Report No. 19067-EAP

Power Trade Strategy for the Greater Mekong Sub-Region

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Energy & Mining Development Unit
East Asia and the Pacific Region

Document of the World Bank
LIST OF ABBREVIATIONS

ADB  Asian Development Bank
ASEAN Association of Southeast Asian Nations (Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Singapore, Philippines, Thailand, and Vietnam)
BOO  Build, Operate, Own
BOT  Build, Operate, Transfer
CO₂  Carbon Dioxide
EAC  Electricity Authority of Cambodia
EDC  Electricité du Cambodge
EDL  Electricité du Lao
EGAT  Electricity Generating Authority of Thailand
EGCO Electricity Generating Company (Thailand)
EPF  Electric Power Forum
ESMAP World Bank’s Energy Sector Management Assistance Program
EVN  Electricity of Vietnam
FGD  Flue Gas Desulfurization
FIMC  Foreign Investment Management Committee
GDP  Gross Domestic Product
GMS  Greater Mekong Sub-region
GNP  Gross National Product
HV  High Voltage
HVDC  High Voltage Direct Current
IDA  International Development Agency
IFC  International Finance Corporation
IPP  Independent Power Producer
JICA Japan International Cooperation Agency
Lao PDR  Lao People’s Democratic Republic
LDC  Load Duration Curve
LOLP  Loss of Load Probability
MEA  Metropolitan Electricity Administration (Thailand)
MEPE  Myanmar Electric Power Enterprise
MIGA  Multilateral Investment Guarantee Agency
MOEP  Ministry of Electric Power (China)
MOU  Memorandum of Understanding
MRC  Mekong River Commission
NEPO  National Energy Policy Office (Thailand)
NGC  National Grid Company (Lao PDR)
NOₓ  Nitrogen Oxides
O&M  Operation and Maintenance
PEA  Provincial Electricity Authority (Thailand)
PM  Particulate Matter
PPA  Power Purchase Agreement
PPP  Purchasing Power Parity
RCC  Regional Coordination Committee
ROW  Right-of-Way
SADC  Southern African Development Commission
SCEP  South-East China Electric Power Corporation
SO₂  Sulfur Dioxide
TNB  Tenaga Nasional Berhad (Malaysia)
T&D  Transmission and Distribution
UCPTE Union of Producers, Transporters and Distributors of Electricity
YPEPB  Yunnan Provincial Electric Power Bureau
YPEPC  Yunnan Provincial Electric Power Corporation

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Map

IBRD# 28721 East Asia Power System
PREFACE

This report is based on the findings of a mission to the People's Republic of China, Lao PDR, Thailand, and Vietnam in March 1997. The team included Enrique Crousillat (team leader), Peter Cordukes (principal financial analyst - power sector reform), John Irving (senior engineer - power planning), Jean-Pierre Charpentier (senior energy specialist - power pooling/trade), and James Barker (power trade). Additional input was provided by David Zoellner (environment), Calum Gunn (power system modeling) and Christine Maurer-Voss and Martin Edmonds (research analysis and report processing). Bonita Brindley provided editorial advice. The report benefited from comments of the peer reviewers Istvan Dobozi and Anil Malhotra, and at an earlier stage from Rafael Moscote, Arun Sanghvi and Barry Trembath. Valuable comments were received also from Noreen Beg, Clifford Garstang, Jack Fritz, Stephan Koeberle, Darayes Mehta, Finn Nielsen, James Schmidt, Linda Schneider, and Jamil Sopher.

The report was cleared by Messrs. Yoshihiko Sumi, Manager, EASEG and Bradley Babson, Senior Advisor, EAPVP.

The environmental component of the study was funded partially by the Global Outlay Program.

The study proposal was endorsed by the ADB-sponsored Third Electric Power Forum of the Greater Mekong Sub-region (GMS) held in Kunming in December 1996. An interim report was presented at the Fourth Electric Power Forum held in Hanoi in November 1997, and the final draft was discussed with the GMS countries at an ESMAP-funded Regional Workshop held in Thailand, June 1998.

The task team is thankful for the cooperation provided by the Asian Development Bank and the Mekong River Commission. We are also profoundly grateful for the efforts of numerous staff and institutions in the region that provided valuable contributions to the production of this report. In particular, for the cooperation of the National Energy Policy Office (NEPO) of Thailand which hosted the June 1998 Workshop.
POWER TRADE STRATEGY
FOR THE GREATER MEKONG SUB-REGION

EXECUTIVE SUMMARY

1. Full scale regional electricity trade represents an unprecedented opportunity for economic and environmental benefits for individual countries and the entire Greater Mekong Sub-region\(^1\) (GMS). The benefits from trading power stem from addressing the mismatches between supply and demand in the region. While the GMS possesses considerable resources of low-cost power generation potential (e.g., hydropower, natural gas and coal), these resources are located in areas far removed from the centers of rapidly growing electricity demand, and are typically separated from them by one or more national borders. Interconnecting areas of supply and demand through the development of an international electricity market in the region would provide more equitable access to cheaper energy, and further, would enhance regional cooperation. Numerous benefits are associated with interconnected power networks. In the GMS, these benefits could include: lower costs, improved quality of supply service, and reduced emissions in greenhouse gases and other pollutants. Extensive trade could reduce generation costs by up to US$10.4 billion for the period 2001-2020. It would also result in significant environmental benefits, primarily from reductions in greenhouse gas emissions, estimated to be worth as much as US$400 million per annum by the year 2020.

A. Background

2. There is growing interest in cross-border power trade in the region, spearheaded by regional and international developers who have commenced hydro developments in Lao PDR to sell power to Thailand through various bilateral arrangements. There are also plans to construct large hydro facilities in Yunnan Province in southwestern China, and to interconnect Thailand, Vietnam and Malaysia. These initiatives raise many questions about how power trade should be developed. Should countries move from bilateral power trade to the development of a regional power grid, and subsequently, to a regional electricity market? Would the current bilateral generation projects bring about the above mentioned benefits? Experience shows that the benefits of electricity trading are not fully met unless an advanced degree of grid integration is achieved, i.e., until the power grid is developed and operated in a coordinated manner. Further, there are barriers to power trading which depend on institutional, political, technical, commercial and financial factors. The assessment of these barriers - and the development of a sound strategy for overcoming them - sets new challenges for the countries of the region and for international organizations.

Study Objectives

3. The main objectives of the present study are to: (a) assess options and formulate a strategy for power trade among the Greater Mekong countries, paying special attention to the barriers to trade and the policy, institutional and commercial framework required to develop and operate efficiently a regional...
power network; and (b) establish the rationale and options for donors' support to power trading and transmission network investment needs within the region.

4. A proposal for the present study was endorsed by the Third Meeting of the GMS Electric Power Forum held in Kunming in December 1996. A fully developed power market represents a long-term goal for the region. In recognition of this consideration, the present study aims to promote the idea of trade, present potential benefits, and propose a process for developing a regional market, and thereby, provide a basis for initiating debate among stakeholders.

B. Barriers to Developing a Regional Power Market

5. Although power trade among the GMS countries is beginning to grow, there are important barriers that could prevent its potential development. The most crucial barriers are:

Policy Barriers
- **National Priorities:** Regional issues are secondary to domestic needs.
- **Regional Protocol:** There is no protocol to encourage countries to plan and develop jointly generation and transmission, and promote opportunity trading.
- **Flexibility in Laws, Regulations and Contracts:** They are being drafted for current conditions within each country without considering the flexibility needed to move towards more competitive electricity markets.
- **Environmental Impact:** Further coordination to address the potential social and environmental impact of an extensive development of hydropower resources is lacking.

Technical Barriers
- **Planning:** Transmission planning for the region is not being coordinated to ensure that an optimal plan is designed to minimize long-term investment.
- **Transmission Facilities:** More transmission facilities are essential to permit significant transfers of electricity between countries.
- **Operations Protocol:** No protocol exists to govern the operation of a regional transmission network.

Institutional Barriers
- **Leadership:** No recognized leadership has been established within the region to facilitate and promote greater regional trade.
- **Independent Regulators:** The absence of an independent regulator in countries other than Malaysia and Thailand creates greater uncertainties for potential developers of projects.

Commercial and Financial Barriers
- **Generation Tariffs:** Existing generation dispatch appears to be on the basis of a flawed system comprising a single-part energy tariff.
- **Transmission Tariffs:** An absence of transmission tariffs limits the ability to identify and evaluate the delivered cost of power.
- **Financing:** The perception of risks associated with country-specific or regional issues constitutes a problem to financial closure.
C. Power Trade Strategy

6. The proposed strategy aims to address these barriers. It proposes a partnership between the private and public sectors based on private sector direct investment and the execution of projects, complemented by an enabling environment to be established by governments.

7. The strategy entails proposing a process to achieve a fully developed and competitive power market rather than prescribing a specific long-term model to follow. It addresses policy, institutional, technical, commercial and financial issues and proposes specific options to prevent barriers in each of these areas. In doing so, the strategy addresses the following overarching issues:

- Regional electricity trade should be second to national and local needs. Nevertheless, the development of extensive power trade would contribute towards national goals.
- Conditions must be established for a public-private partnership to develop power trade in the region.
- Conflicts must be resolved between short- and long-term objectives, between national and regional views, and eventually, between specific projects.
- There must be a common path of fundamental economic practices to allow open access to transmission, cost-based pricing for generation and transmission, flexibility in long-term arrangements, and which avoids duplication of investments.
- Financial and technical assistance must be secured.
- There must be a regional agreement on policy issues and an institutional framework to address market uncertainties and potential conflicts, and to promote regional trade.

8. The main components of the proposed strategy are presented in Table 1. More details are presented in Chapter 5, including a set of immediate steps, and in Annex 5. Suggested sector reform efforts are neither a sufficient nor a necessary condition for multilateral power trade, but rather, should be understood as benchmarks resulting in long-term measures, whose achievement would help ensuring an efficient power market among the GMS countries. According to the development stage and the degree of competitiveness of each country’s power sector, different reform efforts should be on the agenda of each individual country.

9. The strategy proposed by this report was presented and discussed with the GMS countries at a regional workshop held in June 1998. The workshop was an effort to start building consensus towards a multilateral approach to power trade. During the workshop, countries established a regional Experts Group which will be responsible for carrying out studies and formulating recommendations for the development of a regional power market. Also, the meeting reached agreement on a set of short term measures to facilitate a coordinated planning and made proposals for an Action Plan including the following: (i) prepare a Regional Transmission Master Plan; (ii) start working on a regional cooperation agreement (Regional Protocol); and (iii) secure technical assistance for the Experts Group activities. All of the above are consistent with the strategy proposed by this report.

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2 Workshop on Power Trade Strategy in the Greater Mekong Sub-region; held at the Rose Garden Country Resort, Thailand, June 19-20, 1998. World Bank sponsored event funded by ESMAP and hosted by the National Energy Office (NEPO) of Thailand. The event was organized within the GMS initiative in collaboration with ADB.
<table>
<thead>
<tr>
<th>Area</th>
<th>Recommendation</th>
</tr>
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<tbody>
<tr>
<td><strong>Policy</strong></td>
<td><strong>National Priority:</strong> Each country should recognize and endorse international trading in electricity to be an integral part of its policies.</td>
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<tr>
<td></td>
<td><strong>Regional Coordination:</strong> An ad hoc group with no formal structure should assume responsibility for developing the regional protocols and early planning for regional integration. Recently established GMS Experts Group could fulfill this role.</td>
</tr>
<tr>
<td></td>
<td><strong>Regional Protocol:</strong> A formal regional cooperation agreement and permanent organization to coordinate the planning, development, operation and regulation of a future interconnected system should be established.</td>
</tr>
<tr>
<td></td>
<td><strong>Flexibility in Laws, Regulations, and Contracts:</strong> Countries should examine the compatibility of legislation, regulations and contracts to ensure that they permit the required flexibility for the regional market to expand.</td>
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<tr>
<td></td>
<td><strong>Transmission Ownership:</strong> Each government in the region should establish a clear policy of which entity will own and operate the transmission assets within its boundaries.</td>
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<td></td>
<td><strong>Open Access Transmission:</strong> Policies of open access to the transmission network for wholesale competition should be established by each government.</td>
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<td></td>
<td><strong>Environmental Impact:</strong> Environmental issues should be addressed through a regional approach to resolve conflicts between regions/countries, coordinate regulation and incorporate environment issues into overall planning.</td>
</tr>
<tr>
<td><strong>Technical</strong></td>
<td><strong>Regional Transmission Expansion Master Plan:</strong> A master plan should be established to provide information on least-cost plant locations and transmission development.</td>
</tr>
<tr>
<td></td>
<td><strong>Regional Transmission Network Expansion:</strong> Each of the governments in the region should commit to the construction of specific/low risk, least-cost transmission lines.</td>
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<td></td>
<td><strong>Regional Operations Protocol:</strong> Operators of transmission systems should develop an operations protocol to establish procedures to maintain a reliable operation and facilitate trading.</td>
</tr>
<tr>
<td><strong>Institutional</strong></td>
<td><strong>Leadership:</strong> It should be assumed by a regional coordination group (already established: GMS Experts Group).</td>
</tr>
<tr>
<td></td>
<td><strong>Independent Regulator:</strong> Each of the countries should consider establishing an independent regulator in order to reduce financial uncertainties.</td>
</tr>
<tr>
<td></td>
<td><strong>Technical Assistance:</strong> Development community to provide technical assistance to strengthen institutions on power trade issues.</td>
</tr>
<tr>
<td><strong>Commercial and Financial</strong></td>
<td><strong>Generation Tariffs and PPA:</strong> All generation tariffs and PPAs should be constructed on the basis of a two-part tariff: a capacity/availability payment related to fixed costs, and an energy payment function of the actual production and variable energy costs.</td>
</tr>
<tr>
<td></td>
<td><strong>Transmission Tariffs:</strong> Each country should develop a system of transparent transmission tariffs which will provide a firm basis for expansion and operation of the network.</td>
</tr>
<tr>
<td></td>
<td><strong>Generation Risk:</strong> Governments and agencies should take all necessary steps to reduce the uncertainty on the future of generation.</td>
</tr>
<tr>
<td></td>
<td><strong>Transmission Planning and Construction Risk:</strong> Governments and utilities in the region should take measures to reduce the risks associated with transmission planning and construction.</td>
</tr>
<tr>
<td></td>
<td><strong>Taxes and Royalties:</strong> Governments should decide their policy on taxation and royalties on exports of electricity, and communicate it clearly to all interested parties.</td>
</tr>
<tr>
<td></td>
<td><strong>Financial Support:</strong> Official donors should provide adequate financial instruments to support transmission development and power trade in the region.</td>
</tr>
</tbody>
</table>
D. Potential for Economic and Environmental Benefits

10. Power trading within the GMS is more beneficial than self-sufficiency of each country. In general, the benefits from regional power system integration stem from:

- **Reduced or postponed costs.** Lower operation costs due to economic power exchange, postponed and lower investments in generation plants through least-cost development of energy resources, reduced spinning reserve costs.

