade Commenced	Contract Volumes	Contract Term	Contract Price
		Lao PDR to Thailand		
Theun Hinboun hydro project	1998	Must-take for 95% of available output. 1999-2002 sales averaged 1,465 GWh pa	25 years	$0.0484/kWh in Year 1. Indexed at 1% pa
Houay Ho hydro project	1999	126 MW minimum capacity 394.2 GWh annual energy	30 years	n.k.
		China to Vietnam		
220 kV (Ha Giang)	2007	Up to 200 MW 700 GWh in Year 1	44 months	n.k.

Project	Date Trade Commenced	Contract Volumes	Contract Term	Contract Price
		1,000 GWh in Year 2		
220 kV (Lao Cai)	2007	Up to 250-300 MW 1,100-1,300 GWh pa	n.k.	n.k.
		Thailand to Cambodia		
115 kV (Banteay Mean Chey)	2007	Up to 80 MW 13.8 GWh (Nov-Dec 2007 only)	n.k.	Supplied at applicable PEA tariff. Average for 2007 was Bt 2.82/kWh (approx. $0.08/kWh)
		Vietnam to Cambodia		
220 kV (Phnom Penh)	August 2009 (expected)	TBD	n.k.	Under negotiation. Original PPA was for TOU tariff averaging $0.062/kWh in dry and $0.056/kWh in wet seasons

Sources:

Lao PDR to Thailand	Department of Energy Promotion and Development (2009) and http://www.poweringprogress.org/index.php?option=com_content&view=article&id=79&Itemid=108
China to Vietnam	Trung (2008)
Thailand to Cambodia	Electricity Authority of Cambodia (2008)
Vietnam to Cambodia	World Bank (2003) and personal communication with Electricity Authority of Cambodia

5.2 Ownership and finance

At this stage of the regional market's development, no assets have been specifically developed for cross-border electricity trade as part of the market (i.e., for use by third parties and for transit). While a number of export projects and interconnectors have been or are being constructed, these have been developed on a bilateral basis. Export generator projects in Lao PDR have been developed as independent power projects (IPPs). Interconnector facilities are generally owned by the transmission utility in the country in which they are located, with the exception of transmission lines in Lao PDR, which are owned by the related project company. Financing for export projects in Lao PDR is from a mix of national utilities, international developers, commercial banks and IFIs. For an example financing arrangement, see the Nam Theun 2 case study.

Of the interconnectors not associated with export projects from Lao PDR, the World Bank and ADB are jointly financing the majority of the costs of the Vietnam–Cambodia interconnector and are looking at opportunities to finance other interconnectors. The cost of the Vietnam–Cambodia interconnector, including a national control center for Cambodia, is US$95 million, of which US$16 million is being funded by the World Bank under an IDA

credit, US$44 million by an ADB loan, US$11 million by the Nordic Development Fund and the remainder by the government of Cambodia.

5.3 Pricing arrangements

At present, prices for bilateral cross-border trade are set under negotiated PPAs on a case-by-case basis. A summary of current contracts is provided in Table 4.

No transit (wheeling) charges are currently in place. While not explicitly ruled out under Stage 1, the general expectation is that no significant transit transactions will occur at this stage and, therefore, transit tariffs will not be required. This is reflected in the existing RPTOA, which allows contracting parties to mutually determine whether to apply transit charges, and in the draft guidelines on transit charges which do not envisage these being applied during Stage 1.

6 Future plans

The key document setting out future plans for the GMS power market is the Plan of Action for the Energy Sector adopted at the Third GMS Summit held in Vientiane in March 2008. More detailed steps in the development of the institutional and contractual arrangements for the regional power market are contained in the Regional Cross Border Trade Road Map, which was approved by MOU #2 signed at the same summit. These two documents are described in the section that follows.

6.1 Vientiane Plan of Action

The Vientiane Plan of Action identifies four strategic thrusts for the development of the GMS energy sector (including the regional power market):

- ***Strategic Thrust I:*** Broadening GMS energy cooperation through enhanced efficiency and security and sustainable development of energy resources.
- ***Strategic Thrust II:*** Regional power trade development: Building capacity for power trade operation, coordination and grid interconnection.
- ***Strategic Thrust III:*** Regional power trade development: Implementing key GMS interconnection projects for Stage 1 power trading.
- ***Strategic Thrust IV:*** Regional power trade development: Developing generation projects for power exports under Stage 1.

A total of 32 projects and activities are identified as part of the Plan of Action, extending out to 2014. These are separated into three groups:

- ***Group 1***: Ongoing projects or projects for immediate implementation with identified financing.
- ***Group 2***: Projects for implementation later within the plan period and/or projects requiring financing.
- ***Group 3***: Projects with no definite timeline and/or cost estimate and financing.

The power market–related activities identified under Strategic Thrusts I and II, which relate to institutional issues, are listed in Table 5. Under Strategic Thrusts III and IV, the Plan of Action identifies a number of priority interconnection and export projects. These are identified as part of Table 10, which lists planned and proposed interconnectors and export projects in the GMS.

Table 5 Vientiane Plan of Action - Power Market Institutional Activities

Activity	Indicative Timeline	Estimated Cost (US$m)	Remarks

Strategic Thrust I – Broadening GMS energy cooperation			
Group 1 – Ongoing activities and activities for immediate implementation			
Promoting greater interaction between the EPF / RPTCC and WGE / EOC	2008-12	0.05	Included in the EOC work program
Group 2 – Activities for later implementation			
Facilitating sustainable environmentally friendly regional power trading phase 2	2010-12	2.00	To be financed by ADB
Strategic Thrust II – Building capacity for regional power trade			
Group 1 – Ongoing activities and activities for immediate implementation			
Regional power trade coordination and development	Completing in 2008	1.30	Ongoing. Financed by AFD (ADB RETA 6304)
Establishment of regional power database and website	2007-10	0.10	Included in the RPTCC work program
Facilitating sustainable environmentally friendly regional power trading	2008-10	5.00	Ongoing. Financed by SIDA (ADB RETA 6440)
Group 2 – Activities for later implementation			
Developing the Regional Transmission and Regulatory Authority[a]	2010-12	1.00	To be financed by AFD

a The consultant reports prepared for the draft RPTOA identified the need to establish a Regional Regulatory Board and a Regional Transaction Coordinator. From the Vientiane Plan of Action, it is unclear whether the Regional Transmission and Regulatory Authority will be a single combined entity replacing these two proposed separate entities.

6.2 Regional Cross Border Trade Road Map

The next steps in the completion of Stage 1 of the GMS power market and in preparing for Stage 2 are set out in the Road Map approved under MOU #2 in March 2008. The Road Map provides further detail on the regional power market–related activities to be undertaken under Strategic Thrusts I and II of the Vientiane Plan of Action.

The Road Map is reproduced in Table 6. Support will be provided to the GMS countries in undertaking these activities under the ongoing SIDA-funded TA project (ADB RETA 6440).

In its business plan for the GMS for 2009–2011, the ADB has also provisionally allocated funding in 2010 for support to the development of the Regulation Regulatory Board and the Regional TransmissionCoordinator (see Section 4.1.5). This is identified as an activity under the Vientiane Plan of Action, but is not included in the Road Map.

Table 6 Regional Cross Border Trade Road Map, 2008-12

Milestone	Activities	Schedule

Milestone	Activities	Schedule
Timelines to fully achieve Stage 1		
Complete the indicative power interconnection Master Plan	Complete the GMS indicative master plan for power development	2008
	Select priority interconnection projects identified in the master plan	2008-10
	Develop feasibility studies of selected priority projects	2009 onwards
	Update the regional indicative Master Plan	Every two to three years
Complete the study on GMS Performance Standards	Complete the study on GMS Performance Standards and consider for adoption the suggested GMS Performance Standards on new regional interconnections and for the synchronized operation of interconnected grids	2010
	Consider for adoption the proposed transitional arrangements to achieve GMS Performance Standards	2010
Complete the study on Transmission Regulations	Complete the study on Transmission Regulations and consider for adoption the findings of the study to coordinate the operation and power flow control in grid-to-grid interconnection synchronization and operation	2010
Complete the studies on standard regional metering arrangements and power trade rules	Complete the study on standard regional metering arrangements and communications systems in grid-to-grid interconnection for implementation during Stage 1 and consider for adoption the findings of the study	2010
	Complete the study on power trade rules, including resolution mechanisms for disputes outside existing PPAs for implementation during Stage 1, and consider for adoption the findings of the study	2010
Timelines to prepare for Stage 2		
Undertake the study to identify the regulatory barriers to the development of power trade and implementation of next stages	Complete the study to identify the regulatory barriers to development of power trade and consider for adoption the measures and institutional arrangements to address regulatory barriers	2012
Complete the study on a GMS Grid Code (operational procedures)	Complete the study on a GMS Grid Code and consider for adoption the findings of the study, which includes:	2010-12

Milestone	Activities	Schedule
	θ GMS Performance Standards θ Coordination procedures between System Operators to schedule and control cross-border flows, management of deviations θ Metering and communications θ Sharing of power reserves and support during emergencies	
Complete the study on Stage 2 Transmission Regulations to allow third-party access in interconnections, giving priority to contracts / PPAs, including Stage 2 power trade rules and dispute resolution mechanism	Complete the study on Stage 2 Transmission Regulations and consider for adoption the findings of the study to include development of payment agreements / tariffs for third-party use, to compensate countries that host flows linked to third parties' trading	After 2012
	Develop and consider for adoption power trade rules for short-term cross-border trading	By 2012
	Develop and consider for adoption power trade rules for settlement of deviations to scheduled power trade in grid-to-grid interconnections	By 2012

6.3 Physical interconnections

As regards physical development of the regional network, a large number of bilateral projects are proposed or under development, the vast majority of which are export projects located in Lao PDR and Myanmar. Interconnectors between China and Vietnam for bilateral trade are also planned.

The ADB and World Bank have identified a number of interconnection projects for funding specifically as part of the development of the regional network to support power trade in the GMS. These are included in the Vientiane Plan of Action.

These projects are listed in Table 7. Of these, perhaps the most interesting in terms of GMS power market development is the Nabong-Udon Thani interconnection project. This will construct a 500 kV transmission line which will be owned as a joint venture by EGAT and EDL for the purposes of transmitting electricity from four export hydro projects located in Lao PDR to Thailand, for which wheeling charges will apply. As such, it is a first step in the creation of regional interconnectors which are not dedicated to an individual project or user but will have multiple users.

6.4 Major issues

The major issue facing the GMS market appears to be whether and when to move ahead to Stage 2, at which time the market will become "formalized" with permanent institutions in place alongside a formal Grid Code, transit tariffs, and rules for short-term cross-border power trading. Currently, under Stage 1, trade is almost wholly in the form of bilateral agreements between national utilities (or national utilities and IPPs located in neighboring countries). As such, GMS member countries remain free to determine the conditions of trade and when trade will take place. Existing institutions do not have permanent offices or staff and largely act as a means of coordinating the activities of national utilities in developing mechanisms that can form the basis for a future regional market. While the GMS countries have committed to the Road Map, which includes activities to prepare for Stage 2, there is, as yet, no formal agreement committing to the implementation of this stage by a given date. The Vientiane Plan of Action refers only to projects related to Stage 1 of the regional power market, with dates for the commissioning of these projects extending out to 2014.

A move to Stages 3 and 4 appears a long way off, particularly given the implied need to restructure and liberalize national electricity markets before these stages can be implemented. Of the two major GMS importing countries, Vietnam has issued a road map for such liberalization. However, Thailand has ruled out liberalization for the present and intends to maintain a national single-buyer structure.

Table 7 Proposed ADB and World Bank-Funded Interconnection Projects

Project	Country	Year	Cost (US$m)	Funding (US$M)		
				Sponsor	Co-financing	Government
ADB-sponsored						
GMS Northern Power Transmission	Lao PDR	2009	53.5	20.0	30.0	3.5
GMS Nam Ngiep 1 Hydropower Project	Lao PDR	2009	35.0	35.0	0.0	0.0
GMS Nabong – Udon Thani Power Transmission and Interconnection	Lao PDR	2009	84.0	74.0	0.0	10.0
GMS Nam Ngum 3 Project	Lao PDR	2009	52.0	47.0	0.0	5.0
Lao-Vietnam Power Interconnection (Ban Sok – Pleiku)	Lao PDR	2010	150.0	25.0	117.0	8.0
Lao-Vietnam Power Interconnection (Ban Sok – Pleiku)	Vietnam	2010	120.0	30.0	70.0	20.0
World Bank-sponsored						
115 kV transmission: Vietnam – Kampong Cham	Cambodia	n.k.	n.k.	n.k.	n.k.	n.k.
115 kV transmission: Lao PDR border – Stung Treng	Cambodia	n.k.	n.k.	n.k.	n.k.	n.k.
115 kV transmission: Ban Hat – Lao PDR border	Lao PDR	n.k.	n.k.	n.k.	n.k.	n.k.
115 kV transmission: Xeset – Saravan	Lao PDR	n.k.	n.k.	n.k.	n.k.	n.k.

All the above projects are included in the Vientiane Plan of Action as Group 1 projects under Strategic Thrust III (see Section 6.1 for a description of these categories).

Sources: World Bank and ADB (2008)

Bibliography

Major documents and websites consulted in the preparation of this case study are listed below. These are organized as follows:

- Documents published by or prepared for the GMS Program.
- Documents published by or prepared for other international organizations.
- Documents published by or prepared for national governments and utilities and their staff, organized by country.
- Other documents.
- Websites consulted.

Where documents are publicly available on websites, a link is provided in parentheses following the document listing.

Websites consulted on a single occasion are referenced at appropriate locations in the main text.

GMS Program documents

Policy Statement on Regional Power Trade in the Greater Mekong Subregion, January 2000 (http://www.adb.org/Documents/Others/GMS/Sector-Activities/Regional-Power-Trade-IGAandMOU.pdf - also contains the Inter-Governmental Agreement and MOU #1)

Inter-Governmental Agreement on Regional Power Trade in the Greater Mekong Subregion, 3 November 2003, Phnom Penh (http://www.adb.org/Documents/Others/GMS/Sector-Activities/Regional-Power-Trade-IGAandMOU.pdf - also contains the Policy Statement and MOU #1)

Memorandum of Understanding on the Conditions for the Implementation of the RPTOA – Stage #1, 5 July 2005, Kunming (http://www.adb.org/Documents/Others/GMS/Sector-Activities/Regional-Power-Trade-IGAandMOU.pdf - also contains the Policy Statement and Inter-Governmental Agreement)

Memorandum of Understanding on the Road Map for Implementing the Greater Mekong Subregion Cross-Border Power Trading, 31 March 2008, Vientiane (http://www.adb.org/Documents/Events/Mekong/Proceedings/FG6-Appendix3.pdf)

Vientiane Plan of Action for GMS Development 2008-2012, March 2008, Vientiane (http://www.adb.org/Documents/Events/2008/3rd-GMS-Summit/POA-Vientiane2008-2012.pdf)

Electric Power Forum Terms of Reference (http://www.adb.org/Documents/Others/GMS/Sector-Activities/TOR-Energy.pdf)

Regional Power Trade Coordinating Committee Terms of Reference (http://www.adb.org/Documents/Others/GMS/Sector-Activities/TOR-RPTCC.pdf)

Soluziona & Mercados (2008, February): *Long-Run Indicative Master Plan for the GMS Region: Final Report*. Report prepared for the Asian Development Bank.

Soluziona & Mercados (2008, October): *Regional Performance Standards: Final Report*. Report prepared for the Asian Development Bank.

Other international organizations documents

Asian Development Bank (ADB)

ADB (2008, September): *Regional Cooperation Operations Business Plan: Greater Mekong Subregion 2009-11* (http://www.adb.org/Documents/CPSs/GMS/2008/RCOBP-GMS-2009-2011.pdf)

ADB (2009, June): *Building a Sustainable Energy Future: The Greater Mekong Subregion* (http://www.adb.org/Documents/Books/GMS-Sustainable-Energy-Future/GMS-Sustainable-Energy-Future.pdf)

Baardsen, E. (2008): "Power Interconnection in the GMS Region." *ASIA 2008*, 9 March 2008, Da Nang (http://www.adb.org/Documents/Presentations/VRM/GMS-Presentation-Asia-2008.pdf)

Association of South-East Asian Nations (ASEAN)

Heads of ASEAN Power Utilities / Authorities (HAPUA) (2006, Otober): "HAPUA and the ASEAN Power Grid for Optimum Use of Energy Resources." *Regional Energy Policy and Planning in ASEAN for Sustainable Development*. Bangkok, Thailand. 10-11 October 2006. (http://www.asean-sustainable-energy.net/documents/libraries/001/HAPUASecretary%20akhir%20Bangkok%206-10-06.pdf)

Energy Sector Management Assistance Program (ESMAP)

ESMAP (2001): *Development of a Regional Power Market in the Greater Mekong Subregion*. ESMAP Technical Paper 015 (http://www.esmap.org/filez/pubs/86200760022_GMS23874.pdf)

ESMAP (2006): *Options for the Structure of the GMS Power Trade Market: A First Overview of Issues and Possible Options*. ESMAP Technical Paper 108/06 (http://www.esmap.org/filez/pubs/4162007110526_GreaterMekongOptions.pdf)

Greater Mekong Subregion Environment Operations Center (GMS EOC)

Lefevre T. 2009. "ADB GMS RETA 6440: Project Status and Potential Links with GMS EOC and MRC". *WGE 15th Annual Meeting*. Bangkok, Thailand. 2-3 July 2009 (http://www.gms-eoc.org/WGE/Meeting/docs/15-AM-WGE/RETA6440_PotentialLinkages.pdf)

Stockholm Environment Institute (2008, July): *Strategic Environment Assessment for Hydropower in Vietnam: Policy Summary*. Report prepared for Ministry of Industry and Trade and Asian Development Bank (http://www.gms-eoc.org/CEP/Comp1/docs/Vietnam/Hydropower/PolicySummary.pdf)

International Monetary Fund (IMF)

World Economic Outlook (2009, April):(http://www.imf.org/external/pubs/ft/weo/2009/01/index.htm)

Mekong River Commission (MRC)

Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (1995, 5 April): (http://www.mrcmekong.org/agreement_95/agreement_95.htm)

Procedures for Notification, Prior Consultation and Agreement (2003, 30 November): Phnom Penh (http://www.mrcmekong.org/download/programmes/PNPCA.pdf)

Procedures for the Maintenance of Flows on the Mainstream (2006, 22 June): Ho Chi Minh City (http://www.mrcmekong.org/download/programmes/FlowsProcedure.pdf)

Soussan, J. (2009, June): *Phase 1: Background Scoping Paper for a Strategic Environmental Assessment of Proposed Hydropower Developments on the Mekong Mainstream in the Lower Mekong Basin* (http://www.mrcmekong.org/ish/SEA_Phase_1_Paper_Final.pdf)

United Nations Framework Convention on Climate Change (UNFCCC)

Cambodia – Rural Electrification and Transmission Project (RETP) – 220 kV Interconnection between Cambodia and Vietnam, Project Design Document (http://cdm.unfccc.int/UserManagement/FileStorage/L8AHLLI9H94AMYZYARZ64E4XJ3SLL7)

World Bank

World Bank (2003, November): *Cambodia Rural Electrification and Transmission Project: Project Appraisal Document*. Report No. 27015-KH (http://web.worldbank.org/external/projects/main?menuPK=51447259&pagePK=51351007&piPK=64675967&theSitePK=40941&menuPK=64187510&searchMenuPK=51351213&theSitePK=40941&entityID=000012009_20031126114127&searchMenuPK=51351213&theSitePK=40941)

World Bank. n.k. *Greater Mekong Subregion Electricity Market Project* (http://siteresources.worldbank.org/INTTHAILAND/Resources/333200-1211794042917/5033487-1211794196043/gms-regional-power-trade-program.pdf)

National documents

Cambodia

Electricity Authority of Cambodia (2008): *Report on Power Sector for the Kingdom of Cambodia for the Year 2007* (http://www.eac.gov.kh/pdf/reports/Report%20On%20Power%20Sector%20For%20The%20Year%202007.en.pdf)

Ministry of Industry, Mines and Energy (2008): "Cambodian Power Development Plans." *Fifth Meeting of the Planning Working Group (PWG-5)*. Vientiane, 17 June 2008 (www.adb.org/Documents/Events/Mekong/Proceedings/PWG5-Appendix4.1.pdf)

Wasizawa, T. (2009): *Overview on Power Sectors in Cambodia*. Report prepared for MIME and JICA.

China

Berrah, N. (2009, July): *Reforming China's Power Sector: In the Middle of the River* (http://scid.stanford.edu/publicationsprofile/1991)

China Southern Power Grid Co Ltd. (2008): "Update for CSG Grid Planning and International Cooperation Projects." *Fifth Meeting of the Planning Working Group (PWG-5)*. Vientiane, 17 June 2008 (www.adb.org/Documents/Events/Mekong/Proceedings/PWG5-Appendix4.2.pdf)

Lao PDR

Unknown (2008): "Lao PDR." *Fifth Meeting of the Planning Working Group (PWG-5)*. Vientiane, 17 June 2008 (www.adb.org/Documents/Events/Mekong/Proceedings/PWG5-Appendix4.3.pdf)

Department of Energy Promotion and Development. May (2009, May) *Power Projects in Lao PDR* (http://www.poweringprogress.com/download/Electric%20Power%20Plants%20in%20Laos%20%20as%20of%20May%202008.pdf)

Maunsell and Lahmeyer International (2004, August): *Power System Development Plan: Final Report* (http://www.poweringprogress.com/index.php?option=com_jotloader&cid=11&Itemid=97)

Somvichith, S. (2008): "Hydro Power in Lao PDR and Power Development Plan." *Executive Seminar on EDL and Laos Hydro Power Development*. Vientiane, 21 November 2008 (http://www.edl-laos.com/download/Presentation%20to%20EDL%20executive%20seminar%20(21-Nov%202008)-Sanhya.ppt)

Myanmar

Unknown (2007): "Country Report of Myanmar." *Franco-ASEAN Seminar on Power ASEAN: Technology and Policy Options*. Bangkok, 6-7 September 2007 (http://www.burmalibrary.org/docs2/MMpresentation.pdf)

Unknown (2008): "Country Report on Progress of Power Development Plans and Transmission Interconnection Projects: Myanmar." *Fifth Meeting of the Planning Working Group (PWG-5)*. Vientiane, 17 June 2008 (www.adb.org/Documents/Events/Mekong/Proceedings/PWG5-Appendix4.4.pdf)

Wolf, A., and J. Newton (2007): *Case Study of Transboundary Dispute Resolution: Salween River* (http://www.transboundarywaters.orst.edu/research/case_studies/Documents/salween.pdf)

Thailand

EGAT (2007a): *Power System Control and Operation*.