- **Improved conditions on the supply-side.** Reduced coincident peak load of the region, mutually utilized generation reserves for interconnected systems, increased robustness of power supply to meet unexpected events, increased system reliability.

- **Reduced emissions in greenhouse gases and other pollutants.** Lower levels of emissions largely due to a shift from thermal to lower-cost hydro generation.

Current Market Prospects

11. East Asia\(^3\) is a very diverse region. While the constituent national economies differ considerably in structure and size, all have recorded high economic growth rates during the last several years. Their population densities, incomes per capita, and measures of electrification usage and penetration also vary significantly. (Table 2)

Table 2: East Asian Countries - Selected Indicators, 1996

<table>
<thead>
<tr>
<th>Units</th>
<th>Cambodia</th>
<th>Lao PDR</th>
<th>Myanmar</th>
<th>Thailand</th>
<th>Vietnam</th>
<th>Malaysia</th>
<th>Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Area</td>
<td>1000km(^2)</td>
<td>181</td>
<td>237</td>
<td>677</td>
<td>513</td>
<td>329</td>
<td>329</td>
</tr>
<tr>
<td>Population</td>
<td>million</td>
<td>10</td>
<td>5</td>
<td>43</td>
<td>61</td>
<td>76</td>
<td>20</td>
</tr>
<tr>
<td>GDP/capita (PPP)</td>
<td>1,266</td>
<td>2,071</td>
<td>677</td>
<td>13,235</td>
<td>1,263</td>
<td>8,763</td>
<td>21,493</td>
</tr>
<tr>
<td>Electricity Use</td>
<td>kWh/yr/cap</td>
<td>55</td>
<td>55</td>
<td>60</td>
<td>900</td>
<td>198</td>
<td>1,777</td>
</tr>
<tr>
<td>Electrification</td>
<td>%</td>
<td>10(^%)</td>
<td>18(^%)</td>
<td>15(^%)</td>
<td>98(^%)</td>
<td>30(^%)</td>
<td>95(^%)</td>
</tr>
</tbody>
</table>

*Note:* Estimates of GDP use purchasing power parities (PPP) instead of exchange rates as conversion factors.
*Source:* World Bank estimates.

12. Across the region, power demand has grown rapidly over the last decade at annual rates ranging between 10-15 percent. In assessing regional power demand until the year 2020, two different demand scenarios are distinguished in the study.\(^4\)

- **High Demand Growth.** Demand growth is assumed to drop gradually to 7-8 percent as economic growth slows down and electrification targets are met. Thailand will continue to be the principal market accounting for 40 percent of the demand by 2020. Load growth forecasts for the

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\(^3\) East Asia is defined in this study to include Cambodia, China, Lao PDR, Malaysia, Myanmar, Thailand, and Vietnam.

\(^4\) The High Demand Growth scenario was based on economic assumptions current in June 1997. However, with the onset of the economic crisis affecting the GMS, these assumptions were revised downward based on data available in January 1998, and served as the basis for the Low Demand Growth scenario.
GMS indicate regional consumption will grow from 131 TWh (21,000 MW) in 1997, to 600-611 TWh (92,000 MW) in 2020.\(^5\)

- **Low Demand Growth.** Due to the current financial crisis, Thailand’s demand is assumed to increase by 1.5 percent in 1997, stagnate in 1998, increase by 4.1 percent in 1999, and then maintain a growth level of around 5.5 percent per annum from 2000 to 2020. Vietnam’s demand growth is assumed to reduce from an average of 6.3 percent per annum to just over 5 percent. As the major impact of the crisis is most likely limited to Thailand and Vietnam, growth in Laos, Cambodia, Myanmar and Yunnan Province is assumed to be unaffected and thus, the same growth rates under the High Demand Growth are used.

13. If extensive trade were to take place, it would probably be conducted through a 500 kV integrated power transmission network within the six GMS countries. The export of power from Lao PDR is expected to increase to about 3,000 MW due to new hydro projects, allowing this country to build a 500 kV grid. This grid would eventually be integrated into the 500 kV/HVDC transmission system among Vietnam, Thailand, Cambodia, and southern China.

**Economic and Environmental Evaluation**

14. Despite the significant and diverse energy resources in the region, there is a mismatch between each country’s energy resources and their projected demand for electrical power. Regional energy demand can be satisfied in many ways. This study analyzes two extreme alternatives: (i) Self-supply, with self-sufficiency in electricity supply in each country; and (ii) Cooperation, with fully developed power interchange among the countries in the region. The evaluation of these two extremes provides a basis to assess the potential economic and environmental benefits of power trade.

15. Assessments for both the self-supply and power trade cases were conducted for both the Low and High Demand Growth scenarios. This exercise involved evaluating the generation mix for each year between 1997 and 2020, and then estimating the associated investment and operation costs.

- **High Demand Growth.** Self-supply would cause overall renewable energy sources to decline to 20 percent in 2020 while the use of nonrenewable sources (coal, gas, and oil) would increase. Unlimited power interconnection under the cooperation case would increase the use of renewable sources to 33 percent by 2020. Lao PDR, Myanmar, and Yunnan Province in China would then export power, while Vietnam and Thailand would import. The cumulative reduction in generation investment and operating costs for the power interconnection cooperation case over the self-sufficiency case would reach US$13.7 billion for the period 2001-2020. The majority (US$13.4 billion) of this reduction is attributable to savings in operating costs.

- **Low Demand Growth.** Lower demand primarily delays the benefits of power trade in the cooperation case, as it takes more years for the additional capital costs of hydro investment to be offset by the significant savings to be realized from reduced operating costs. Power trade now requires comparatively greater investment costs, mainly because the larger proportion of hydro

\(^5\) Norconsult International A.S., Sub-regional Energy Sector Study for the Greater Mekong Sub-region, funded and published by ADB, October 1995; and NEWJEC Inc. / MRC, Mekong Integrated Transmission System Study (Basin-wide), funded by the Government of Japan and published by MRC Secretariat, September 1996.
plant in the generation mix (with its low availability) requires a greater reserve margin. The operational cost savings, however, are of a similar order under both demand scenarios, because the magnitude of hydro-based energy dispatched does not markedly change for the lower growth rate assumption. Hence, although the cumulative benefits from 2001-2020 reduce to US$10.4 billion, the benefits from operational cost savings will continue to be viable long after this planning horizon, particularly since hydro plants generally have a significantly greater plant life than thermal units.

16. Extensive power trade would also result in significant environmental benefits. These would stem from a substantial reduction in greenhouse gas and pollutant emissions caused by the substitution of hydropower generation for a large proportion of coal-fired and oil-fired generation. Under the High Demand Growth scenario, the reduction in emissions is projected to be 31 percent for SO₂, 12 percent for NOx, 18 percent for Particulate Matter, and 17 percent for CO₂. Although the monetary value of such reductions is difficult to calculate, currently accepted cost estimates suggest that power trade could result in emission abatement benefits of up to US$400 million per annum by 2020, relating primarily to the lower level of CO₂ emissions. As noted above (para. 10), under the Low Demand Growth scenario, the magnitude of hydro-based energy dispatched annually can be practically the same as under the High Demand Growth scenario. Hence, although a reduction in electricity demand would clearly decrease the overall magnitude of thermal plant-based emissions, the absolute difference in emissions given self-sufficiency or power trade would be similar under either scenario.

17. The benefits from reduced emissions must be contrasted with the impacts from increased hydropower development and additional transmission lines. Environmental issues should be addressed through a regional approach to resolve conflicts between regions/countries, coordinate regulation, and incorporate environmental issues into overall planning. Also, impact mitigation programs will need to be developed for each hydropower project on a case-by-case basis, and should consider a responsible approach in addressing potential social and environmental conflicts. Failure to mitigate these impacts in an effective and sustained manner could become a serious constraint to hydro development and, hence, a barrier to power trade.

E. Power Sector Structures and Reform Efforts

Government Policies on Electricity Trading

18. Although none of the countries has established a long-term policy with respect to regional power integration, they have taken actions to promote private sector investment that are conducive to increased regional power trade.

19. There is growing interest in arranging bilateral sales from Lao PDR and China to Thailand. The Government of Thailand has agreed to buy 3,000 MW from Lao PDR by the year 2006 and several projects are moving forward. The Ministry of Electric Power (MOEP) in China is encouraging studies of Yunnan's Jing Hong hydropower plant and associated transmission lines to Thailand, through Lao PDR, with the support of the Lao and Thai Governments. Vietnam and Lao PDR have signed a MOU to buy/sell about 2,000 MW of power by 2010.

20. Channels for regional sector cooperation have been established. The regional Electricity Power Forum (EPF) sponsored by the ADB as part of the GMS initiative provides an opportunity for the countries to discuss how to develop this cooperation. The Mekong River Commission has been
conducting regional studies on the interconnection of the GMS power systems. Finally, ASEAN countries have established a technical working group to coordinate interconnection efforts.

Table 3: Status of Power Reform in Greater Mekong Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Fully Integrated Sector</th>
<th>Separate Regulation</th>
<th>Degree of Unbundling</th>
<th>IPPs Permitted</th>
<th>Single Buyer Model</th>
<th>Transmission Access</th>
<th>Wholesale Competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>Under study</td>
<td>Distribution and Generation (in progress)</td>
<td>☑</td>
<td>☑</td>
<td>Limited access planned</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Malaysia</td>
<td>est. 1991</td>
<td>Unbundling of generation &amp; transmission under consideration</td>
<td>☑</td>
<td>☑</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>China</td>
<td>Under study</td>
<td>Partial unbundling of generation &amp; transmission</td>
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<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Vietnam</td>
<td>Law being drafted</td>
<td>Generation and transmission to be operated as cost centers</td>
<td>☑</td>
<td>☑</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>Not planned</td>
<td>Creation of separate transmission company being considered</td>
<td>☑</td>
<td>☑</td>
<td>Under study</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cambodia</td>
<td>Law being drafted</td>
<td></td>
<td>☑</td>
<td>☑</td>
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<tr>
<td>Myanmar</td>
<td></td>
<td></td>
<td>☑</td>
<td>☑</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Sector Reform Efforts

21. Extensive power trading, beyond the existing proposals for bilateral power purchases, requires an approach to opening the power sectors, including compatibility in sector structures, conditions for private entry, and market competitiveness. So far, reform is opening up the sector to private generation. Although independent power producers (IPPs) are legal in all countries, their ability to attract private investment varies. However, all countries are moving towards a single buyer model with different degrees of competition.

22. Experience with power sector reforms in other regions suggests that countries move towards policy measures sequenced to (i) allow competition at entry in generation through the introduction of IPPs and, through this practice, set up a single buyer model; (ii) establish separation - vertical, horizontal, or both - to introduce more competition into the single buyer model; (iii) establish open access to transmission systems to enable generators to wheel power to distributors and large customers, i.e., an open access model; and (iv) form a national and, ultimately, a regional power pool or wholesale market. As an overarching measure, an autonomous regulatory framework tailored to the needs of each stage could be established. Nevertheless, examples of regional power trade indicate that not all of the above mentioned measures are pursued in the same order or scope. This suggests that, for power trade to take place, uniform reforms are not necessary. However, it can be argued also that, in the long term, sector reform would help to introduce more competition and efficiency into the power trade process and, hence, help to realize its full potential.
Chapter 1: INTRODUCTION

1.1 Full scale regional electricity trade represents an unprecedented opportunity for economic and environmental benefits for individual countries and the entire Greater Mekong Sub-region (GMS). The benefits from trading power stem from addressing the mismatches between supply and demand in the region. While the GMS possesses considerable resources of low-cost power generation potential (e.g., hydropower, natural gas and coal), these resources are located in areas far removed from the centers of rapidly growing electricity demand, and are typically separated from them by one or more national borders. Interconnecting areas of supply and demand through the development of an international electricity market in the region would provide more equitable access to cheaper energy and, further, would enhance regional cooperation. Numerous benefits are associated with interconnected power networks. In the GMS, these could include: reduced investments in reserve capacity, increased reliability, improved load curve shapes, complementarity in production, reduced greenhouse gases, scale effects and, above all, access by final consumers to the cheapest and most environmentally sustainable sources of electricity in the region, i.e., hydropower and gas.