EGAT (2007b): *Thailand Power Development Plan*. Approved by Cabinet, 19 June 2007.

EGAT (2008): "Updated Status of Thailand Power System." *Fifth Meeting of the Planning Working Group (PWG-5)*. Vientiane, 17 June 2008 (www.adb.org/Documents/Events/Mekong/Proceedings/PWG5-Appendix4.5.pdf)

Energy Regulatory Commission (2009): *Thailand Regulatory Developments 2009* (http://www.erc.or.th/Doc/thailand.pdf)

Energy Industry Act 2007 (http://www.erc.or.th/Doc/Energy%20Industry%20Act%202007%20-%20actual%20-%20En.pdf)

PricewaterhouseCoopers (2000, January): *Review of Electric Power Tariffs*. Report prepared for the Energy Policy and Planning Office (http://www.pea.co.th/th/eng/page.php?name=ElectricityTariffs)

Provincial Electricity Authority tariffs (http://www.pea.co.th/th/eng/page.php?name=ElectricityTariffs)

Vietnam

Establishment and Stipulation of Functions, Duties, Authorities and Organization of the Electricity Regulatory Authority under the Ministry of Industry, Decision of the Prime Minister No. 258/2005/QĐ-TTg dated 19 October 2005.

Approval of the Roadmap, the Conditions to Establish and Develop the Levels of the Power Market in Vietnam, Decision of the Prime Minister No. 26/2006/QĐ-TTg dated 26 January 2006.

Master Plan for National Power Development for 2006-15 with a Perspective to 2025 (Master Plan VI), Decision of the Prime Minister No. 110/2007/QĐ-TTg dated 18 July 2007.

Tariffs for 2009 and Market Tariff Mechanism for 2010-2012, Decision of the Prime Minister No. 21/2009/QĐ-TTg dated 12 February 2009.

Economic Consulting Associates (2006, October): *Bulk Power, Distribution Margin, Retail Tariff Design and Development of an Independent Creditors Model: Final Report*. Report prepared for Electricity of Vietnam and World Bank.

Electricity Regulatory Authority of Vietnam (2007, June): *Vietnam Power System*. Internal presentation.

Institute of Energy (2008): "Progress of Vietnam Power Development and Interconnection Projects." *Fifth Meeting of the Planning Working Group (PWG-5)*. Vientiane, 17 June 2008 (www.adb.org/Documents/Events/Mekong/Proceedings/PWG5-Appendix4.6.pdf)

PB Associates (2009, February): *Analysis and Implementation of Water Valuation in Vietnam: Interim Report*. Report prepared for the National Load Dispatch Center and World Bank.

Trung, N. Q. (2008): *Introduction to the Electric Power System of Vietnam*. Presentation by National Load Dispatch Center.

Other documents

Garrett, B. (2004): *Comments on Indicative Master Plan on Power Interconnection in GMS Countries* (http://palangthai.org/docs/CommentsADBMasterPlanGMSPowerGrid.pdf)

Garrett, B. (2005): *Comments on Study for a Regional Power Trade Operating Agreement in the Greater Mekong Subregion* (http://www.palangthai.org/docs/CommentsRPTOA.pdf)

Major websites

Asian Development Bank: http://www.adb.org

Asian Development Bank– Greater Mekong Subregion: http://www.adb.org/gms/

China Southern Grid Power Company Limited: http://eng.csg.cn/

Department of Energy Promotion and Development (Lao PDR): http://www.poweringprogress.com/

Electricité du Cambodge (EDC): http://www.edc.com.kh/

Electricité du Laos (EDL): http://www.edl-laos.com/

Electricity Authority of Cambodia (EAC): http://www.eac.gov.kh/

Electricity Generating Authority of Thailand (EGAT): http://www.egat.co.th/

Electricity of Vietnam (EVN): http://www.evn.com.vn/

Energy Regulatory Commission (ERC, Thailand): http://www.erc.or.th/

GMS Environment Operations Center: http://www.gms-eoc.org/

Mekong River Commission: http://www.mrcmekong.org/

World Bank: http://www.worldbank.org

A1 National power markets

A1.1 Cambodia

Existing market

The electricity industry in Cambodia is small and electrification levels are very low, at around 16% to 20%. There are two existing isolated 115 kV transmission systems—one around the capital, Phnom Penh, and the other in the northwest connecting Bantey Meanchay, Siem Reap and Battambang. Elsewhere, supply is in the form of isolated MV systems around the main provincial towns, notably Siem Reap, border areas and along the main national roads and individual isolated mini-grids.

The government has set targets of electrifying 100% of villages by 2020, including through battery charging stations, and of providing grid-quality electricity supplies to 70% of households by 2030.

Demand has grown quickly in recent years, along with the rapid expansion of Cambodia's economy. Capacity on the Phnom Penh system, at 188 MW, is already inadequate to meet unconstrained peak demand, which was estimated at 206 MW in 2007.

The dominant entity is Electricité du Cambodge (EDC), the state-owned vertically integrated electricity utility which supplies Phnom Penh and major provincial towns. In 2007, EDC supplied 1,221 GWh to 286,660 customers, accounting for 90%of total national sales and 70% of total national customer numbers.

Elsewhere, supply is by a large number of rural electricity enterprises (REEs), some of which are connected to MV grids and others which operate isolated mini-grids using diesel generators. The REEs vary greatly in size, with the largest isolated system having sales of 3,04 MWh in 2007 to 1,241 customers. By contrast, the smallest had sales of just 3.2 MWh in 2007 serving 240 customers. The largest grid-connected system had annual sales of 31,532 MWh and served 6,300 customers—still far below those of EDC.

The vast majority of electricity supplied in Cambodia is generated from fuel oil and diesel plants. There is a small amount of hydro generation and, in the northwestern grid and in border areas, imports from Thailand and Vietnam (in 2007 totalling around 155 GWh or 10% of total national energy generated and imported). EDC has some generating capacity and also relies heavily on purchases from independent power producers (IPPs). The various REEs in most cases generate their own supplies but, in some cases, purchase from EDC, IPPs or imports.

Electricity tariffs are not uniform and are very high in Cambodia by international standards, due to the dependence on oil-fired generation. To this are added the high unit costs resulting from the small and dispersed loads in rural areas. Tariffs vary greatly between the Phnom Penh system, other urban areas and rural areas. The vast majority of REEs charge tariffs of 2,000 Riels/kWh (approximately 50 USc/kWh) or above.

The primary legislation governing the electricity industry is the Electricity Law 2001. This establishes the Electricity Authority of Cambodia (EAC) as the regulatory body for the

industry and creates a licensing framework under which all power suppliers are required to hold a license issued by EAC. The law also gives EAC power to regulate tariffs and technical and performance standards of licensees. The Ministry of Industry, Mines and Energy (MIME) is identified as the entity responsible for setting and administrating policies, strategies and planning in the power sector. A substantial amount of secondary legislation has been issued detailing various aspects of the Law. Much of this is available from EAC's website (www.eac.gov.kh).

Other than state-owned licensees, no licensee may own more than one licence or have a direct financing interest in another licensee.

Future developments

The major ongoing development in the Cambodian electricity industry is the development of a national transmission network. Initially this is taking the form of a number of HV transmission lines connecting to neighboring countries of Vietnam and Thailand, followed later by cross-border connections to Lao PDR. This will allow the import of lower-priced power to the northwestern grid and a new southern grid. Over time, these lines are expected to be extended to create a single interconnected national grid.

The major interconnectors in operation or under development are as follows:

- The 115 kV northwestern grid of 203 km in length connecting Thailand to Bantey Meanchay, Siem Reap and Battambang. This entered service in 2007. The line was financed and is operated by Cambodia Power Transmission Co Ltd (CPTL) under a 30-year BOT agreement with EDC. The import capacity is 80 MW.

- A new 230 kV line of 110 km connecting Vietnam to Takeo and Phnom Penh. This line is expected to commission shortly. The import capacity is 220 MW. The line will be extended to Kampot and Sihanoukville in 2010 and 2011, respectively.

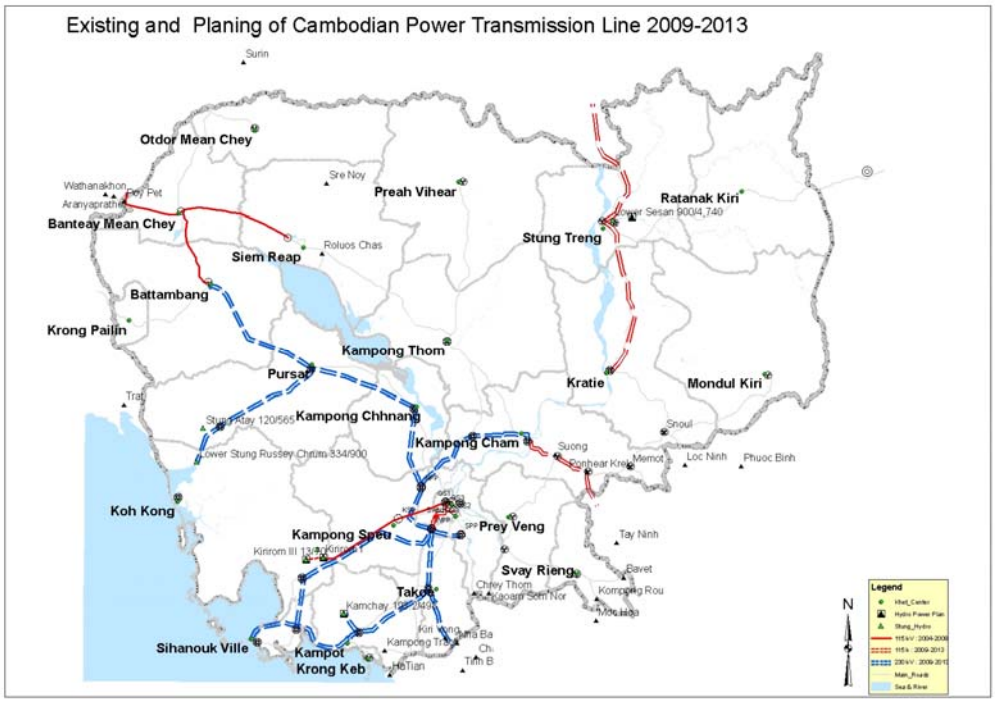
- A new 110 kV[25] line of 68 km connecting Vietnam to Kampong Cham, due to commission in 2010. The import capacity is 20 MW.

- A new 115 kV line of 56 km connecting southern Lao PDR to Stung Treng, due to commission in 2010. The import capacity is 20 MW.

Figure 10 shows the various existing and planned lines.

[25] This is a nonstandard transmission voltage in Cambodia and will require interface transformers.

Figure 10 Cambodia Transmission Grid



Source: Wasizawa (2009)

The other major development in the industry is the introduction of new hydro and coal-fired IPPs, initially allowing the replacement of existing oil-fired IPPs and, in time, allowing Cambodia to move from an importer of electricity to an exporter.

Motivation for power trade

Cambodia's immediate motivation for engaging in power trade is to obtain supplies to border regions currently not served and to obtain power supplies for the Phnom Penh region at lower costs than the existing fuel oil–fired IPPs. Existing and planned interconnectors are related to these requirements. However, in the longer term there is potential for Cambodia to become a significant exporter to Thailand and possibly Vietnam. As well as hydro projects, this might include export projects using offshore gas from recently discovered reserves and imported coal (in part as a means of bypassing the limitations on developing large-scale coal projects in Thailand).

A1.2 China (Yunnan and Guangxi)

Existing market

China's electricity market is both massive in size and highly complex in organization. The Chinese members of the GMS, Yunnan province and Guangxi autonomous region, are two of five provinces served by the transmission network owned and operated by the central

government-owned China Southern Power Grid Co Ltd (CSG), which also covers Guangdong, Guizhou and Hainan provinces.

CSG was formed in 2002 as part of the reorganization of the former State Power Corporation (SPC), which itself had been established in 1997 following the abolition of the former Ministry of Electric Power, which had been both policymaker and the main utility in the power sector. Also formed at the same time were the State Grid Corporation, which owns and operates the transmission network in provinces outside the region served by CSG, and five state-owned generating companies. While these five ex-SPC generating companies remain the largest generators in China, their combined capacity accounts for only 40% of the country total. The remainder is owned by a mix of central and provincial government-owned generating companies and by state and private enterprises.

CSG is structured into the Extra High Voltage power transmission company, which operates inter-province lines, five provincial transmission companies, a power generating company (with 4.3 GW of mainly pumped storage capacity), a power exchange, a load dispatch center and various other affiliated and subsidiary companies. Its total service area is around 1 million km^2, supplying 33.3 million customers in a region with 230 million inhabitants. Total sales in 2008 were 483 TWh and the region's installed capacity was 140 GW. The Yunnan provincial transmission company alone supplies 1.4 million customers, with a network at 110 kV and above of 25,500 km. The Guangxi transmission company supplies 1.75 million customers with a network of 17,800 km.

It remains a feature in much of China that provinces are relatively weakly interconnected, and provincial markets are to some extent autonomous—although this is changing with the ongoing West-East Transmission Project, of which the Southern Corridor is contained in CSG's service area. Currently, the transmission corridor contains twelve 500 kV lines (eight AC and four DC), with a total transmission capacity of over 18 GW. These are used to transmit power from Yunnan, Ghuizhou and Guangxi provinces and regions to Guangdong province.

In 2007, Yunnan province had an installed capacity of 22.2 GW (around 17% of the total within CSG's area in that year) relative to a peak demand of 11.4 GW. Total generation was around 90 TWh or 16% of the regional total while consumption was around 75 TWh or 13% of the regional total. The difference was largely exported to Guangdong. Guangxi autonomous region had an installed capacity of 19.8 GW (15% of the CSG total), a peak demand of 11.5 GW, total generation of 68 TWh and total consumption of a similar level.

CSG's grid is interconnected with that of Vietnam at both 220 kV and 110 kV. There are also 11 interconnectors to the Hong Kong grid and three with the Macau grid. During 2007, CSG exported 2.8 TWh to Vietnam, 4.0 TWh to Hong Kong and 1.7 TWh to Macau.

Outside China, CSG is represented by its wholly owned subsidiary, CSG International. Currently, within the GMS region, in addition to its power exports to Vietnam, CSG is developing the Vinh Tan 1 coal plant in Vietnam, the Nam Tha I hydro project in Lao PDR, the Sambor hydro project in Cambodia and 10 hydro projects along the Thalwan river in Myanmar.

Although a national regulatory agency, the State Electricity Regulatory Commission (SERC), was established in 2003, power sector regulation continues to largely be undertaken by the central government through the National Development and Reform Commission (NDRC). It

is NDRC that takes decisions on electricity tariffs (although SERC can make proposals), power planning and project approvals. However, in practice, it can be difficult for NDRC to enforce decisions where provincial governments are opposed to these.

Motivation for power trade

China's interest in energy trade appears to derive from a combination of import and export opportunities, including the potential for Chinese firms to develop projects in GMS countries for the regional market. Chinese firms are active in project development in Cambodia, Lao PDR, Myanmar and Vietnam—although not all of these are directed at exports to the regional market.

A1.3 Lao PDR

Existing market

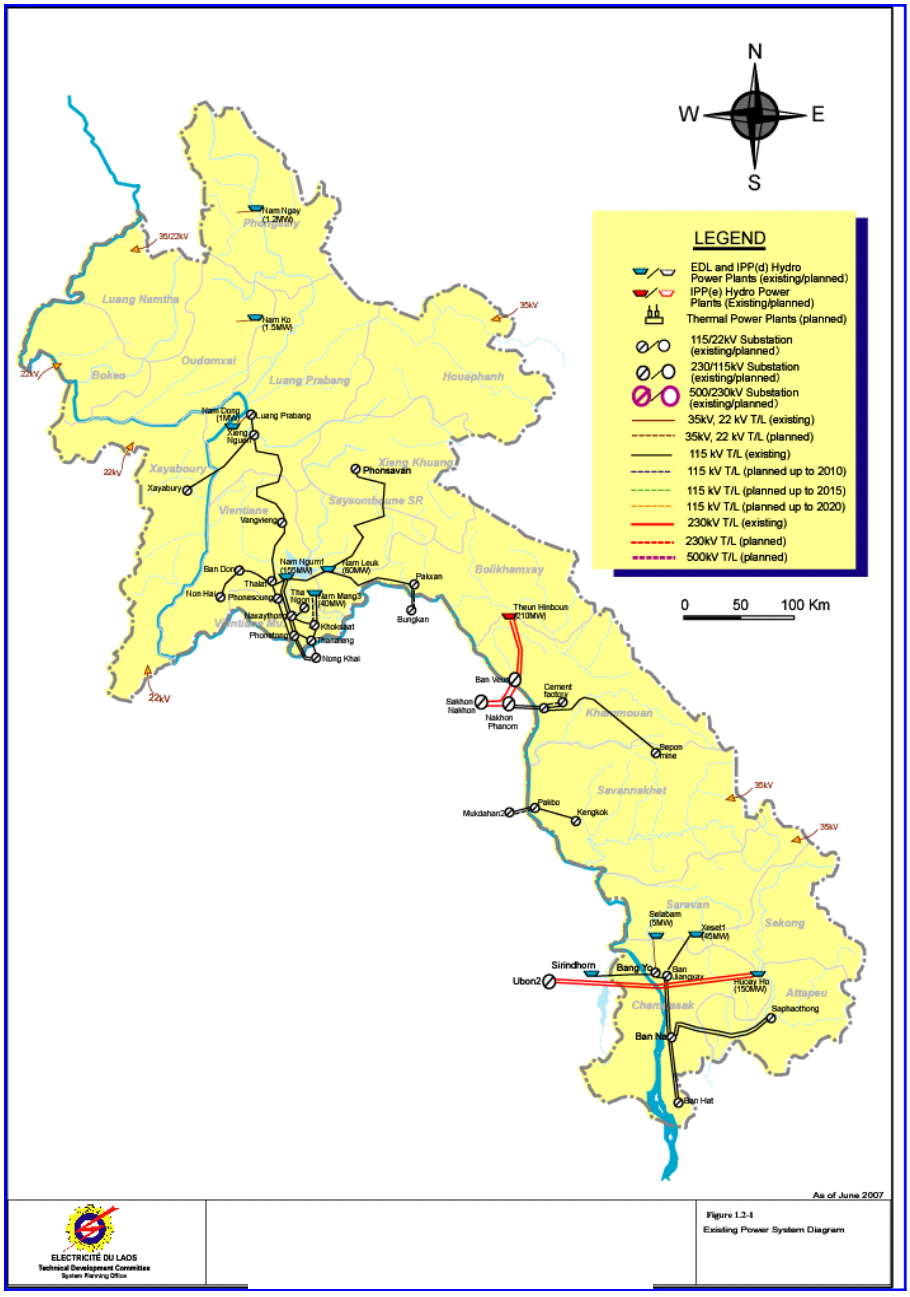
The main electricity utility in Lao PDR is Electricité du Laos (EDL), the state-owned vertically integrated generation, transmission and distribution utility. However, the majority of generating capacity in the country is owned by two IPPs, the Theun Hinboun and Houay Ho hydro projects, with a combined capacity of 360 MW as compared to the 309 MW of hydro capacity owned by EDL and small amounts of capacity owned by provincial governments. EDL is a partner in both IPPs, owning 60% of the Theun Hinboun project and 20% of the Houay Ho project.

The Theun Hinboun and Houay Ho projects are primarily intended for export to Thailand. The 1,088 MW Nam Theun 2 hydro IPP is due to commission during 2009 and, of its capacity, 75 MW will be made available to EDL.

Currently, there is no national grid in Lao PDR. A small number of 230 kV lines exist for export from IPPs. The northern-central area extending out from Vientiane is served by a 115 kV grid supplied from EDL-owned generation and imports from Thailand, and accounts for around 60% of total national electricity sales of 1,300 GWh. Three small isolated grids in the southern-central and the southern regions are supplied by imports from Thailand at 115 kV, and there are also a number of MV interconnections with Thailand (Figure 11).

Electricity coverage is growing rapidly, with household electrification rates increasing from 43% in 2003 to 59% by 2007 with 40% of villages connected to electricity supplies. The government has set targets to achieve 70% household electrification by 2010 and 90% by 2020, largely by expansion of the 115 kV grid.

Figure 11 Lao PDR Transmission Grid



Source: Somvichith (2008)

Future developments

Alongside the electrification program, there are plans to establish a national transmission grid in Lao PDR. This would be achieved by interconnecting existing and new EDL-owned lines with transmission lines developed for export projects and, potentially, with interconnectors developed to allow trade between China, Thailand and Vietnam via Lao PDR.

A major expansion of generating capacity is also planned. EDL is planning to develop a total capacity of 324 MW in the form of hydro generation projects with a further 882 MW to be developed as IPPs for the domestic market and 548 MW to be made available as EDL's share in the capacity of new export projects.

Motivation for power trade

The government of Lao PDR views export hydro projects as a major source of social and economic development, particularly given the limited industrial potential of the country. Export hydro projects provide a means of earning revenues and of developing electricity capacity to meet domestic needs. The government has been very active in promoting export projects, opening up the power sector to private and foreign investment in 1993 and with the first IPP commissioning in 1998.