Background

1.2 There is growing interest in cross-border power trade in the region, spearheaded by regional and international developers who have commenced hydro developments in Lao PDR to sell power to Thailand through various bilateral arrangements. There are also plans to construct large hydro facilities in Yunnan Province in southwestern China, and to interconnect Thailand, Vietnam and Malaysia. These initiatives raise many questions about how power trade should be developed. Should countries move from bilateral power trade to the development of a regional power grid, and subsequently, to a regional electricity market? Is there a role for international organizations to help establish a basis for future regional development? If this is the case, what should that role be?

1.3 Power trade developed through specific bilateral generation projects and associated transmission lines will bring about some of the above mentioned benefits. Nevertheless, experience shows that the benefits of electricity trading are not fully met unless an advanced degree of grid integration is achieved, i.e., until the power grid is developed and operated in a coordinated manner, including a regional competitive electricity market. Further, there are barriers to power trading which depend on institutional, political, technical, commercial and financial factors. The assessment of these barriers - and the development of a sound strategy for overcoming them - sets new challenges for the countries of the region and for international organizations.

Study Objectives

1.4 The main objectives of the present study are to: (a) assess options and formulate a strategy for power trade among the Greater Mekong countries, paying special attention to the barriers to trade, and the policy, institutional and commercial framework required to develop and operate efficiently a regional power network; and (b) establish the rationale and options for donors’ support to power trading and transmission network investment needs within the region.
Audience and Scope

1.5 A proposal for the present study was endorsed by the Third Meeting of the GMS Electric Power Forum (EPF) held in Kunming in December 1996. A fully developed power market represents a long-term goal for the region. In recognition of this consideration, the present study aims to promote the idea of trade, present potential benefits, and propose a process for developing a regional market, and thereby, provide a basis for initiating debate among power sector policy makers, power utilities and regional and multilateral agencies supporting regional integration. This debate was initiated at a regional workshop organized by the World Bank (Thailand, June 1998). The study will be made available also to private sector developers.

1.6 Although the present report mainly focuses on the countries of the Greater Mekong Sub-region, the assessment of the potential economic and environmental benefits and the regional sector reform efforts often extends to Malaysia and Singapore. They represent two important participants in future trade.
Chapter 2: POTENTIAL FOR ECONOMIC AND ENVIRONMENTAL BENEFITS

2.1 Power trading within the Greater Mekong Sub-region is more beneficial than self-sufficiency within each country. In general, the benefits from regional power system integration result from:

- **Reduced or postponed costs.** Lower operation costs due to economic power exchange, postponed and lower investments in generation plants due to least-cost development of regional energy resources, and reduced spinning reserve costs.
- **Improved supply-side conditions.** Reduced coincident peak load of the region as compared to the sum of the individual peak loads for each country, mutually utilized generation reserves for interconnected systems, increased robustness of power supply to meet unexpected events, like load growth above forecast or delayed commissioning of generation and transmission projects or both, and increased system reliability.
- **Reduced emissions in greenhouse gases and other pollutants.** Lower levels of emissions largely due to a shift from thermal to lower-cost hydro generation in the longer-term.

2.2 The present study confirms that lower cost, reduced coincident peak load, and reduced emissions are associated with trading. It compares economic benefits and environmental impact between power trading and self-sufficiency in Annex 1 and Annex 2 - both summarized in this chapter.

Economic Evaluation

The Current Market and its Prospects

2.3 East Asia\(^1\) is a very diverse region. While the constituent national economies differ in structure and size, all have recorded high economic growth rates in recent years. Their population densities, incomes per capita, and measures of electrification usage and penetration also vary significantly (Table A1.1). For instance, Cambodia has the lowest electricity consumption in the region at 55 kWh per capita per year. This rate of consumption is more than 100 times lower than the level in Singapore, which has the highest demand. Across the region, power demand has grown rapidly over the last decade at annual rates ranging between 10-15 percent. While the current economic problems of the region will likely temper this growth in the future, power demand is still expected to grow at a healthy pace.

2.4 On the demand side, Thailand will continue to be the principal market in the GMS.\(^2\) Thailand will likely account for about 40 percent of total demand by 2020, although this share may be as much as 10 percent lower than its current level, due to demand growth in Cambodia, Myanmar, and Vietnam. Demand is mainly suppressed by the lack of generation capacity (Myanmar, southern Vietnam), or by

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\(^1\) East Asia is defined in this study to include Cambodia, Lao PDR, Myanmar, Thailand, Vietnam, Malaysia, Singapore, and China.

\(^2\) Greater Mekong Sub-region (GMS) is defined to include: Cambodia, Lao PDR, Myanmar, Thailand, Vietnam, and Yunnan Province of China.
constraints (as exhibited by high system losses) in the transmission and distribution systems (Cambodia, Lao PDR, northern Vietnam, Yunnan Province). Power demand growth in the southern Chinese border provinces of Yunnan and Guangdong, and in the Guangxi Zhuang Autonomous Region, is expected to be high also. One recent assessment of load growth of the GMS (Norconsult Study) expects regional consumption to grow from 91 TWh (14,500 MW) in 1993, to 131 TWh (21,000 MW) in 1997, to 600 TWh (92,000 MW) in 2020 with capital requirement to increase from US$5 billion in 1994 to US$14 billion in 2020.4

2.5 If it is likely that Malaysia and Singapore will grow at about the same rate as Bangkok, East Asia can be grouped into main load centers of larger geographic power supply regions. These are North/North East Region (Myanmar, northern and northeastern Thailand and northern Vietnam), South East Region (Cambodia, central Lao PDR, and southern Vietnam), Bangkok, and the South Peninsular Region (Malaysia, Singapore, and southern Thailand). The aggregate figures in Table A1.2 highlight the increasing importance of the South East Region’s power market, as its market share will grow the most - from a 5 percent share in 1995 to 17 percent in 2020.

2.6 The GMS countries have diverse energy resources. The region is well endowed with hydro resources. Most of the exploitable capacity is in southern China, Lao PDR, and Myanmar. Within China, 14 schemes have been identified in Yunnan Province for the Lacang (i.e., the upstream portion of the Mekong) totaling about 20,000 MW. A combined development of run-of-river mainstream projects and storage tributaries is expected to be very feasible, but would require cooperation agreements among the riparian countries. Other main river basins are the Jinsha (200 TWh), Thanlwin (137 TWh), Red River (41 TWh) and Ayeyarwaddy (39 TWh). The exploitable potentials by country are: Cambodia 8,000 MW, Lao PDR 20,000 MW, Myanmar 25,000 MW, Thailand 10,000 MW, Vietnam 15,000 MW, and Yunnan 90,000 MW. Within Yunnan, the Jinsha basin has potential for about 40,000 MW in 12 schemes, about half of which could be developed for export. Of the three countries with surplus hydro for export, Lao PDR has the most ambitious plans in place, as it hopes to develop an estimated 13,000 MW of its hydro resources utilizing tributaries of the Mekong.

2.7 Regarding thermal generation, there are significant coal resources in China (about 30,000 mt fueling for over 30 years), and lesser supplies in Lao PDR, Thailand, and Vietnam. Gas will likely be the fuel of choice until offshore reserves are depleted. It is estimated that offshore gas supplies in the region could fire 18,000 MW of new generation by 2005. Most development potential for gas and oil is in the territorial waters of Myanmar, Thailand, Vietnam, and to a lesser extent, in Cambodia. Thailand’s gas consumption now is about 1.4 bcf/year, and is expected to rise to 2 bcf/year by 2000. Oil resources will likely be reserved for export.

2.8 While the GMS possess considerable energy resources, these are located in areas far removed from the centers of rapidly growing electricity demand, and are typically separated from them by one or more national borders. To address this mismatch, there are two alternatives for meeting increased demand: self-sufficiency in electricity supply in each country or power interchange/trade among the

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4 In contrast, the Newjec/Mekong River Commission (MRC) Study forecasts higher consumption for 2020: 611 TWh (93MW). NEWJEC Inc./ MRC, Mekong Integrated Transmission System Study (Basin-wide), funded by the Government of Japan and published by MRC Secretariat, September 1996.

5 See Norconsult Study.
countries. The most recent studies that compare these options for the GMS until 2020 are the Norconsult Study and Newjec/MRC Study. In the self-sufficiency case of the Norconsult Study, overall renewable energy sources decline to 20 percent by 2020, while nonrenewable sources increase to 80 percent if medium demand growth is assumed. (Table A1.4) Thailand would experience the largest gross increase in energy consumption, namely five times higher than in 1997. It would satisfy this growth with some small additional hydropower developments and a large increase in domestically produced coal and gas sources. In contrast, for power interchange, only 67 percent would come from nonrenewable sources and 33 percent from renewable. (Table A1.5) In this case, Lao PDR, Myanmar, and Yunnan Province would export power, while Thailand and Vietnam would import power.

2.9 If trade were to take place, it would probably be conducted over a 500 kV integrated power transmission network within the six GMS countries. High voltage direct current (HVDC) transmission links would be needed. The export of power from Lao PDR is expected to increase to about 3,000 MW due to new hydro projects, allowing Lao PDR to build a 500 kV grid. This grid would eventually be integrated into the 500 kV/HVDC transmission system among Cambodia, southern China, Thailand, and Vietnam.

Economic Evaluation

2.10 Power interconnection in the GMS may be economically feasible, as there are significant benefits associated with trading. In general terms, the savings from regional power system integration primarily stem from a reduction in system operation costs. In assessing the potential economic benefits associated with sub-regional power trade, the current study has used Norconsult’s base demand projection as the basis for a High Demand Growth scenario. However, to reflect the impact that the current regional crisis may have on these benefits, the current study has developed an additional electricity demand scenario for the sub-region, based on more pessimistic rates of growth. Under the Low Demand Growth scenario, Thailand’s demand is assumed to increase by 1.5 percent in 1997, stagnate in 1998, increase by 4.1 percent in 1999, and then maintain a growth level of around 5.5 percent per annum from 2000 to 2020. This contrasts with Norconsult’s low demand scenario, which has an average growth rate for Thailand of 6.4 percent per annum. Vietnam is also considered to be affected by the crisis, although Norconsult’s low demand scenario is assessed as satisfactorily denoting its impact. Yunnan Province is considered unaffected, and due to their small contribution to overall electricity consumption, the demand for Cambodia and Laos is left unchanged. These projections are combined to produce the current study’s Low Demand Growth scenario for the GMS, which is used in a sensitivity analysis of the benefits of power trade.

2.11 Dispatch Model. This present study assesses the generation mix that would occur in each year between 1997 and 2020. It evaluates the distribution of annual investment and operation costs. To this end, a dispatch model was developed to determine the GWh production from each block of generation plant under a self-supply case and a cooperation case. These are two extreme cases and so allow an assessment of an upper bound to the potential benefits of power trade, under both the High and Low Demand Growth scenarios. The dispatch model carries out a full systems analysis, by dispatching the

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6 The self-sufficiency case is called self-supply case in the model of the current study and Reference Scenario in the Norconsult Study. Both cases assume national self-sufficiency. The unlimited power interchange case is called cooperation case in the model of the current study and Trade Scenario in the Norconsult Study. All cases assume the same energy demand forecast, but differ with regards to some assumptions affecting the annual costs (see Annex 1).
different power plants according to the forecasted load requirements. It comprises four components: (i) demand; (ii) supply; (iii) dispatch, which determines the level of annual generation for each plant using a merit order based on marginal cost and by placing blocks of plant under the system load duration curve (LDC); and (iv) cash flow. The cash flow component determines the present value cost of investing in and operating the entire generation system by collating the capital costs of new generation (including interest during construction) with the fixed and variable costs for both new and existing plants.

2.12 This study heavily draws on the Norconsult Study, especially for the plant investment program under the High Demand Growth scenario. Norconsult quantified the benefits due to a reduction in the coincident peak and in economic power transfer through the replacement of thermal power by hydropower while contrasting self-sufficiency and power interchange. The best prospects identified for economic hydropower transfers were: (i) substitution of more expensive hydropower in Vietnam and thermal power in Thailand with inexpensive hydropower from Lao PDR (where not rendered uneconomic when accounting for transmission costs); (ii) replacement of thermal power in Thailand by hydropower from Yunnan Province (via transmission links through Lao PDR in particular) as it was considered to be a viable option depending on the future market for coal prices at Bangkok; and (iii) use of hydropower projects in northern Vietnam and southeastern Myanmar, which could compete economically with coal-fired plants to supply Thailand. Norconsult’s power interchange case developed a related plant investment schedule that ensures individual country reserve margins of 15 percent. The annual cost savings were estimated to be up to US$1.54 billion (accounting for the cost of transmission) from the power interchange case over the self-sufficiency case.