A1.4 Myanmar

Existing market

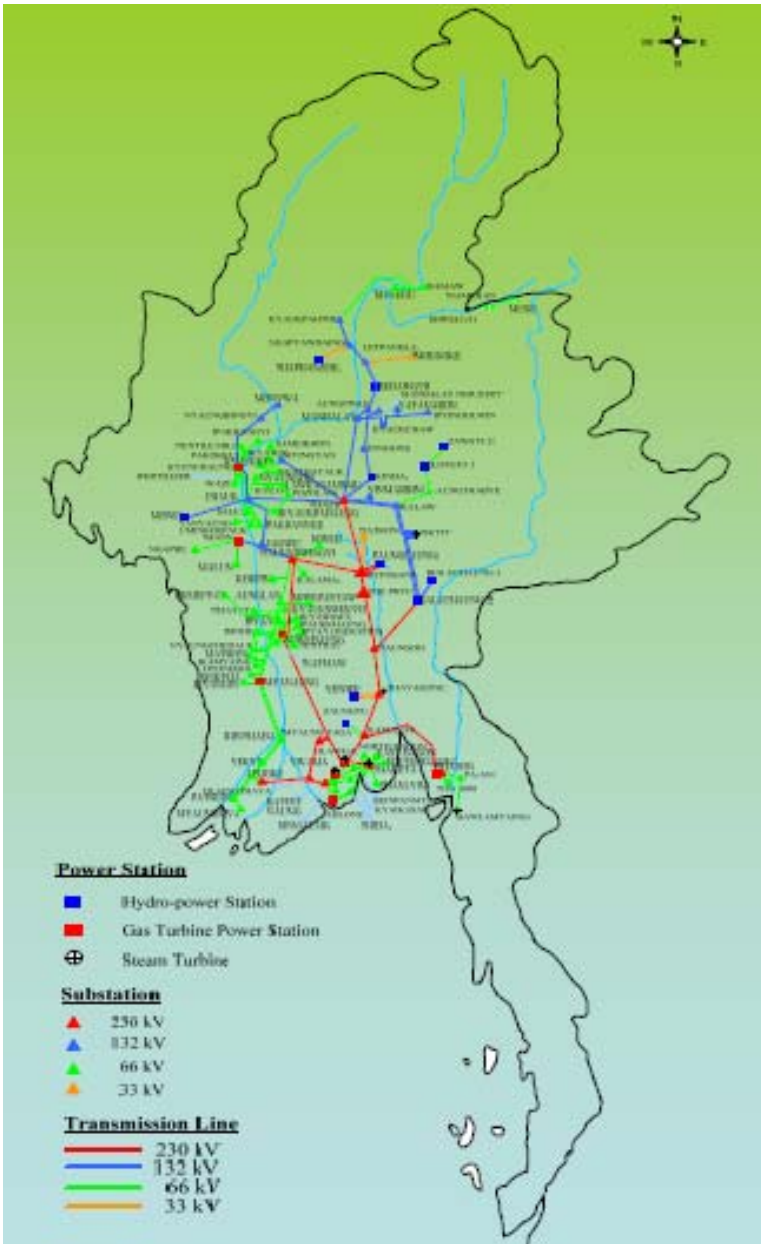
The Ministry of Electric Power (MEP) was established in 1997 as policymaker and owner for the power sector. In May 2006, the ministry was separated into two entities:

- Ministry of Electric Power (1), responsible for planning, construction and operation of hydro power projects as well as Myanmar's existing coal plant.
- Ministry of Electric Power (2), responsible for transmission system planning, investment and operation, distribution and supply of electricity purchased from MEP (1) and operation of existing gas, oil and diesel-fired generating plants.

Larger hydro power projects are being developed on an IPP basis in partnerships between MEP (1) and Chinese and Thai companies. The Ministry of Agriculture and Irrigation is also involved in one of the smaller projects under development.

There is no separate regulatory agency. Figure 12 shows the existing transmission grid.

Figure 12 Myanmar Transmission Grid



Source: Presentation at PWG-5 (2008)

Future developments

Myanmar has ambitious plans for the expansion of its hydro generating capacity to meet domestic demand and for export. The latter are discussed later in this case study. A total of 14 hydro projects with a combined capacity of 10,772 MW are identified as under implementation with another 13 with a combined capacity of 23,645 MW identified for implementation in the near future. Of these, 12 projects totalling 23,930 MW have agreements in some form with foreign investors, including Yunnan Power Development and CPI, both of China, and MDX Group and EGAT of Thailand.

Alongside this, there are plans for major expansion of the existing 230 kV transmission network. This is currently 918 miles in length, with an additional 995 miles under construction and plans for a further 3,265 miles of line. Future plans also include the development of a 500 kV grid of 1,795 miles in length.

Motivation for power trade

Similar to Lao PDR, the driving motivation for power trade in Myanmar appears to be the potential for export earning. Myanmar has large unexploited hydro resources which are proving of interest to Chinese and Thai developers.

A1.5 Thailand

Existing market

The Thai power sector has three main state-owned entities:

- The Electricity Generating Authority of Thailand (EGAT), which undertakes generation and owns and operates the national transmission grid.
- The Metropolitan Electricity Authority (MEA), which undertakes distribution and supply in Bangkok and surrounding provinces.
- The Provincial Electricity Authority (PEA), which undertakes distribution and supply in the remainder of Thailand.

There are also a number of IPPs, small power producers (SPPs) and very small power producers (VSPPs). The latter two are smaller IPPs which meet specific requirements for technology and fuel (renewable energy sources or combined heat and power producers). These are entitled to standard contract arrangements and premiums above the standard feed-in tariff paid by EGAT. Previously they were accepted on a must-take basis, but recently accepted projects have been limited to those using renewable energy. Larger IPPs have been procured through two competitive tendering rounds, the first in the mid-1990s and a second, for 4,400 MW of capacity, completed in December 2007 with projects commissioning in 2011–2013.

EGAT operates as a single buyer, purchasing all output from IPPs and SPPs and onselling this, together with output from its own generators, to MEA and PEA at a bulk supply tariff. Output from VSPPs is purchased by MEA and PEA.

As of early 2009, there were 28 licensed generators owned by EGAT, two generators previously owned by EGAT but which were partially privatized, seven IPPs, 60 SPPs and 118 VSPPs. The mix of each licensee type in power generation in 2007 and planned for 2021 is shown in Table 8.

Table 8 Thailand Power Generation by Licensee Type

Licensee Type	Share (2007 actual)	Share (2021 planned)

Licensee Type	Share (2007 actual)	Share (2021 planned)
EGAT	45%	39%
IPP	42%	20%
SPP	10%	7%
VSPP	<1%	2%
Import	3%	17%

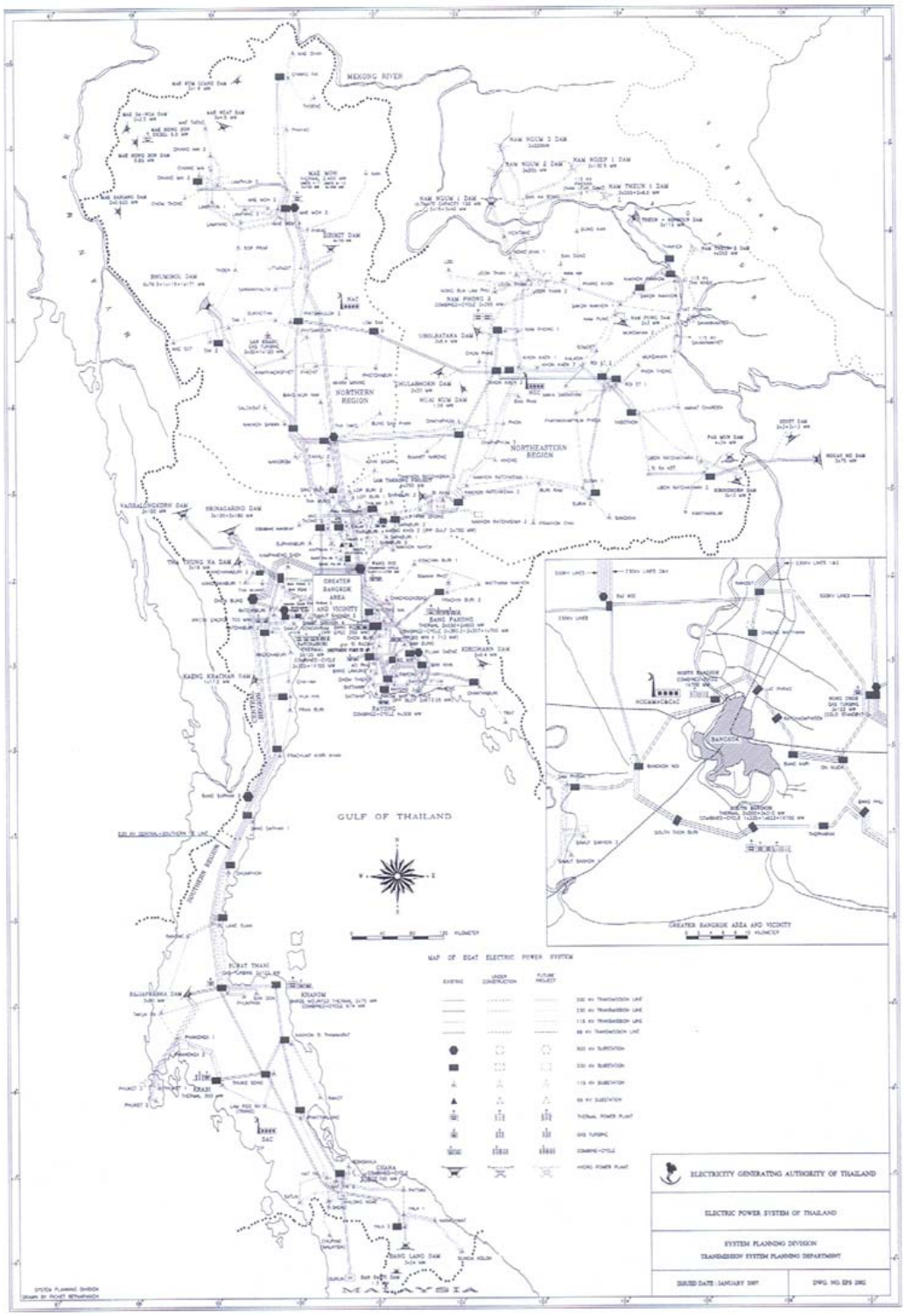
Source: Energy Regulatory Commission (2009)

An Energy Regulatory Commission (ERC) was established under the Energy Industry Act of 2007. The ERC is responsible for licensing, reviewing power development plans, approving technical codes and setting tariffs in conformity with tariff policies set by the National Energy Policy Council and the Cabinet.

Thailand follows a policy of a uniform national tariff. Since the costs of electricity provision of PEA are much higher than those of MEA, lump sum financial transfers are made from MEA to PEA to subsidize rural electrification. This subsidy amounted to around 10 billion baht (or around US$315 million) in 2008. In 2009, the subsidy arrangements were changed to also require EGAT to transfer US$81 million to PEA given EGAT's higher allowed financial return compared to that of MEA and PEA. New subsidy arrangements are expected to be implemented through a Power Development Fund financed by an industry levy from 2010. These will take the form of payments for delivery of defined Public Service Obligations (PSO).

Currently power purchased from neighboring countries amounts to 640 MW, which accounts for just over 2% of demand. In the northeast, Thailand has five lines already supplying power from Lao PDR, with a further two lines under construction and four more planned for the future. In the south, two lines are operating between Malaysia and Thailand. At MV level, additional interconnectors exist between Thailand and Cambodia and Lao PDR. The grid is shown in Figure 13.

Figure 13 Thailand Transmission Grid



Source: EGAT (2007b)

Future developments

During the 1990s, Thailand investigated the possibility of introducing a power pool. Concerns over security of supply, particularly following the 2001 California problems, led to the rejection of this option and a cabinet-level decision that an enhanced single-buyer model would be adopted as the future industry structure. Under this, EGAT will continue as a generator, transmission system owner and the single buyer but will establish an independent system operator function (although ownership would remain with EGAT).

During the run-up to the second IPP round, there was discussion as to whether EGAT's share of new generation capacity should be limited in order to promote private investment. In practice, EGAT seems likely to continue to dominate generation in the future with limits on its share of future capacity being rejected (under current plans, its share of total generation in Thailand will remain steady at around 45%, although its share in overall supply will fall due to rising imports).

An attempt to corporatize and partially privatize EGAT during 2005 and 2006 met heavy political opposition and was eventually ruled illegal by the courts due to a failure to fully comply with legal requirements for corporatization of state enterprises. Subsequently, privatization of EGAT and other state-owned energy enterprises appears to have been abandoned.