2.13 The dispatch model of this study and the two cases assume:

- **Adjusted Investment Programs.** Under the High Demand Growth scenario, the investment programs from both Norconsult’s self-sufficiency and power interchange case were used as a bases for the self-supply and cooperation cases, respectively. However, the investment programs were adjusted to ensure both a satisfactory reserve margin (above 15 percent) and no unserved energy in the dispatch model. The Newjec/MRC Study was used where there were gaps and/or inconsistencies. Under the Lower Demand Growth scenario, these investment programs have been modified, although not optimized, to minimize the amount of excess installed capacity in Thailand and Vietnam for the self-supply case, and on an overall sub-regional basis for the cooperation case. The installed capacities in both the self-supply and cooperation cases have been revised downward by reducing the amount of generic coal-fired plant included in the investment programs of Thailand and Vietnam.

- **Capital costs and operational unit costs are updated relative to the Norconsult Study.** For the power trade case: (i) unlimited interconnection; (ii) unconstrained power flow; and (iii) losses are independent of dispatch and of the interconnection layout. Thus, the resulting cost savings of the generation system can be considered as upper bound to the actual potential.

2.14 Although the dispatch model approximates an optimal dispatch of generating plants, it does not optimize the investment program. In all cases, there may be alternative investment options with a lower present value cost.

2.15 **Cost Comparisons in the Dispatch Model.** Figure A1.3 shows the combined annual investment and operating cost (including fuel cost) of the GMS generation system from the dispatch model for the self-supply and cooperation cases under the High Demand Growth scenario. The large cost increase in both scenarios in 2014 is primarily due to the new investment required to offset many thermal plant
retirements by that year. The total annual costs for power interconnection are lower than for the self-supply case, except for some earlier years, where they are slightly higher. This is because, although the interconnection case has lower annual operating costs after 2002, the investment program brings forward investment in capital-intensive hydro plants. Hence, the cumulative costs under the cooperation case do not reveal a significant advantage over the self-supply case until after 2010.

2.16 The cumulative reduction in generation investment and operating costs for the cooperation case over the self-supply case reaches US$13.7 billion by 2020 under the High Demand Growth scenario, neglecting generation investment prior to 2000. (Table 2.1) Most of this (US$13.4 billion) is due to savings in operating costs. The reduced generation investment and operating costs due to power trade must then be compared to transmission investment needed to achieve such trade. Regarding interconnection costs, the Norconsult Study concluded that a net benefit of at least US$400 million between 1995 and 2000 would result from power interconnection - given an estimated cost of around US$190 million for limited interconnection.

2.17 If full and unconstrained interconnection were established immediately, the projected present value of the stream of annual reduction in generation investment and operating costs from 1997 to 2020 due to power trade would be US$4.1 billion. A more realistic timeframe for full interconnection would be around 2010. By 2010, neglecting sunk investment prior to that year, the estimated present value of annual reductions in generation investment and operation costs until 2020 would be US$7.4 billion. This is higher than the present value for 1997 because significant hydropower investment is required before 2010. As the model assumes unconstrained interconnection, it means that this model's results are upper bounds to the benefits, which may be realized.

2.18 The impact of applying the Low Demand Growth scenario is primarily to delay the benefits of power trade, as it takes more years for the additional capital costs of hydro investment to be offset by the significant savings to be realized from reduced operating costs. Benefits are not clearly apparent until after 2014. Power trade now requires comparatively greater investment costs, mainly because the larger proportion of hydro plant in the generation mix (with its low availability) requires a greater reserve margin. However, the operational cost savings are of a similar order under both demand scenarios, because the magnitude of hydro-based energy dispatched does not change markedly for the lower growth rate assumption. Hence, although the cumulative benefits from 2001-2020 reduce to US$10.4 billion, the benefits from operational cost savings will continue to be viable long after this planning horizon, particularly since hydro plants generally have a significantly greater plant life than thermal units. It is interesting to note, that under the Low Demand Growth scenario, the cumulative savings of operations costs amount to US$14.5 billion, but capital costs result in dis savings of US$4.1 billion (hence the net benefit of US$10.4 billion). (Table 2.1)

7 Assuming immediate interconnection, the cumulative generation cost savings between 1997 and 2000 would be US$2 billion of which US$1.7 would be attributable to capital cost savings.
### Table 2.1: Comparison of Self-Supply and Cooperation Cases

<table>
<thead>
<tr>
<th></th>
<th>Self-Supply Scenario</th>
<th>Cooperation Scenario</th>
<th>Generation</th>
<th>Cost Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Capital Cost</td>
<td>O&amp;M Cost</td>
<td>Total Cost</td>
<td>Capital Cost</td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>High Demand Growth</td>
<td>2001-2005</td>
<td>19,032</td>
<td>23,236</td>
<td>42,268</td>
</tr>
<tr>
<td></td>
<td>2006-2010</td>
<td>30,264</td>
<td>32,253</td>
<td>62,517</td>
</tr>
<tr>
<td></td>
<td>2011-2015</td>
<td>38,154</td>
<td>40,140</td>
<td>78,294</td>
</tr>
<tr>
<td></td>
<td>2016-2020</td>
<td>42,696</td>
<td>51,593</td>
<td>94,289</td>
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<tr>
<td>Generation Cost Savings (cumulative 2001-2020)</td>
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<td></td>
</tr>
<tr>
<td>Low Demand Growth</td>
<td>2001-2005</td>
<td>12,228</td>
<td>18,056</td>
<td>30,284</td>
</tr>
<tr>
<td></td>
<td>2006-2010</td>
<td>21,801</td>
<td>23,670</td>
<td>45,472</td>
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<td></td>
<td>2016-2020</td>
<td>29,020</td>
<td>34,488</td>
<td>63,508</td>
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<tr>
<td>Generation Cost Savings (cumulative 2001-2020)</td>
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</tbody>
</table>

### Environmental Benefits and Impacts of Regional Power Trade

2.19 If regional power trade is developed on a least-cost basis, an interconnected power system would also have significant environmental benefits. These would mainly result from a substantial reduction in greenhouse gas and pollutant emissions caused by the substitution of hydropower generation for much of coal-fired and oil-fired generation. Given the assumptions of the High Demand Growth scenario, by 2020, thermal generation is forecasted to be around 16 percent lower under a regional power trading regime than would be if countries in the region remained primarily self-sufficient in electricity supply. The resulting reduction in emissions is projected to be up to 31 percent for SO₂, 12 percent for NOₓ, 18 percent for particulate matter, and 17 percent for CO₂. (Table 2.2) The monetary value of these reductions is difficult to estimate, but accepted environmental cost estimates suggest that power trade could result in emission abatement benefits of up to US$400 million per annum by 2020, although these benefits primarily relate to a decrease in CO₂ emissions. As noted above (para. 2.18), under the Low Demand Growth scenario, the magnitude of hydro-based energy dispatched annually can be practically the same as under the High Demand Growth scenario. Hence, although reduced electricity demand will clearly decrease the overall magnitude of thermal plant-based emissions, the absolute difference in emissions given self-sufficiency or power trade will be similar under either scenario.

### Table 2.2: Comparison of Emissions Under Self-Supply and Cooperation Cases in 2020

<table>
<thead>
<tr>
<th>Medium Generation</th>
<th>Thermal Generation (GWh)</th>
<th>CO₂ (10⁹ tons)</th>
<th>SO₂ (10⁹ tons)</th>
<th>NOₓ (10⁹ tons)</th>
<th>Particulate Matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Scenario</td>
<td>480,754</td>
<td>432,128</td>
<td>840</td>
<td>1,379</td>
<td>180</td>
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<tr>
<td>Trade Scenario</td>
<td>401,996</td>
<td>357,385</td>
<td>578</td>
<td>1,216</td>
<td>148</td>
</tr>
<tr>
<td>Percentage Difference</td>
<td>-16%</td>
<td>-17%</td>
<td>-31%</td>
<td>-12%</td>
<td>-18%</td>
</tr>
<tr>
<td>Trade/Reference Scenario</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.20 The benefits from reduced (thermal) emissions must be contrasted with the impacts from increased hydropower development and additional transmission lines. It should be emphasized that a relatively high reliance on hydropower generation as favored under power trade would significantly increase thermal emissions under drought conditions. (see Tables A2.2 and A2.4) If drought conditions were assumed, hydropower generation would be lowered, which would be compensated by higher thermal generation (i.e., coal, gas, oil), resulting in higher absolute thermal emissions of CO$_2$, SO$_2$, NOx, and Particulate Matter - under both cooperation and self-supply. Drought conditions compared with normal conditions would, however, lead to relatively higher increase in emissions under cooperation than under self-supply.

2.21 Impact mitigation programs will need to be developed for each hydropower project on a case-by-case basis, and should consider: resettlement issues, appropriate reservoir size, multi-purpose and innovative uses for the reservoir and affected areas, reservoir stabilization, and watershed management and monitoring.
Chapter 3: POWER SECTOR STRUCTURES AND REFORM EFFORTS

3.1 If a regional power grid becomes a reality, many policy issues will arise: Who will plan, finance, construct, own and operate the grid facilities? Who will regulate them and set prices for wheeling? How can the countries' different political and economic systems and power sector reforms be made compatible to form a regional power market? What is the scope for competition and how could it be fostered? This chapter addresses the region's sector reform efforts as a framework for discussing the policy measures for competitive trade in Chapters 4 and 5.

Government Policies on Electricity Trading

3.2 Although none of the countries has established a long-term policy with respect to regional power integration, they have taken actions to promote private sector investment that are conducive to increased regional power trade.

3.3 There is growing interest in arranging bilateral sales from Lao PDR and China to Thailand. The Government of Thailand has agreed to buy 1,500 MW from Lao PDR by the year 2000 and projects for this amount of power seem to be moving forward. An agreement to purchase an additional 1,500 MW by 2006 was signed in June 1996. The Ministry of Electric Power (MOEP) in China is encouraging studies of the Jing Hong hydropower plant and associated transmission lines to Thailand, through Lao PDR, with the support of the Lao and Thai Governments. Vietnam has expressed interest in purchasing about 2,000 MW of power from Lao PDR by 2010 and a Memorandum of Understanding (MOU) has been signed to this effect. Opportunities also exist for purchases by Thailand from Myanmar and Cambodia. A summary of current private power generation initiatives is presented in Annex 3.

3.4 Channels for regional sector cooperation have been established. The regional Electricity Power Forum (EPF) sponsored by the Asian Development Bank (ADB) as part of the GMS initiative provides an opportunity for countries in the region to discuss how to develop this cooperation. The countries of the Association of Southeast Asian Nations (ASEAN) have established a technical working group to coordinate interconnection efforts. Further, the MRC has been conducting regional studies on the interconnection of the GMS power systems. At the regional EPF in Kunming (December 1996), participants discussed the potential to expand power trade beyond the bilateral sales now contemplated, and encouraged all Governments to consider how to develop a regional power market. As discussed in Chapter 2, possibilities exist for further High Voltage (HV) transmission links, e.g., from Lao PDR to Vietnam, Vietnam to China and, in the long-term, a grid linking most of the ASEAN countries.
Sector Structures

3.5 The power sectors are structured differently in Thailand, Vietnam, Lao PDR, Cambodia, Myanmar, Malaysia, and China:

- **Thailand** — has three Government-owned utilities: Electricity Generating Authority of Thailand (EGAT), Metropolitan Electricity Administration (MEA), and Provincial Electricity Authority (PEA). EGAT is responsible for bulk supply; MEA is responsible for the distribution in Bangkok; PEA supplies the rest of the country. These utilities are well established, profitable and well-managed. The Government plans to privatize them through stock exchange listings.

- **Vietnam** — Electricity of Vietnam (EVN) was established in 1995, as a wholly Government-owned holding company for the power sector. It coordinates the three formerly fully-integrated power companies, which had been based in Hanoi, Danang and Ho Chi Minh City.

- **Lao PDR** — the national utility Electricité du Lao (EDL) was established in 1961 and is responsible for all supply in the country. However, electricity supply is largely restricted to the capital city of Vientiane and the provincial towns, since transmission facilities are limited.

- **Cambodia** — Electricité du Cambodge (EDC) is a state-owned utility responsible for the supply of electricity nationwide. Electricity supply is largely restricted to the capital city of Phnom Penh and a few provincial towns; there are no transmission facilities in Cambodia.

- **Myanmar** — Myanmar Electric Power Enterprise (MEPE) was constituted in 1989 as a Government-owned fully integrated utility. It is responsible for planning, designing, constructing, maintaining and operating electric supply facilities throughout the country.

- **Malaysia** — Tenaga Nasional Berhad (TNB) operates as a fully integrated power company; it purchases all power produced by independent power producers (IPP).

- **China** — In the Yunnan Province in China, the Yunnan Provincial Electric Power Corporation (YPEPC) operates as a fully integrated power company, wholly-owned by the Government. The South-East China Electric Power Corporation (SCEP) has been set up as a joint venture company at Guangzhou by China's central government, the State Energy Investment Corporation and Guangdong, Guangxi, Guizhou and Yunnan in 1991. SCEP constructs and manages jointly-funded generation and transmission projects.