Overall, therefore, little change in the existing industry and market structure is expected in the short to medium term.

Motivation for power trade

The original motivation at the national level for the development of power trade within the GMS was Thailand's rapid demand growth in the 1990s alongside its economic growth. During this period, Thailand was concerned about securing access to low-cost energy supplies. Environmental opposition effectively ruled out further large-scale hydro expansion within Thailand,[26] making imports of power from hydro projects located in Lao PDR, Myanmar and Yunnan especially attractive. A summary of the various intergovernmental Memoranda of Understanding (MOUs) entered into by Thailand for power import from GMS countries during the 1990s is provided in Box 1.

Following the Asian financial crisis of 1997, Thailand's economic growth and energy demand growth have slowed markedly. Despite this, Thailand has continued to remain committed to large-scale future imports. This appears to be partly due to the cost advantages of hydro imports and partly due to a desire to diversify away from the current dependence on natural gas for power generation. Domestic opportunities for such diversification are very limited—large-scale hydro development and increased coal-fired

[26] The last major dam built in Thailand was the 136 MW Pak Mun project completed by EGAT in 1994. This project has been widely criticized as having severe negative impacts on local fisheries and requiring large-scale resettlement for little benefit in terms of electricity generated (output has averaged only around 290 GWh, although EGAT has argued the plant was always supposed to operate as peaking capacity). Protests by affected villagers spread to Bangkok and have led to interventions at the cabinet level both to order EGAT to open the dam gates to restore fisheries and to close them as governments have changed.

generation face very strong opposition on environmental grounds. Nuclear generation is now being planned but also seems likely to face strong opposition domestically.

Box 1 Thailand's Power Import MOUs

Lao PDR

Thailand signed its first MOU with Lao PDR in 1993 for the import of 1,500 MW of power by 2000. In 1996 a second MOU was signed for the import of a total of 3,000 MW by 2006. A third MOU was signed in 2006, which increased the purchase amount to 5,000 MW by 2015. In December 2007, the quantity to be purchased was further increased to 7,000 MW by 2020, including the Hong Sa lignite-fired project. Further amendments to these MOUs mean that currently Thailand is committed to purchasing 1,500 MW by 2010, 7,000 MW by 2015 and 10,000 MW by 2017.

To date, two hydro projects with a combined capacity of 340 MW are operating under the MOU with a further two, including Nam Theun 2, with a capacity of 1,535 MW, under construction and due to commission in 2009–2010.

As part of recent revisions to the national Power Development Plan to accommodate reduced demand growth forecasts, Thailand intends to postpone the planned date of a number of future import projects by one to two years. However, no cancellations are proposed. This is in line with the experience of the slowdown in Thai demand post-1997 when projects were postponed but not cancelled.

Myanmar

An initial MOU was signed in July 1997 for the purchase of 1,500 MW of hydro capacity by 2010. In May 2005, a new MOU was signed for the development of five hydro power projects on the Salween River for which the Myanmar government proposed two initial projects with a combined capacity of 8,200 MW.

There appears to be some ambivalence in the Thai government's attitude toward this MOU. In June 2007 the energy minister in the then military-installed government, Dr Piyasavasti Amarand, was reported to have said that Thailand was not looking to buy any power from Myanmar.[27] In part this appears to have been a response to concerns that the MOU resulted from what were seen as excessively close links between the former prime minister, Thaksin Shinawatra, and the Myanmar government. However, in March 2009, EGAT was hopeful of shortly signing an MOU for the Hutgyi project on the Salween River, one of the plants covered under the second intergovernmental MOU.[28]

China

In 1998, Thailand signed an MOU with China for the import of 3,000 MW by 2017. Imports would be by interconnectors passing through Lao PDR, making it necessary to agree to transit payments to be made to Lao PDR. At present, no agreement has been reached on these payments, and progress on developing export projects under the MOU remains stalled.

[27] http://www.bernama.com/bernama/v3/news_lite.php?id=266639 (accessed 7 May 2009)

[28] http://www.nationmultimedia.com/search/read.php?newsid=30098476&keyword=burma+hydro+mou (accessed 7 May 2009)

A1.6 Vietnam

Existing market

Economic development in Vietnam has driven strong growth in electricity demand, with the system barely being able to keep pace. Since 1990, power generation increased about fourfold from 17.7 TWh in 1998 to 65.9 TWh in 2008. See Figure 14.

Vietnam's power sector is currently dominated by Electricity of Vietnam (EVN). EVN was established following completion of the first 500 kV interconnector between North, Central and South Vietnam, allowing integrated operation of a national grid. At its establishment, EVN absorbed the existing generation, transmission and distribution assets of the three regional power companies (PCs) to form a national vertically integrated monopoly utility.

In recent years, EVN and the sector structure have undergone a series of reforms. New generators have entered in the form of IPPs developed by other state-owned entities[29] and private investors. EVN has also been carrying out a process of equitizing many of its own generators. This involves the establishment of these generators as independent legal entities and the subsequent sale of minority shareholdings through IPOs and to employees with EVN retaining a majority stake. With the recent sharp fall in Vietnam's stock markets, the equitization process is effectively on hold at present.

EVN directly and through its equitized subsidiaries currently owns around 70% of installed generating capacity, other state entities own around 16.4% in the form of IPPs, and foreign-invested build-operate-transfer (BOT) projects own around 13.2%.

EVN itself has been corporatized and transformed into a holding entity for a large number of subsidiaries. In addition to its generating subsidiaries, these include the new National Power Transmission Corporation (NPTC), which operates the high-voltage 500 kV and 220 kV transmission network and the National Load Dispatch Center (NLDC), which schedules and dispatches the high-voltage transmission network and generators greater than 30 MW. A new single buyer unit has also been established within EVN—allowing it to take advantage of EVN's government backing.

Operation of the low-voltage transmission network and distribution is undertaken by 11 power companies (PCs). These include the historic three regional PCs, which now largely serve rural areas, as well as an additional eight PCs serving major urban centers. All but one are wholly owned by EVN. The exception is Khanh Hoa Joint Stock Power Company, which has been equitized but in which EVN remains the largest shareholder.

The power sector is facing severe challenges in meeting investment needs resulting from the rapid demand growth. Lack of funds has led to many projects being delayed by up to three years. Installed capacity has been growing more slowly than demand, leading to a narrowing reserve margin. While the 2008 reserve margin remained close to 20%, this is insufficient in a hydro-dependent system with wide seasonal fluctuations in output. Load

[29] These include Vietnam Coal and Minerals Corporation (Vinacomin), Petro Vietnam (PVN), Lilama (the state-owned manufacturer of generating equipment and other heavy machinery) and the Song Da Construction Corporation (the main hydro power plant construction firm).

shedding has been experienced since 2004 and became very significant in 2008 when drier-than-normal conditions were experienced.

To meet the urgent investment requirements, Vietnam is pursuing a strategy of gradual opening of the power market to external investors, accompanied by measures to facilitate private investment. Central to the strategy is the Electricity Law, which came into effect on 1 July 2005. The Electricity Law establishes a new framework for the power sector, comprising:

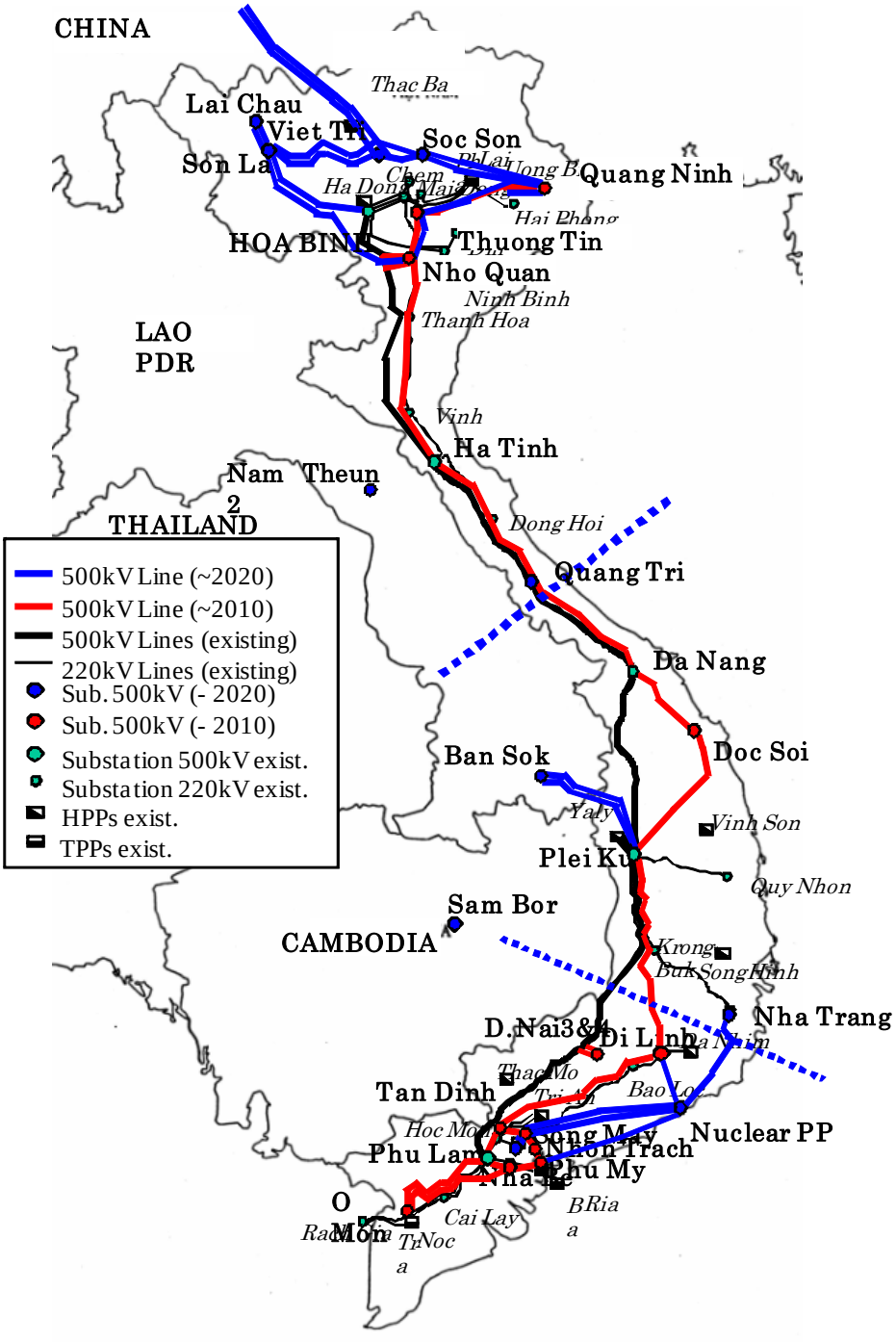
- A continuing mandatory central planning process at national and provincial levels for the purposes of identifying new investments.
- The introduction of a competitive generation market and its gradual extension to wholesale and retail competition.
- The establishment of a new regulatory agency, the Electricity Regulatory Authority of Vietnam (ERAV), under the Ministry of Trade and Industry (MOIT).

Under Prime Minister Decision #26/2006/QĐ-TTg, a road map for the introduction of the competitive power market has been approved. A three-phase process is envisaged, in each case split into a pilot and full step:

- Phase 1 (2005–2014): Competitive Generation Market (CGM). This initially comprises an internal power pool within EVN followed by establishment of the full market from 2010. All power will be sold to a single buyer who will onsell to PCs which retain their regional monopolies.
- Phase 2 (2015–2022): Wholesale Competitive Market. Selected large customers will initially be able to purchase directly from generators, with this right gradually being extended.
- Phase 3 (from 2024): Retail Competitive Market. Small customers in some provinces will be allowed to choose this supplier, with this right being subsequently extended to all customers.

ERAV is responsible for overseeing the power planning process, approving the selection of developers of generation projects, licensing of electricity entities, overseeing implementation of the power market, proposing electricity retail tariffs for approval by the prime minister, and monitoring the competitive power market.

Figure 14 Vietnam Transmission Grid



Source: Electricity Regulatory Authority of Vietnam (2007)

Future developments

ERAV is leading the development and implementation of the full CGM, which will come into operation in 2010 in accordance with the approved road map. The general design

selected for the CGM is a cost-based power pool (CBP). Participation in the CBP will be mandatory for all generators with a capacity in excess of 30 MW except for existing foreign-invested BOTs, which hold long-term PPAs for their full capacity. To enable recovery of fixed costs, a capacity adder in the form of a Capacity Add-On payment will be paid during hours when the system is short of capacity. This payment will be calculated as the difference between the costs of a Best New Entrant generator and the revenues that this generator is projected to earn in the coming year from the CBP. Generators (other than foreign-invested BOTs) will also hold standard contracts for differences (CfDs) which provide greater revenue certainty for these generators and the single buyer.

Alongside the introduction of the CGM, ERAV is leading a reform of existing electricity tariff regulation in order to create a market-oriented tariff system. Major changes to the existing tariff structure were introduced in February 2009 which increased average retail tariffs from March 2009 by 9% and sets out plans for gradual elimination of existing cross-subsidies from industrial and commercial to residential customers over a five- to six-year period. Current distinctions between urban and rural residential customer tariffs will also be removed and, from 2010, PCs will be allowed to negotiate tariffs below the regulated level with industrial and commercial customers, introducing an initial element of competitive pressure.

Motivation for power trade

Vietnam's rapid economic growth since the introduction of the Doi Moi reforms in 1986 has seen the country's electricity demand expand at double-digit rates. This has driven increasing interest in electricity imports—both to relieve short-term supply constraints, as with current imports from China, and as a means of providing access to long-term, low-cost power supplies, as in the various hydro projects under development in Lao PDR. Vietnam signed an intergovernmental MOU with Lao PDR in 1998 for the import of 2,000 MW of power. A number of project-specific MOUs have been signed.

A2 Electricity supply

Table 9 GMS Current and Planned Installed Capacity

MW	Coal	Gas	Oil	Hydro	Renewables	Nuclear	Total
Cambodia							
2007 actual	-	-	297	13	5	-	**315**
2020 planned	1,300	-	-	1,955	5	-	**3,230**
China							
Guangxi 2007 actual	11,113	-	-	8,734	-	-	**19,847**
Yunnan 2007 actual	9,858	-	-	10,402	-	-	**20,260**
2020 planned				Not available			
Lao PDR							
2007 actual	-	-	17	673	-	-	**690**
2020 planned	1,800	-	-	7,747	-	-	**9,547**
Myanmar							
2007 actual	120	726	70	803	-	-	**1,718**

MW	Coal	Gas	Oil	Hydro	Renewables	Nuclear	Total
2020 planned	120	726	70	11,539	-	-	**12,455**
Thailand							
2007 actual	4,117	14,594	4,735[a]	3,424	279	-	**27,149**
2020 planned	5,570	31,228	3,962[a]	3,424	2,140	2,000	**48,324**
Vietnam							
2009 actual	2,980	6,139	814[a]	6,086	-	-	**16,019**
2020 planned	18,350	16,151[b]	-	17,195	1,717	2,000	**55,413**

a Capacity with dual oil/gas firing is shown as oil.

b Includes a small amount of oil-fired capacity

Sources: Compiled by ECA from country documents

Cambodia Electricity Authority of Cambodia (2008), Ministry of Mines and Energy (2008) and Wasizawa (2009)

China China Southern Power Grid (2008)

Lao PDR Department of Energy Promotion and Development (2009) and Somvichith (2008)

Myanmar Presentation at Franco-ASEAN Seminar (2007) and Presentation at PWG-5 (2008)

Thailand EGAT (2007) and EGAT (2008)

Vietnam Prime Minister Decision No. 110/2007/QD-TTg, Institute of Energy (2008), PB Associates (2009) and personal communication with the Electricity Regulatory Authority of Vietnam

Table 10 Existing and Planned GMS Trade Projects

Project	Market	Type	Capacity (MW)	Status	Date	Notes
Cambodia						
Lower Sesan 1	Vietnam?	Hydro	90	n.k.	2012	Group 2 project under the Vientiane Plan of Action
Lower Sesan 2 + Lower Srepok 2	Vietnam	Hydro	420	MOU for FS signed	2016	Included in Vietnam MP (2014-15). Group 3 project under the Vientiane Plan of Action (2014)
Sesan 3	Vietnam	Hydro	375	MOU for pre-FS signed	2017	Included in Vietnam MP (2017)
Sambor	Vietnam?	Hydro	2,600	MOU for FS signed	2019	
Lower Srepok 3	Vietnam?	Hydro	330	MOU for FS signed	TBD	
Lower Srepok 4	Vietnam?	Hydro	235	MOU for FS signed	TBD	
Stung Treng	Vietnam?	Hydro	980	MOU for FS signed	TBD	
Koh Kong	Thailand	Coal	3,600	Suspended?	TBD	
China						
110 kV	Vietnam	Interconnector	60	In service	2006	
220 kV (Lao Cai)	Vietnam	Interconnector	250	In service	2006	
220 kV (Ha Giang)	Vietnam	Interconnector	200	In service	2007	
Jinghong	n.k.	Hydro	n.k.	Under construction?	2009	Group 1 project under the Vientiane Plan of Action (2009)
500 kV	Vietnam	Interconnector	700	FS underway	2017	Included in Vietnam MP (2017). Group 1

Project	Market	Type	Capacity (MW)	Status	Date	Notes
						project under the Vientiane Plan of Action (2011)
500 kV	Vietnam	Interconnector	700	FS underway	2018	Included in Vietnam MP entering in 2018 (earlier in Vientiane Plan of Action)
500 kV	Vietnam	Interconnector	700	FS underway	2019	Included in Vietnam MP entering in 2019 (earlier in Vientiane Plan of Action)
500 kV	Lao PDR + Thailand	Interconnector	n.k.	Discussions suspended	TBD	Group 3 project under the Vientiane Plan of Action (2013)
Lao PDR						
Nam Ngum 1	Lao PDR + Thailand	Hydro	155	In service	1971	Not included in export totals[a]
Se Xet 1	Lao PDR + Thailand	Hydro	45	In service	1990	Not included in export totals[a]
Nam Leuk	Lao PDR + Thailand	Hydro	60	In service	2000	Not included in export totals[a]
Nam Mang 3	Lao PDR + Thailand	Hydro	40	In service	2004	Not included in export totals[a]
Se Xet 2	Lao PDR + Thailand	Hydro	76	Under construction	2009	Not included in export totals[a]
Theun Hinboun	Thailand	Hydro	210	In service	1998	
Houay Ho	Thailand	Hydro	150	In service	1999	
Nam Theun 2	Thailand	Hydro	1,088	Under construction	2009	Included in Thailand MP entering in 2009

Project	Market	Type	Capacity (MW)	Status	Date	Notes
Nam Ngum 2	Thailand	Hydro	615	Under construction	2013	Included in Thailand MP entering in 2011
Ban Hat – Stung Treng	Cambodia	Interconnector	20	n.k.	2010	Group 1 project under the Vientiane Plan of Action (2011)
Nabong – Udon Thani	Thailand	Interconnector	n.k.	n.k.	2010	Group 1 project under the Vientiane Plan of Action
Nam Mo – Ban Mai	Vietnam	Interconnector	n.k.	n.k.	n.k.	Group 3 project under the Vientiane Plan of Action (2013)
Xekaman 3	Lao PDR + Vietnam	Hydro	250	Under construction	2010	Included in Vietnam MP (2010). Group 1 project under the Vientiane Plan of Action (2009)
Nam Ngum 3	Thailand	Hydro	440	Under construction	2014	Included in Thailand MP entering in 2013. Group 1 project under the Vientiane Plan of Action (2013)
Hong Sa	Lao PDR + Thailand	Coal	1,800	Under negotiation (CA/PPA)	2015	Included in Thailand MP starting in 2013–2014
Nam Ngiep 1	Lao PDR + Thailand	Hydro	278	Under negotiation (CA/PPA)	2015	Included in Thailand MP (2014). Group 3 project under the Vientiane Plan of Action (2014)
Theun Hinboun expansion	Lao PDR + Thailand	Hydro	280	Under negotiation (CA)	2012	Included in Thailand MP (2012). Group 3 project under the Vientiane Plan of Action (2014)
Nam Theun 1	Lao PDR + Thailand	Hydro	523	Under negotiation (CA/PPA)	2014	Included in Thailand MP (2014). Group 3 project under the Vientiane Plan of Action (2013)

Project	Market	Type	Capacity (MW)	Status	Date	Notes
Xepian-Xemanmoy	Thailand	Hydro	390	MOU signed	2015	Group 2 project under the Vientiane Plan of Action (2010)
Xekong 4	Thailand or Vietnam	Hydro	600	MOU signed	TBD	Included in Vietnam MP (2014). Group 3 project under the Vientiane Plan of Action (2012)
Nam Kong 1	Thailand or Vietnam	Hydro	150	MOU signed	TBD	Included in Vietnam MP (2016). Group 3 project under the Vientiane Plan of Action (2012)
Xekong 5	Thailand or Vietnam	Hydro	400	MOU signed	TBD	Included in Vietnam MP (2016). Group 3 project under the Vientiane Plan of Action (2013)
Nam Bak 1	Thailand	Hydro	80	MOU signed	TBD	
Nam Ou	China or Thailand	Hydro	1,100	PDA signed	2013-16	Included in Thailand MP entering in 2014 / Included in Vietnam MP entering in 2019
Don Sahong	Thailand	Hydro	n.k.	PDA signed	2015	
Dak E Mule	Vietnam	Hydro	130	MOU signed	TBD	
Xekaman 4	Vietnam	Hydro	155	MOU signed	TBD	
Nam Ngiep 2	Lao PDR + Thailand	Hydro	155	Suspended?	TBD	
Nam Mo	Vietnam	Hydro	150	PDA signed	2014	Included in Vietnam MP (2012). Group 3 project under the Vientiane Plan of Action (2013)
Xekaman 1	Lao PDR + Vietnam	Hydro	322	PDA signed	2013	Included in Vietnam MP (2013). Group 1

Project	Market	Type	Capacity (MW)	Status	Date	Notes
						project under the Vientiane Plan of Action (2011)
Pak Lay	Lao PDR + Thailand	Hydro	1,320	MOU signed	TBD	
Luang Prabang	Lao PDR + Vietnam	Hydro	1,410	MOU signed	TBD	
Xayaboury	Lao PDR + Thailand	Hydro	1,260	MOU signed	TBD	
Pakbeng	Lao PDR + China + Thailand	Hydro	1,300	MOU signed	TBD	
Sanakham	Lao PDR + China + Thailand	Hydro	500	MOU signed	TBD	
Xekong 3	Lao PDR + Vietnam	Hydro	150	MOU signed	TBD	
Ban Koum	Lao PDR + Thailand	Hydro	2,330	MOU signed	TBD	
Nam Ngum 4A	Lao PDR + Vietnam	Hydro	60	MOU signed	TBD	
Nam Ngum 4B	Lao PDR + Vietnam	Hydro	60	MOU signed	TBD	
Nam Xam	Lao PDR + Vietnam	Hydro	750	MOU signed	TBD	
Lat Sua	Lao PDR + Thailand	Hydro	800	MOU signed	TBD	
Myanmar						
Lower Ta Sang	Thailand	Hydro	200	PDA? signed	2010	
Ta Sang 1	Thailand	Hydro	2,133	PDA? signed	2016	