3.6 Restructuring existing utilities in the region is moving forward cautiously in most cases. Although all countries are reforming their power sectors, each is progressing at a different pace and the Governments vary in their objectives and commitment to open their power sectors to competition. At this point, there is very little evidence of meaningful cooperation in the operation of their respective power systems. Progress in establishing separate regulatory mechanisms has been limited as well. China, Malaysia and Lao PDR have adopted new electricity laws, and Vietnam and Cambodia have made substantial progress in drafting new laws. However, only Malaysia has set up a regulatory function which, for now, is within the Ministry responsible for the power sector.
### Sector Reform Efforts

#### Table 3.1: Status of Power Reform in Greater Mekong Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Fully Integrated Sector</th>
<th>Separate Regulation</th>
<th>Degree of Unbundling</th>
<th>IPPs Permitted</th>
<th>Single Buyer Model</th>
<th>Transmission Access</th>
<th>Wholesale Competition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>Under study</td>
<td>Distribution and Generation (in progress)</td>
<td>✓</td>
<td>✓</td>
<td>Limited access planned</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Malaysia</td>
<td>✓</td>
<td>est. 1991</td>
<td>Unbundling of generation &amp; transmission under consideration</td>
<td>✓</td>
<td>✓</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>China</td>
<td>Under study</td>
<td>Partial unbundling of generation &amp; transmission</td>
<td>✓</td>
<td>✓</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Vietnam</td>
<td>✓</td>
<td>Law being drafted</td>
<td>Generation and transmission to be operated as cost centers</td>
<td>✓</td>
<td>✓</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>✓</td>
<td>Not planned</td>
<td>Creation of separate transmission company being considered</td>
<td>✓</td>
<td>✓</td>
<td>Under study</td>
<td>No</td>
</tr>
<tr>
<td>Cambodia</td>
<td>✓</td>
<td>Law being drafted</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Myanmar</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

### Thailand

3.7 In Thailand, EGAT is being unbundled to separate its thermal generation functions from transmission. Under the new sector structure, EGAT’s transmission entity will be responsible for power purchases but, IPPs will be allowed limited access to the transmission to enable some direct sales to be contracted with large consumers. In the future, open transmission access will be permitted. Consultants have proposed eventual transition to full retail competition but this approach has yet to be decided.

3.8 In May 1992, EGAT established its own generation subsidiary, EGCO, by selling it the Rayong combined-cycle power plant and the 750 MW Khanom project. In November 1994, EGCO became a listed company on the local stock exchange with EGAT holding 48 percent of issued shares and it is now participating in EGAT’s IPP solicitations. EGAT’s existing thermal plants are being transferred to three new subsidiaries, with EGAT holding less than 50 percent. Each subsidiary will own about 5,000 MW of EGAT’s existing plant. Each company is expected to seek a stock exchange listing and trade some shares publicly; the balance would be held by EGAT, which will retain responsibility for hydro and transmission facilities. EGAT will also be responsible for power purchases from all local and international sources including EGCO, IPPs, cogenerators and EGAT’s new thermal subsidiaries.
3.9 PEA's distribution functions are being separated into five separate subsidiary companies. The restructuring and corporatization of MEA was decided and an action plan has been approved by the Government.

3.10 The National Energy Policy Office (NEPO) is looking at options to increase competition in the power sector. To this end, it is undertaking a study* to examine how to regulate the restructured sector and separate the Government's policy functions from its regulatory role. It will look at the feasibility of opening up EGAT’s transmission system so generators can sell directly to distributors and large consumers, and it will propose a pricing system for use of the transmission system. A previous study examined bulk supply pricing, and proposed regulations and adjustments to existing policy and legislation.

**Vietnam**

3.11 Under the new holding company structure in Vietnam, generation and transmission are centrally managed by EVN. Distribution is handled by five subsidiary companies; each with an independent account, but all report functionally to EVN. There are plans to operate generation and transmission as cost centers in 1998 and, ultimately, as profit centers. EVN has a management board which reports to the Ministry of Industry. Consultants from the Electricity Supply Board (Ireland) are examining EVN's institutional structure, particularly its distribution subsidiaries, so they can suggest how these could be strengthened. So far, there is no separate regulatory mechanism, but EVN is creating a regulatory framework to separate the Government’s policy making and regulatory functions. Finally, EVN has agreed to undertake a study to consider private financing options for distribution, which would be financed by a Japanese grant.

**Lao PDR**

3.12 In Lao PDR, ADB is financing an EDL study on how to coordinate new transmission facilities for the planned new IPPs and how to set up a National Grid Company. A separate study by Norconsult, on the formation of the grid company is being financed with Norwegian assistance. EDL is also considering the possibility of placing all export power plants in separate profit centers and, ultimately, in a separate generation company. This would manage EDL's share in Build-own-transfer (BOT) generation projects. It would also separate EDL's local supply functions from its major generation and transmission activities, which would be focused largely on exports of power to Thailand and Vietnam. A law/degree on BOT/BOO drafted by the Ministry of Justice is currently in the pipeline.

**Cambodia**

3.13 EDC operates the power system in Phnom Penh and three provincial towns, Sihanoukville, Siemreap and Kampong Cham, with an installed capacity of about 95 MW. There are about 20 isolated

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systems serving other parts of the country. EDC, formerly the Ministry of Mines, Industry and Energy, is now an autonomous, wholly-owned, commercial corporation, responsible principally for running the existing facilities. The isolated systems are expected to be gradually transferred to EDC. The Government approved an IPP for 35 MW, which was commissioned in 1997, and signed a power purchase agreement (PPA) for a second IPP in Phnom Penh. PPAs have been signed for two provincial towns. A draft electricity law would establish a separate regulator, the Electricity Authority of Cambodia (EAC), but it has yet to be approved by the National Assembly.

**Myanmar**

3.14 Private participation in power has been possible since 1994. Investment opportunities include taking over existing generation, transmission and distribution facilities from MEPE, and direct investment in new power plants, transmission and distribution under either BOT or joint venture arrangements. MEPE has been discussing private participation with several interested parties since then.

**Malaysia**

3.15 In February 1997, the Government decided to transfer TNB's generation to a separate subsidiary company, and it is also considering separating transmission from distribution. The dominant focus of restructuring has been to encourage IPPs and to establish the existing utility's transmission entity as the power purchaser or single buyer. In Malaysia, IPPs provide 30 percent of the generation capacity on the peninsula and are required to sell their output to TNB.

**China**

3.16 In 1993, as part of China's overall power sector reform, the Yunnan Provincial Electric Power Corporation (YPEPC) was converted to corporate status. YPEPC dispatches the power generation plants, but is moving to separate generation from transmission and distribution. New generation plants are being set up as separate companies financed jointly by State and Provincial investors. YPEPC retains the joint function; it administers the sector in Yunnan, develops annual and long-term plans, and oversees energy conservation and safety matters. It also arranges prefeasibility and design studies for new projects. Elsewhere, especially in China's coastal provinces, bureau functions are separate from power company operating functions. This will occur in Yunnan later as regulations are issued under China's new Electricity Law, approved in late 1995.

3.17 As in other provinces, Yunnan is developing the purchasing agency model and has signed long-term PPAs with investors undertaking joint projects. So far, these are all public corporations, Chinese banks and Provincial or State Governments. They will be established as limited companies but will not be IPPs because they are public projects and without limited recourse financing. These include Quijiang (600 MW), Yangzhonghai (800 MW), Dachaoshan, Xuanwei and Luosiwan.

3.18 SCEP has completed construction of the 1,320 MW Tianshengqiao-2 hydro project and is constructing Tianshengqiao-1 (1,200 MW) which should be commissioned about 1998. The cost of Tianshengqiao-2 is being shared 50 percent by Guangdong, 20 percent by Guangxi Zhuang Autonomous Region and 10 percent by Guizhou. SCEP will also build the 4,200 MW Longtan multi-purpose hydro plant expected to start in 1999. SCEP has built also a 500 kV high voltage transmission system connecting the power networks of the three other provinces with Guangzhou. This large scale generation
and transmission system aims to satisfy Guangdong’s power needs but, in the long term, SCEP would develop the hydropower resources of the Lancang River (Mekong) for the Thai market.

3.19 SCEP already follows principles of a commercially managed system. It sells energy to the provincial utilities at prices subject to the approval of the State Bureau of Prices and, unlike other transmission utilities in China, has established a transmission tariff. SCEP is also proceeding to examine options for Regional Power Pooling with Bank support.

**Future Development of the Power Market**

3.20 Extensive power trading, beyond the existing proposals for bilateral power purchases, requires an approach to opening the power sectors. If power trade is to develop beyond the existing proposals for bilateral power purchases, it has to be economically attractive to all countries. However, other conditions have to be met in the long-term, such as an opening of power sectors, including some degree of compatibility in sector structures, conditions for private entry, and market competitiveness. To assess the potential for power trade, it is useful to look at the main market options vis-à-vis the ongoing reform efforts. The main options which could be considered are: (i) the **Single Buyer Model;** (ii) the **Third Party or Open Access Model;** and (iii) the **Spot Market or Wholesale Market (Power Pool) Model.** These three models can be three phases of a natural sequence.

- A **single buyer** market is characterized by an entity such as EGAT purchasing power from producers on a contract basis. EGAT is already doing this. In this model, each country would have its own single power purchaser. This approach would not require a radical separation of integrated utilities nor significant reform of the power sector - except for some degree of vertical or horizontal separation (or both) to make it more competitive. However, the benefits of this model could be limited by contract sales based on firm energy under long-term contracts. It may also lead to major inefficiencies in investment decisions, especially duplicating transmission infrastructure. Long-term contracts should be structured like IPP contracts, by providing separate payments for capacity and energy to compensate producers who can maintain high plant availability levels.

  More competitive single buyer models require some vertical and horizontal separation of generation, transmission and distribution. Vertical separation facilitates competition for supply among power generators and enables the costs of transmission to be identified and prices set for grid use. These would normally need to be regulated through a transparent and predictable price review mechanism. Partial vertical separation can be achieved by separating accounts within an integrated utility; sometimes this has led to establishing internal power purchase markets. Vertical separation is not likely to succeed in the region because accounting and costing data reliability vary widely and the accuracy of these data are difficult to confirm.

  Sufficient horizontal separation of generation and distribution would increase the scope for competition. For example, this normally requires establishing four to five power producer groups of similar size and characteristics. This should lead to better bulk purchasing provided that one large generator does not command excessive market power. The Thai market is developing in this manner; EGAT is the power purchaser.

- **Under the open access or third party** model, transmission systems are opened up to generators so they can wheel power, via the transmission system, directly to distributors or large bulk customers. Experience has shown that lack of open access to transmission has hindered trade. Transmission access should, therefore, be regulated, and prices should be compatible,
transparent, and efficient. Vertical separation avoids conflicts of interest which can occur if a transmission entity were to favor its own generation source. The lack of vertical separation is a main constraint in the region, especially in Thailand, China’s Yunnan Province and Vietnam. Thailand and China are now addressing this issue. In a few years, Thailand plans to allow generators limited access to its transmission network.

Under the open access model, most exchanges are based on long-term contractual agreements, but scope should emerge for short-term trading if countries have spare capacity or energy that they wish to sell. This could facilitate the development of a spot market if the parties could agree on organization, regulation, and specific dispatch arrangements. Generators could be dispatched and paid according to the system marginal cost at different periods or through a bidding process. In this case, the potential conflict between long-term contractual dispatch agreements and short-term economic merit dispatch could be solved through a wholesale market.

- The final stage of developing regional competition could be to form a regional **power pool** or **wholesale market** to facilitate trade. This would allow regional power producers to sell directly to any distributor or bulk customer. But a regional power pool could be blocked by political objections to power trade and to regional organizations. It could also founder on the lack of a suitable regulatory framework to guarantee a fair and efficient market, including mechanisms to facilitate and coordinate trade. Most likely, each country would decide to maintain its own single central dispatch facilities (i.e., a national tight-pool arrangement) while establishing an unconfined coordination between national pools (an international loose pool). Power pools favor trade and provide clearer signals to power producers and purchasers on the cost of generation, but it must be ensured that a few large generators do not dominate the market and inhibit competitive power pooling.

3.21 Power sector reform in each country and the whole region shows that initial measures have facilitated the beginning of power trade. (Table 3.1) However, it is still not clear how far countries will go to improve the conditions for a more extensive trade required to materialize the large economic and environmental benefits identified in Chapter 2. So far, reform is opening up the sector to private generation. Although IPPs are legal in all countries, their ability to attract private investment has varied. In Thailand and Lao PDR, the IPP business appears to be booming; in other countries this process is quite slow. All countries are, however, moving towards a single buyer model with different degrees of competition. The degree of competition relies on the overall transparency in the IPP entry process and the extent to which countries retain the existing fully-integrated utility, as opposed to establishing vertical or horizontal separation. In this regard, Thailand is making the most progress in unbundling distribution and generation, while Malaysia, China and Lao PDR are considering separating generation from distribution.

3.22 Generally speaking, reform efforts are cautious. In China, the central Government is moving slowly to encourage competition for supply by generators. No special attention appears likely to be given to Yunnan Province because of its possible involvement in the export of power. Governments in Vietnam, Lao PDR and Cambodia appear reluctant to relinquish control of the sector. Vietnam is separating generation and transmission, but it is not apparent whether the Government will permit full unbundling to facilitate competition. In Cambodia’s power sector, the system is too small, and the scope for efficiency increases too limited, to contemplate unbundling it.

3.23 Most Governments are not contemplating open access yet. Apart from Thailand, Malaysia could be considered ready to move towards open access because it has several IPPs providing about 30 percent
of its system generating capacity. But establishing effective regulation of competition and prices is lagging; Malaysia is the only country with regulatory mechanisms.

3.24 In summary, most countries in the region have taken measures to allow competition in generation establishing a single buyer model. This has triggered private interest in several bilateral agreements. To achieve greater power trade benefits, however, a more reliable competitive environment is desirable. Experience with power sector reforms in other regions suggests that countries move towards policy measures sequenced to (i) allow competition at entry in generation through the introduction of IPPs and, through this practice, set up a single buyer model; (ii) establish separation - vertical, horizontal, or both - to introduce more competition into the single buyer model; (iii) establish open access to transmission systems to enable generators to wheel power to distributors and large customers, i.e., a full vertical separation to create an open access model; and (iv) form national and, ultimately, a regional power pool or wholesale market. As an overarching measure, an autonomous regulatory framework tailored to the needs of each stage could be established. Nevertheless, examples of regional power trade indicate that not all of the above mentioned measures are pursued in the same order or scope. This suggests that, for power trade to take place, uniform reforms are not necessary. However, it can be argued also that, in the long term, sector reform would help to introduce more competition and efficiency into the power trade process and, hence, helps realizing its full potential.
Chapter 4: ISSUES AND BARRIERS TO DEVELOPING A REGIONAL POWER MARKET

4.1 In general, it appears that countries in the Greater Mekong Sub-region are increasing their power trade. First, most have introduced reforms to facilitate it (Chapter 3). Also, they are supported by regional and multilateral agencies in their power integration efforts. And, most importantly, regional and international private developers are investing in major export projects, initially in hydro projects in Lao PDR to sell power to Thailand. Nevertheless, actual and potential barriers still exist to cross-border trading within the region. These barriers fall into four categories: Policy, Technical, Institutional and Commercial/Financial.

Policy Barriers

National Priorities

4.2 The GMS countries primarily focus on institutional development and strengthening their domestic electricity sectors.

4.3 Countries within the region do not generate enough power to meet their needs and provide enough backup to ensure reliable service. Further, in most, the transmission and distribution systems are not developed enough to exploit their production capability on a reliable basis. Consequently, each country’s policies attempt to overcome these problems. While regional trade in power can be one solution, not all the countries see it as important a factor as rehabilitating or reforming their power sectors. In addition, although it is not always stated, national security concerns regarding self-sufficiency constitute an important policy objective in several countries. This focus on domestic needs acts as an actual barrier to trade.

4.4 A review of each country’s policy goals shows that, except for Lao PDR and Thailand, the primary focus is domestic. In the former, since its development is being geared primarily for export to neighboring countries, trading of electricity is assigned the highest priority. Thailand, which is the dominant country in terms of electricity requirements, also appears to place a high value to regional trading, at least to the extent that it is competitive with the domestic development of private generation. To this end, it is looking to import low-cost hydro-electricity, mainly from Lao PDR, through a series of enclave projects developed by groups of private investors in the form of IPPs. (Annex 3)

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10 An example of a “potential” barrier is a lack of a regional operations protocol to govern the interaction between system operators that control the networks in neighboring countries. However, until transmission lines are completed, the lack of a regional operations protocol will not actually impede trade. Therefore, though there may not be an immediate need for a regional operations protocol, this may become an “actual” barrier at some future date.

11 Lao PDR has, and is still developing, an economic policy to attract foreign investors - particularly to encourage private investment in power generation for export. The Foreign Investment Management Committee (FIMC), within the Prime Minister’s Office, provides a “one-stop shop” service for developers seeking a concession to build a power project in the country. The Foreign Investment Law of 1994 protects the property and investments of foreigners from requisition, confiscation or nationalization.
4.5 Vietnam is a centrally planned economy which aims to attain self sufficiency in generation, rather than relying on trade with neighboring countries. It has an ambitious investment program of about US$1.5 billion per year over the next 10 years. The concept of regional trade is emerging slowly.

4.6 In China, trade in electricity with neighboring countries is a new concept which has yet to mature. As its need for electricity is large, the central government assigns a higher priority to meeting domestic requirements. However, in southern China, two of four provinces share borders with other GMS\textsuperscript{1} countries and Yunnan province has a huge hydro potential (about 90,000 MW), as well as coal, which could be developed for export.

4.7 In Cambodia, several projects have potential for electricity import, especially from Lao PDR and Vietnam, but no clear strategy has been developed. At present, EDC's main concern is to retrofit and expand its supply and distribution systems in Phnom Penh and provincial cities.

**Regional Protocol**

4.8 No regional protocol exists that recognizes the long-term benefits of regional trading or encourages each country to jointly plan and develop generation and transmission, and promote opportunity trading.

4.9 Because no such protocol exists, and because governments have not developed policies that could minimize barriers or taken positive actions to promote regional trade, the agencies and entities within the countries have not pursued cross-border transactions.

4.10 The bilateral agreements (MOUs) which link Lao PDR to Thailand and Vietnam are the basis for pursuing specific cross-border trading opportunities. However, no such agreements have been reached in other countries and power trade is currently a private project-driven process, rather than a response to regional policy. Without the benefit of a regional policy consensus, reinforced through the framework set by protocol, cooperation among countries to address most of the barriers is likely to be limited.

**Flexibility and Compatibility in Laws, Regulations and Contracts**

4.11 The laws, regulations and contracts being drafted seem designed for current conditions within each country without adequately considering the flexibility and compatibility needed to move towards more competitive models of electricity markets.

4.12 Countries are adopting or considering different ways to restructure their power sectors. The most advanced within the region is the single buyer industry structure and market in Thailand, which constitutes a practical first step to strengthen the electricity sector. Regulations are being drafted and PPAs negotiated with independent producers. However, it seems that many laws, regulations and PPAs include long-term provisions that will make the move to more competitive markets difficult.

\textsuperscript{1} Yunnan Province shares borders with both Lao PDR and Vietnam, and the Guangxi Zhuang Autonomous Region borders Vietnam.
4.13 One example is the lack of flexibility to reassign parts of the generation output purchased under a long-term PPA. Without this, there will be limited scope for introducing more competition. While competitive markets may not be desirable in the near-term, they could offer considerable economic gains in the future. Thus, if the policies do not include flexible provisions for all laws, regulations and contracts, customers might not be provided with the most efficient use of regional resources.

Transmission Ownership

4.14 Generation developers are unsure about which entity will be responsible for owning and operating transmission assets.

4.15 Timely development of transmission is essential to financing and constructing new generation. At present, there is some degree of uncertainty in several countries as to which agency or entity will be responsible for building and operating transmission facilities. For example, in Lao PDR, private developers are building transmission lines from project sites to the Thai border to connect to EGAT’s transmission system; but, for one site, it has not yet been decided whether a country-owned entity, as yet undesignated, or the private developer, will build the lines.

4.16 In China, while it is decided that the government will build the transmission lines, it is unclear which government entity will build the transmission from a proposed hydro project to the border with Lao PDR.

4.17 Such uncertainties are barriers to developing projects in general, and projects for cross-border trading in particular. In order for generation developers to reach financial closure, contracts must be in place for constructing the associated transmission facilities. Therefore, each country must have a clear policy about ownership and operation of transmission facilities.

Open Access to Transmission

4.18 Policies generally do not exist which ensure that transmission facilities will be open for use by all generating plants, on a nondiscriminatory basis.

4.19 Transmission investments come in lumps - i.e., a fixed investment typically provides a certain amount of transport capability above that which a certain plant needs. This capacity could be available to transport part or all of the output of another plant.

4.20 Where private generation developers are planning to build transmission lines to connect their plants to load-serving points, it is unclear if a subsequent generator would be allowed to connect to the lines constructed by the first generator. In the near-term, this may be more a potential than an actual barrier to trade. However, it could become actual if a new plant required the construction of additional transmission facilities; this could put the proposed project at a competitive disadvantage, particularly if the first plant added a unit at the existing site.

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13 In several countries, the first priority is to overcome inadequate investment in generation and delivery systems while the introduction of competitive forces into the sector remains a secondary and longer-term objective.
4.21 Open access is limited in the case of the single-buyer market, such as is being implemented in Thailand. In this case, only generators are permitted to have open access to transmission facilities. It would be opened to buyers at some future date when, and if, a competitive market were introduced which allowed load entities to shop for power.

4.22 Another issue is open access for through flows or wheeling. For example, there is no policy allowing a third country such as Lao PDR to permit sales from Vietnam to Thailand. It has agreed in principle to allow the output of the Jing Hong plant in China to be transported through its system into Thailand. And, although active regional trading in the future will require that through flows occur unimpeded, it is unclear if the current lack of a such policy would be a barrier in the near-term.

Environmental Impact

4.23 There is no coordinated effort to address the potential social and environmental impact stemming from an extensive development of hydropower resources in the region.

4.24 If power trade proceeds on a least-cost development basis it would bring about significant environmental benefits. The potential reduction in emissions is projected to be up to 31 percent for SO2, as much as 12 percent and 18 percent for NOx and particulate matter respectively, and 17 percent for CO2. However, the benefits from reduced emissions must be contrasted with the social and environmental impact from increased hydropower development. Environmental issues should be addressed through a regional approach to resolve conflicts between regions/countries, coordinate regulation and incorporate environmental issues into overall planning. Failure to mitigate these impacts in an effective and sustained manner could become a serious constraint to hydro development and, hence, a barrier to power trade.14

Technical Barriers

4.25 There are both actual and potential technical barriers to developing regional trade. The most obvious is a lack of transmission facilities to connect the countries; others are the lack of coordinated planning and an operations protocol.

Uncoordinated Planning

4.26 Transmission planning for the region is not being coordinated to ensure that an optimal plan is designed to minimize investment in the long-term, ensure an efficient dispatch and provide a technically sound operation of the network.

4.27 Uncoordinated planning is an actual barrier to regional trade. Various entities in the region have carried out transmission studies, sponsored by the MRC and other donors. Also, a number of planning studies are focused on the immediate problem of identifying the least-cost option for delivering the output of a specific plant to a designated point. However, the task team was unable to identify a master plan for the

14 Export hydropower projects pose a specific problem with environmental, social and political dimensions: they can adversely impact the host country (e.g., loss of land or biodiversity, resettlement requirements), while benefiting the purchasing/importing country.
region. Steps should be taken to bring together the various national transmission plans so as to offer a coherent picture of possible developments. This may involve Lao PDR playing a pivotal role. Another constraint identified by the team was the absence of a study or tool available to investigate the dynamic stability of the whole interconnected network.

**Insufficient Transmission Facilities**

4.28 A fundamental barrier to regional trade is the lack of enough transmission facilities to permit significant transfers of electricity between countries.

4.29 Currently, plans exist to develop project-specific transmission facilities to deliver output from one country to another. About six to eight projects will probably be developed in Lao PDR for delivery to Thailand, and each will require transmission development. However, it is somewhat uncertain if and when many of these generation projects and their associated transmission facilities will be developed.

4.30 To develop a robust market in electricity trading, physical facilities must be in place. Moreover, a network of facilities is needed, rather than point-to-point links for delivering the output of specific generating plants to specific loads. A network would provide parallel facilities to ensure delivery of electricity in the event of scheduled or unscheduled outages. If the network is extensive, this would allow buyers of electricity to shop among competing producers. At present, no such regional network exists.

**Operations Protocol**

4.31 No protocol exists to govern the operation of a regional transmission network.

4.32 Such a protocol may include detailed requirements related to the planning, design and operation of an inter-connected transmission system. Presently, the limited amount of cross-border transmission minimizes the need for uniform operational arrangements. Therefore, the lack of a regional protocol or grid code is a potential barrier to trade.

4.33 However, it will need to be established before interconnection facilities are placed in commercial service. The reliability and quality of service may be at risk if operators in the respective countries are unclear as to what procedures govern routine and emergency operations. Also, if one system designs and constructs facilities to a standard which is lower than another, it may impose a reliability risk on the system with higher standards. It is unknown if operators have met and begun to work out these arrangements.

**Institutional Barriers**

4.34 There are both actual and potential institutional barriers to trade within the region. One actual barrier is the lack of leadership and a potential barrier is the lack of independent regulators.

**Leadership**

4.35 No established leadership exists within the region that all parties recognize as the driving force to facilitate and encourage greater regional trade.

4.36 Agencies such as the ADB and MRC provide valuable support in promoting regional integration as well as undertaking important conceptual studies on a regional transmission network. The ADB-sponsored
regional EPF has helped facilitate thinking and debate among key parties in the region with regard to international energy sources and cross-border issues.