Project	Market	Type	Capacity (MW)	Status	Date	Notes
Ta Sang 2	China + Thailand	Hydro	4,977	PDA? signed	2022	
Hutgyi	Thailand	Hydro	1,200	MOU signed	2012	
Ta Pein 1	China	Hydro	240	n.k.	2010	
Shweli 1 - Yunnan	China	Interconnector	n.k.	n.k.	2011	Group 3 project under the Vientiane Plan of Action
Shweli 2	China	Hydro	460	MOU signed	TBD	
Shweli 3	China	Hydro	360	MOU signed	TBD	
Tanintharyi	Thailand	Hydro	600	MOU signed	TBD	
Upper Thanlwin	Thailand	Hydro	4,000	n.k.	TBD	
Lower Thanlwin	Thailand	Hydro	500	n.k.	TBD	
Ywathit	Thailand	Hydro	800	n.k.	TBD	
Maykha Basin	China	Hydro	13,600	MOU signed	TBD	
Thailand						
115 kV (Banteay Mean Chey)	Cambodia	Interconnector	80	In service	2007	
Lao PDR Northern Transmission Project	Lao PDR	Interconnector	n.k.	n.k.	2010	Group 1 project under the Vientiane Plan of Action
Vietnam						
220 kV (Phnom Penh)	Cambodia	Interconnector	220[b]	Construction complete?	2009	

Project	Market	Type	Capacity (MW)	Status	Date	Notes
110 kV (Kampong Cham)	Cambodia	Interconnector	20	Under construction?	2010	Group 1 project under the Vientiane Plan of Action

Shaded projects are those identified in the Vientiane Plan of Action (see Section 6 for definition of the groups used). Projects that form part of the Plan of Action or are identified for funding by IFIs, but which lie only within one country, are not included. Projects such as the Lao PDR Northern Transmission Project, which will facilitate imports from Thailand to northern Lao PDR, are shown as an export project for Thailand although most investments will be made in Lao PDR.

a These projects only export surplus power. They are primarily used to supply domestic demand

b Initial exports are likely to be significantly lower due to capacity constraints

CA	Concession Agreement	FS	Feasibility Study	MP	Master Plan	MOU	Memorandum of Understanding
n.k.	Not known	PDA	Project Development Agreement	PPA	Power Purchase Agreement	TBD	To be determined

Sources: Compiled by ECA from country documents

Cambodia Electricity Authority of Cambodia (2008), Ministry of Mines and Energy (2008) and Wasizawa (2009)

China China Southern Power Grid (2008)

Lao PDR Department of Energy Promotion and Development (2009) and Somvichith (2008)

Myanmar Presentation at Franco-ASEAN Seminar (2007) and Presentation at PWG-5 (2008)

Thailand EGAT (2007) and EGAT (2008)

Vietnam Prime Minister Decision No. 110/2007/QD-TTg and Institute of Energy (2008)

Where different dates or capacities are given in documents for the importing and exporting countries concerned, those in the exporting country documentation have been used. Other dates are shown in parantheses in the Notes column.

Figure 15 Lower Mekong Basin hydro projects

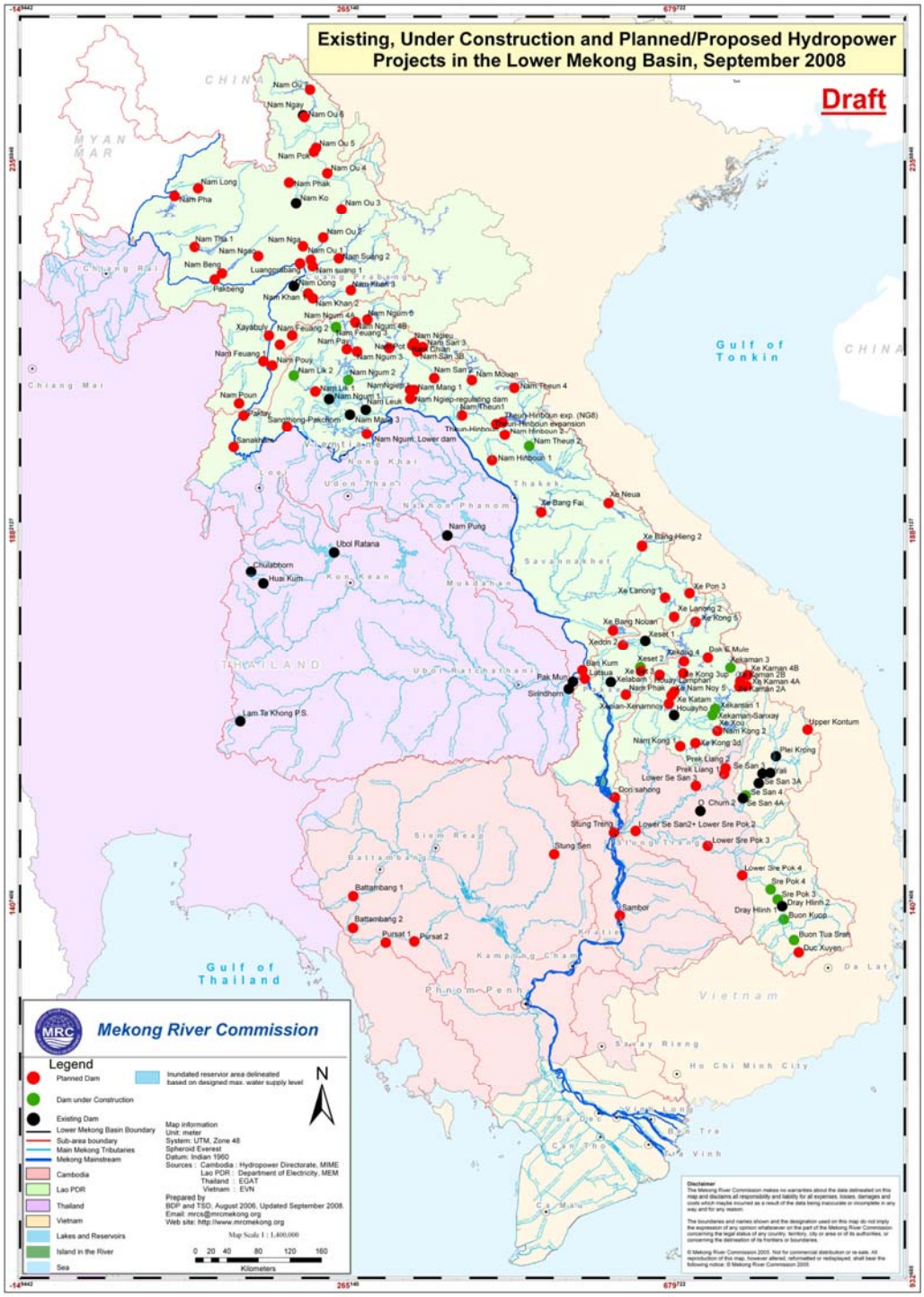


Figure 16 Myanmar Hydro Projects

1	Kabaung	30
2	Kengtawn	54
3	Shweli (1)	600
4	Pathi	2.2
5	Kun	60
6	Phyu	40
7	Shwekyin	75
8	Yeywa	790
9	Thahtay	102
10	Upper Paunglaung	140
11	Tasang	7110
12	Kyee-on Kyee-wa	70
13	Bu-ywa	41
14	Myo Gyi	30
15	Manipur	340
16	Nancho	30
17	Thaukyegat	140
18	Tamanthi	1200
19	Ann	15

Source: Presentation at PWG-5 (2008)

A3 Electricity demand

Table 11 Electricity Peak Demand in GMS Member Countries

All in MW	Cambodia (grid)	China (China Southern Grid)	China (Yunnan and Guangxi)	Lao PDR	Myanmar	Thailand	Vietnam
2000	70	37,890		173		14,918	4,893
2001	78			192		16,126	5,655
2002	88			198		16,681	6,552
2003	101			232		18,121	7,408
2004	116			271		19,326	8,283
2005	133	69,590		328		20,538	9,299
2006	165			349		21,064	10,187
2007	205	87,000	22,900	416		22,586	11,290
2008	240			621		22,568	12,640
2009	318			808		25,225	
2010	432	114,030		945		26,635	19,117

All in MW	Cambodia (grid)	China (China Southern Grid)	China (Yunnan and Guangxi)	Lao PDR	Myanmar	Thailand	Vietnam
2011	546			1,195		27,996	
2012	768			1,690		29,625	
2013	931			1,927		31,384	
2014	1,160			2,176		33,216	
2015	1,349			2,223		35,251	31,495
2016	1,546			2,267		37,382	
2017	1,746			2,314		39,560	
2018	1,937			2,365		41,795	
2019	2,148			2,422		44,082	
2020	2,401			2,494		46,481	47,607
Average annual growth in demand							
2000-07	16.5%	12.6%		13.3%	4.9%[a]	6.1%	12.0%
2007-20	20.9%			14.8%		5.7%	11.7%

Shaded cells are actual data. Blanks indicate data unavailable

a 2000-08. Calculated using generation data

Sources:	Compiled by ECA from various country documents.
Cambodia	Electricity Authority of Cambodia (2008), Ministry of Mines and Energy (2008) and Wasizawa (2009). Historic demand to 2007 is for EDC's Phnom Penh system only. Forecast demand is updated demand forecast prepared by Ministry of Industry, Mining and Energy.
China	China Southern Power Grid (2008). Growth in peak demand is for China Southern Grid as a whole.
Lao PDR	Somvichith (2008)
Myanmar	Historic demand growth is for generation. 2000 data is from ASEAN Energy Centre. (http://www.aseanenergy.org/energy_sector/electricity/myanmar/electricity_prod_sales_00.htm). 2008 data is from Myanmar Central Statistical Organisation (http://www.csostat.gov.mm/S10MA02.asp, accessed 8 May 2009). Myanmar adopts a year from April to March of the successive year for statistical purposes. Hence, data for 2000 represent April 1999 to March 2000.
Thailand	EGAT (2007). As a result of the economic downturn, a revised PDP was approved by Cabinet in March 2009. The details are not publicly available in English but reports indicate that consumption by the end of the planning period (2021) is forecast to be 11% below that in the 2007 PDP, and further adjustments to the demand forecasts for the 2016-21 period are possible. (see http://pepei.pennnet.com/display_article/355679/6/ARTCL/none/none/1/Thailand-scales-back-long-term-power-consumption-forecast-by-11-per-cent/).
Vietnam	Electricity Regulatory Authority of Vietnam (2007), Institute of Energy (2008) and Trung (2008)
	Where multiple forecasts are provided, the base case is shown.

A4 Contracts

Copies of GMS agreements (IGA, MOU #1, MOU #2, the Vientiane Plan of Action, the Road Map and the RPTOA) are available from websites. Please refer to the Bibliography for locations where these agreements can be downloaded.