4.37 However, the task team was unable to detect any consensus to identify the activities needed to establish the infrastructure for cross-border trading. While annual meetings and discussions among country representatives are important, more frequent activity is required to create a sense of momentum for building a regional approach. It is still unclear which group or agency will provide day-to-day leadership that will be respected by the key players. This ambiguity constitutes an actual barrier to regional trade.

Independent Regulators

4.38 Except for Malaysia and Thailand, the other countries are not creating independent regulators.

4.39 When governments create independent regulators, potential developers are more assured that tariffs will not be changed arbitrarily. This concern may be greatest with regard to transmission tariffs.

4.40 While the increased certainty associated with a predictable regulatory regime—such as that required for transmission service—would facilitate trading, the lack of independent regulators does not necessarily impede it. Many European countries have engaged in regional trading without having independent regulators. In such cases, the required predictability is sought through long-term contractual arrangements.

Commercial and Financial Barriers

4.41 A number of actual and potential commercial and financial barriers to regional trade were identified. These barriers include generation and transmission tariffs, generation and transmission development risks, taxes and royalty uncertainties, and commercial and official financing.

Generation Tariffs

4.42 Existing generation dispatch within the region appears to be on the basis of one-part generation tariffs and purchase power agreements. PPA structures are also not uniform and appear to include impediments to future market development.

4.43 Current and planned pricing of generation within the countries is usually based on one-part energy tariffs. This is an actual barrier to economic trade because such tariffs do not provide information about costs at the margin and, therefore, do not provide adequate price signals for dispatch decisions. Only in Thailand was there evidence of a move towards a two-part.

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15 It should be noted that Vietnam and Cambodia are working on the development of power sector laws that would introduce an independent regulatory body.

16 A one-part tariff is a system which encompasses all costs in a single price per kWh. This system fails to reflect a real cost structure and, hence, provides the wrong signal for dispatch decisions and consumers. Conversely, a two-part availability tariff has proven to be workable and to provide the proper signals and incentives to generators. Through this system, fixed costs are paid upon availability and an energy fee is paid on the basis of incremental costs. The true merit order dispatch is therefore based on actual performance of the generators and not on average values.
4.44 One-part tariffs lead to uneconomic dispatch decisions such as: (a) the displacement of no storage hydro (run-of-river) in favor of stored energy hydro; this could happen in Lao PDR if the one-part price of the stored energy hydro project is lower than the price of run-of-river plant; and (b) the most acute case, when thermal generation is used to displace hydro generation; this occurs sometimes in southern China when Yunnan Province hydro production capacity may be unused at the same time as relatively expensive fossil fuels are being burned in Guangdong Province.

4.45 Dispatch decisions should be made by comparing the variable costs of production; however, a one-part tariff does not provide the information needed. Such an approach to pricing bulk electricity acts as a barrier to economic trading both within a country and across-borders.

**Transmission Tariffs**

4.46 Long-term contracts or tariff certainty is necessary to cover fixed investment costs of transmission. However, transmission tariffs have not yet been developed within the region, except on a case by case basis.

4.47 Transmission is being developed within the region, as with the Theun-Hinboun hydro project in Lao PDR. However, costs for this and other projects are bundled into a delivered capacity and energy price at a remote point from the plant. The task team was unable to identify an established tariff that could finance the creation and expansion of a transmission network.  

4.48 Because major investments will be required to develop a regional transmission system, the lack of unbundled transmission tariffs should be regarded as an actual barrier.

**Generation Risk**

4.49 There is a great deal of uncertainty about which and when specific generation projects will be developed.

4.50 Such uncertainties pose an actual barrier to developing trade. Many generation projects are in various stages of planning, particularly for delivery to a single buyer (EGAT): These include thermal generation projects in Thailand which are competing against potential projects in Lao PDR and China. However, few export projects have reached financial closure; thus, they should be assigned varying degrees of uncertainty.

4.51 The relatively low prices of recent bids for thermal projects in Thailand raises questions as to the financial viability of the least competitive hydro projects. Since many of them are for cross-border deliveries, regional trade may be at risk in the short-term. Over the long-term, however, the viability of hydro projects should increase, as the depletion of natural gas would increase Thailand’s avoided costs. In addition, the recent financial crisis in Thailand poses a new source of uncertainty on the power market and, in particular, the commissioning date of many projects.

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17 Ideally, a systematic tariff methodology should be developed and uniformly adopted by the countries in order to provide long-term security for investors.
Transmission Construction Risks

4.52 There is considerable uncertainty about the development of transmission lines. First, there is concern that government agencies, particularly those with little experience in managing transmission construction, cannot be relied upon to complete projects on time. Second, uncertainty about which generation projects will be built poses a major constraint for the design and development of an optimal transmission system.

4.53 Developers expressed concern about the reliability of government agencies to install transmission lines in time to meet the scheduled completion of related generating plants. There are varying levels of experience in planning, engineering, and constructing transmission within the region. Although some countries, such as Vietnam agencies, have demonstrated the ability to build transmission on an accelerated time table, there remains some doubt about the technical and/or financial capability of other agencies.

4.54 The two Nam Ngum hydro projects in the northern region of Lao PDR illustrate the potential conflict between individual private initiatives and the public interest, as well as the cost of uncertainty. Nam Ngum 2 and Nam Ngum 3 are being developed by different groups, but both plants are intended to deliver power to Thailand at its Nong Khai 2 station. A common transmission path could be used for part of the distance between Nong Khai 2 and the Nam Ngum projects, so as to avoid duplicated investments. To achieve economies of scale, this portion of the line should be built and operated as a 500kV system. However, the 500 kV system would cost more than the 230kV lines which would be built for each of the plants independently. If it is certain that both plants will be built, the solution would be straightforward: the 500 kV line would be built to the point where it divides into 220kV lines to each of the Nam Ngum projects. However, if this decision is taken and one of the plants is not built, the capital expended could have been better applied elsewhere.

Taxes and Royalties

4.55 The uncertainty regarding taxes and royalties is an actual barrier to developing export generation in some countries.

4.56 Taxes and royalties can have a major impact on the earnings of potential developers or raise the price of production to an uncompetitive level. Some developers are concerned about the lack of clarity in the tax regime for export projects in a number of countries, which constitutes a constraint to private investment and an actual barrier to power trade.

Accounting and Costing Issues

4.57 Excessive diversity between each countries' accounting and costing practices for bulk and retail electricity is another actual barrier to the future development of a regional wholesale market.

4.58 Development of trade will depend on costs of power in neighboring countries. Comparison of bulk and retail electricity rates in the region is extremely difficult because all have different currencies which are mostly not convertible and most existing power suppliers do not prepare separate cost information for generation and transmission. For example, in Vietnam and China, electricity prices have historically been subsidized through low-cost Government loans and grants. China has followed a multi-tiered pricing system depending on the type of financing used for the power plant. Consumer tariffs are determined by the power
plant which supplies their needs. In Yunnan, the average revenue per kWh sold is about 30 fen (about US 3.8 cents). Current costs of power being purchased by EGAT are about 1.23-1.35 Baht/kWh from IPPs and 1.33 - 1.45 Baht/kWh from Lao projects (about US 4.9-5.8 cents/kWh). Due to such diverse accounting and costing practices, it is difficult for a wholesale market to develop on the basis of each power plant’s costs. These differences make it impractical to verify the respective cost of production of each plant on a regional grid. This suggests that a loose pool arrangement is likely to be more appropriate to fostering future electricity trade in the region.

**Financing**

4.59 *Although many export projects may be economically attractive, the perception of risks associated with country-specific or regional issues constitutes a problem to financial closure.*

4.60 Many opportunities exist for developing power generation for export in the region. Economically viable projects appear to be numerous and private investors are ready to face this challenge. Nevertheless, funding may be hampered by the financiers’ perception of risk related to country specific issues and/or the multinational character of projects oriented towards a regional market. Although the nature and degree of the risks vary from country to country, the more common are the financial weakness of buying utilities, foreign exchange convertibility, government interference, breach of contracts or concession agreements and possibly the seller’s lack of access to transmission lines. These can adversely affect the financial viability of projects and, hence, make financial closure more difficult.

4.61 In addition to financial instruments available from private sector financial institutions, official credits, loans or guarantee instruments may be needed to make the commercial banks comfortable, so as to reach closure for many projects. A discussion on how the World Bank could help support private sector development for power trading is presented in Annex 6.
Chapter 5: POWER TRADE STRATEGY FOR THE GREATER MEKONG SUB-REGION

5.1 This chapter outlines a regional strategy to facilitate power trade among the GMS countries. It contains recommendations to address previously identified barriers and issues, plus a set of “next steps” to implement the strategy, and is followed by annexes which elaborate on selected issues. The strategy entails proposing a process to achieve a fully developed and competitive power market rather than prescribing a specific long-term model to follow.

Background and Strategy

5.2 In the GMS, investment in generation and transmission is progressing in a pattern similar to that in many countries and regional subdivisions within countries. The priority is to develop a load generation balance within a region. Nations and regions within nations normally wish to attain a large degree of independence in their production of electricity and, in fact, this approach usually yields the maximum benefits for the least investment. Typically, it is more economical to build strong regional systems and then interconnect them than it is to force development of a transmission network that is more extensive geographically, but less robust.

5.3 Regional electricity trade should not be an objective elevated above national and local needs. Nevertheless, the development of extensive power trade within the region would provide considerable economic and environmental benefits and, therefore, contribute towards achieving national goals. As discussed in Chapter 4, there are actual and potential barriers to fully developed power sector trade. Consequently, the proposed strategy aims to facilitate power trade among the countries by addressing these barriers. This strategy supports current private efforts by proposing a partnership between private and public sectors based on private sector direct investment and execution of projects oriented towards trade, and complemented by an enabling environment to be established by governments.

5.4 This strategy suggests a process to achieve a fully developed and competitive power market rather than state a specific and uniform model.\textsuperscript{18} Suggested reform efforts are neither a sufficient nor a necessary condition for multilateral power trade, but rather, should be understood as benchmarks resulting in long-term measures, whose achievement would help ensuring an efficient power market within the GMS countries. According to the development stage and the degree of competitiveness of each country’s power sector, different reform efforts should be on the agenda of each individual country.

\textsuperscript{18} Such as the most suitable power pool and dispatching system for the region. This proposal acknowledges that the choice of a regional pool is a long term issue beyond the control of any single country. Therefore, instead of discussing the details of an “optimal model”, it is recommended that countries should follow basic principles of economic efficiency and competition as a way to guarantee that the process will not prevent reaching a sound market solution in the long term.
5.5 The strategy addresses policy, institutional, technical, commercial and financial issues, and proposes specific measures to prevent barriers in each of these areas. In doing so, the strategy addresses the following overarching issues:

- Conditions must be established for a public-private partnership to develop power trade in the region.
- Conflicts must be resolved between short- and long-term objectives, between national and regional views, and eventually, between specific projects.
- There must be a common path of fundamental economic practices which allow open access to transmission, cost-based pricing for generation and transmission, flexibility in long term arrangements, and which avoids duplication of investments.
- That financial and technical assistance are required.
- There must be a regional agreement on policy issues and an institutional framework to address market uncertainties and potential conflicts, and to promote regional trade.

5.6 Table 5.1 presents the strategy; each component is discussed in Annex 5; Annex 6 discusses how the World Bank could support private sector development for power trading.

5.7 The strategy proposed by this report was presented and discussed with the GMS countries at a regional workshop held in June 1998. The workshop was an effort to start building consensus towards a multilateral approach to power. The meeting reached agreement on a set of short term measures to facilitate a coordinated planning and made proposals for an action plan including the following main initiatives: (i) prepare a Regional Transmission Master Plan; (ii) start working on a regional cooperation agreement (Regional Protocol); and (iii) secure technical assistance required to support the region’s interconnection and power development efforts. All of the above are consistent with the strategy proposed by this report.

5.8 During the workshop, countries established a regional Experts Group (EG) for the GMS which will be responsible for carrying out studies and formulating recommendations for the development of a regional power market. The group is integrated by two members per country: a representative of the energy policy agency and a second member from the utility responsible for transmission. The EG is expected to exert the leadership needed to take the next steps toward formulating a policy protocol and initiate the required momentum to keep the process going.

Next Steps for the Near Term

1. Establish an Action Plan for the Development of the Policy and Operations Protocol. The EG should establish the process by which the policy and the operations protocol will be created. This should include the identification of local resources, technical assistance requirements and a timetable consistent with the internal procedures.

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19 Workshop on Power Trade Strategy in the Greater Mekong Sub-region; held at the Rose Garden Country Resort, Thailand, June 19-20, 1998. A World Bank sponsored event funded by ESMAP and hosted by the National Energy Office (NEPO) of Thailand. The workshop was organized within the GMS initiative in collaboration with ADB.
of each country. It is expected that protocol development will require a significant commitment of resources from all of the participants. Multi-disciplinary teams will be necessary, including political, economic, legal, technical, and other related skills. In addition, those who are selected to draft the protocols should have access to decision makers in their respective governments.

2. **Develop Draft of Policy Protocol.** The protocol should lay the foundation for network expansion and trading in the region. It should include: (a) a clear statement of the policy of each government to develop their systems to minimize barriers and to promote regional power trade; and (b) establish a permanent organization of participating countries to plan for regional development. A suggested content for the protocol is presented in Annex 6.

3. **Identify and Disseminate Best Practices.** Concurrent with protocol development, the RCC should identify and disseminate best practices in the region which could be of benefit to other parties. These practices, if adopted by most countries, could be instrumental in ensuring that development is consistent with competitive power trade objectives. The RCC should select examples of power purchase agreements; power procurement and negotiation procedures; and transmission tariff design, among others, and present them to participating countries.

4. **World Bank Initiatives.** The Bank presented the findings of this report at the above mentioned power trade workshop. Follow-up activities will be designed to support the GMS countries preferences as express in the Action Plan to be formulated by the Experts Group and discussed at the Fifth Electric Power Forum (scheduled for November 1998 in Bangkok). Further support to be provided by the World Bank could comprise:

- Provision of assistance to facilitate the operation of the EG.
- Dissemination of cross-regional electricity trade experience, including potential economic and environmental benefits, commercial and technical operational aspects, and implementation process.
- Assistance to draft policy and operational protocols.
- Assistance to facilitate integrated transmission planning.
Table 5.1: Power Trade Strategy for GMS - Proposed Strategy

<table>
<thead>
<tr>
<th>Area</th>
<th>Recommendation</th>
<th>Priority</th>
<th>Responsible Entity(ies)</th>
<th>Resources Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policy</td>
<td><strong>National Priority:</strong> Each country should recognize and endorse international trading in electricity to be an integral part of its policies to strengthen its electricity sector.</td>
<td>Immediate</td>
<td>Energy policy agencies.</td>
<td></td>
</tr>
<tr>
<td>Regional Coordination:</td>
<td><strong>Immediate</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>An ad hoc group with no formal structure should assume responsibility for developing the regional protocols and early planning for regional integration. Recently established GMS Experts Group could fulfill this role.</td>
<td>Immediate</td>
<td>Agreement among governments (region's policy makers)</td>
<td>Group to be integrated by representatives of each country energy policy agencies supported by technical staff of utilities.</td>
</tr>
<tr>
<td>Regional Protocol:</td>
<td>Establish a formal regional cooperation agreement and permanent organization for the coordination of planning, development, and operation. Permanent organizations would include an entity to coordinate operational procedures of the different national dispatching centers and, in the long term, a regional regulator for a power pool.</td>
<td>Immediate need to develop a first draft.</td>
<td>Responsible government agencies, Energy Policy agency, the proposed regional Coordination Committee and Foreign Affairs.</td>
<td>Regional Coordination Committee supported by multidisciplinary team and specialized consultants.</td>
</tr>
<tr>
<td>Flexibility in Laws, Regulations, and Contracts:</td>
<td>All countries within the region should examine the compatibility of legislation, regulations and contracts to ensure that they permit the required flexibility to allow the regional market to expand.</td>
<td>Short to medium term.</td>
<td>Energy policy agencies.</td>
<td>Government agencies staff supported by specialized consultants. Type and magnitude of support is country-specific.</td>
</tr>
<tr>
<td>Transmission Ownership:</td>
<td>Each government in the region to establish a clear policy of which entity will own and operate the transmission assets within its boundaries.</td>
<td>Immediate</td>
<td>Energy policy agencies.</td>
<td></td>
</tr>
<tr>
<td>Open Access Transmission:</td>
<td>Policies of open access to the transmission network for wholesale competition should be established by each government.</td>
<td>Short to medium term, depending on each country's pace of reform and development of transmission systems.</td>
<td>Energy policy agencies.</td>
<td>To be addressed as part of sector reform preparatory efforts.</td>
</tr>
<tr>
<td>Area</td>
<td>Recommendation</td>
<td>Priority</td>
<td>Responsible Entity(ies)</td>
<td>Resources Required</td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>------------------</td>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Environmental</td>
<td>Environmental Impact: Environmental issues to be addressed through a regional approach to resolve conflicts between regions/countries, coordinate regulation, strengthen institutions and incorporate environment issues into overall planning (e.g., assessment of externalities into Master Plan, establishment of baseline conditions).</td>
<td>Short term.</td>
<td>Government agencies responsible for environmental policy and management.</td>
<td>Agencies’ specialized staff supported by donor funded TA.</td>
</tr>
<tr>
<td>Technical</td>
<td>Master Plan on Regional Transmission Expansion: Develop a master plan for transmission to guide investment decisions. Provide information on plant locations and transmission development which fits better within the regional transmission expansion plan.</td>
<td>Immediate.</td>
<td>Region’s power utilities.</td>
<td>Team of experienced utility engineers supported by donor funded experts.</td>
</tr>
<tr>
<td></td>
<td>Regional Transmission Network Expansion: Each of the governments in the region should commit to the construction of specific/low risk transmission lines which will ultimately form an efficient regional network.</td>
<td>Short to medium term, specific to each country’s interconnection needs.</td>
<td>Commitment: governments. Implementation: public-private partnership.</td>
<td>Commercial and official financing.</td>
</tr>
<tr>
<td></td>
<td>Regional Operations Protocol: The operators of transmission systems within the region should develop an operations protocol to establish procedures and processes as necessary and maintain a reliable operation required to facilitate trading.</td>
<td>Medium term.</td>
<td>Utilities responsible for the operation of transmission systems in each country.</td>
<td>Utilities’ staff supported by specialized consultants.</td>
</tr>
<tr>
<td>Institutional</td>
<td>Leadership: To be assumed by a regional coordination group (already established: GMS Experts Group).</td>
<td>Immediate.</td>
<td>Agreement among governments (region’s policy makers).</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Independent Regulator: Each of the countries should consider establishing an independent regulator to reduce financial uncertainties.</td>
<td>Short to long medium term, depending on the pace of sector reform in each country.</td>
<td>Energy policy entity in each country.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Technical Assistance: Development community to provide technical assistance to strengthen institutions on power trade issues.</td>
<td>Continuous; in the short to medium term.</td>
<td>Bilateral and multilateral agencies.</td>
<td>Funding and management capability.</td>
</tr>
<tr>
<td>Area</td>
<td>Recommendation</td>
<td>Priority</td>
<td>Responsible Entity(ies)</td>
<td>Resources Required</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Commercial and Financial</td>
<td><strong>Generation Tariffs and PPA:</strong> All generation tariffs and PPAs should be constructed on the basis of a capacity payment, which is a function of the amount of generating capacity available and the related fixed costs, and an energy payment function of the actual production and the variable energy cost.</td>
<td>Short term; to be applied to all new PPAs.</td>
<td>Energy policy and/or regulatory agencies.</td>
<td>Technical assistance may be needed in countries yet to define a tariff policy.</td>
</tr>
<tr>
<td></td>
<td><strong>Transmission Tariffs:</strong> Each country should develop a system of transparent transmission tariffs which will provide a firm basis for expansion and operation of the network.</td>
<td>Short to medium term, depending on each countries' transmission system development.</td>
<td>Energy policy and/or regulatory agencies.</td>
<td>Technical assistance likely in most countries.</td>
</tr>
<tr>
<td></td>
<td><strong>Generation Risk:</strong> Governments and agencies which are procuring generation should take all necessary steps to reduce the uncertainty as to which projects are most likely to reach successful financial closure and actually be brought on line.</td>
<td>Short term.</td>
<td>Energy planning agencies. Only in specific countries.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Transmission Planning and Construction Risk:</strong> Governments and utilities in the region should take measures to reduce the risks associated with transmission planning and construction.</td>
<td>Short term.</td>
<td>Governments and utilities responsible for transmission planning and development.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Taxes and Royalties:</strong> Governments should decide their policy on taxation and royalties on exports of electricity, and communicate it clearly to all interested parties.</td>
<td>Immediate.</td>
<td>Energy policy agency and, when necessary, legislative branch.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Financial Support:</strong> Official donors should provide adequate financial instruments to support transmission development and power trade in the region.</td>
<td>Continuous; in the short to medium term.</td>
<td>Bilateral and multilateral agencies.</td>
<td></td>
</tr>
</tbody>
</table>
Annex 1: POTENTIAL ECONOMIC BENEFITS

1. Power trade in the Greater Mekong Sub-region has the potential for significant economic benefits. This annex analyzes the regional market, demand and supply. A dispatch model was developed for the study comprising two principal cases: (i) self-sufficiency on the basis of existing country power development plans; and (ii) power cooperation on the basis of least-cost development of resources. These cases are investigated under both a High Demand Growth scenario and a Low Demand Growth scenario, which adjusts the combined power investment programs for the sub-region appropriately downward. The Low Demand Growth scenario is intended to reflect the possible adverse effect of the recent financial crisis in Thailand on the growth in electricity demand.

The Regional Market

2. East Asia is large and diverse. The region covers 2,000,000 km² in area, and is home to 200 million people living in seven different countries, with another 180 million living in the adjacent southern China provinces. While the constituent national and provincial economics differ in structure and size, all have recorded high economic growth rates in recent years. Their population densities, incomes per capita, and measures of electrification usage and penetration also vary significantly. (Table A1.1) For instance, Cambodia consumes 55 kWh per capita per year, and thus, has the lowest electricity consumption in the region. This is more than 100 times lower than the level in Singapore, which has the highest demand.

Table A1.1: East Asian Countries - Selected Indicators, 1996

<table>
<thead>
<tr>
<th></th>
<th>Cambodia</th>
<th>Lao PDR</th>
<th>Myanmar</th>
<th>Thailand</th>
<th>Vietnam</th>
<th>Malaysia</th>
<th>Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Area</td>
<td>1000km²</td>
<td>181</td>
<td>237</td>
<td>677</td>
<td>513</td>
<td>329</td>
<td>329</td>
</tr>
<tr>
<td>Population</td>
<td>million</td>
<td>10</td>
<td>5</td>
<td>43</td>
<td>61</td>
<td>76</td>
<td>20</td>
</tr>
<tr>
<td>GDP/capita (PPP)</td>
<td>US$/cap</td>
<td>1,266</td>
<td>2,071</td>
<td>677</td>
<td>13,235</td>
<td>1,263</td>
<td>8,763</td>
</tr>
<tr>
<td>Electricity Use</td>
<td>kWh/yr/cap</td>
<td>55</td>
<td>55</td>
<td>60</td>
<td>900</td>
<td>198</td>
<td>1,777</td>
</tr>
<tr>
<td>Electrification</td>
<td>%</td>
<td>10%</td>
<td>18%</td>
<td>13%</td>
<td>98%</td>
<td>30%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Note: Estimates of GDP use purchasing power parities (PPP) instead of exchange rates as conversion factors. The PPP conversion factor is defined as the number of units of a country’s currency required to buy the same amounts of goods and service in the domestic market as one dollar would buy in the United States. Source: World Bank estimates.

Demand Forecasts - Growth Prospects

3. Power demand in the East Asian region is typified by high growth. This growth has persisted for several years and, until recently, it was considered that such growth rates would most likely be sustainable. Because of network supply constraints, growth in some countries has even been limited to lower levels and the underlying demand often met by captive generating plants. However, the recent financial crisis in Thailand has resulted in considerable uncertainty as to the longer term implications on regional economic growth, and the subsequent effect on the rate of growth for electricity demand. As yet, it is unclear whether the crisis will only result in a short-term reduction in growth rates, followed by a recovery to previously expected demand levels, or whether this is a turning point in the region’s development, resulting in reduced growth rates in electricity demand for the foreseeable future.
4. The most recent assessment of electricity demand growth for key geographic zones of the region is provided by the Newjec/MRC Study of 1996.\(^1\) Compared with this study, the earlier Norconsult Study\(^2\) predicts lower growth for the underdeveloped areas and faster growth for Thailand. Using a simplified trend analysis, the latter study forecasts regional (medium) consumption to grow from 91 TWh (14,500 MW) in 1993, to 131 TWh (21,000 MW) in 1997, and to 600 TWh (92,000 MW) in 2020.\(^3\) On a country basis, Thailand has the largest gross increase in energy consumption between 1997 and 2020 - from 89 TWh to 411 TWh.\(^4\) The sub-regional consumption growth would require an increase in capital investment from US$5 billion in 1994 to US$14 billion in 2020. Table A1.2 presents high, medium (base) and low generation forecasts along with average annual demand growth rates (as percentages) of each country for the period 1993-2020. (Although the Norconsult and Newjec/MRC studies have very different demand forecasts for individual countries, the total demand for all countries and the demand forecasts for the interconnected system are similar.)

Table A1.2: Demand Forecast for 2020 and Annual Growth Rates, 1993-2020 (Percent)

<table>
<thead>
<tr>
<th>Demand, 2020</th>
<th>Low</th>
<th>Base</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>415,242 GWh</td>
<td>597,298 GWh</td>
<td>830,799 GWh</td>
<td></td>
</tr>
<tr>
<td>Average annual growth</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cambodia</td>
<td>6.4</td>
<td>8.0</td>
<td>9.2</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>5.9</td>
<td>7.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Myanmar</td>
<td>3.8</td>
<td>6.6</td>
<td>6.9</td>
</tr>
<tr>
<td>Thailand</td>
<td>6.4</td>
<td>7.6</td>
<td>9.0</td>
</tr>
<tr>
<td>Vietnam</td>
<td>6.7</td>
<td>8.0</td>
<td>8.7</td>
</tr>
<tr>
<td>Yunnan</td>
<td>4.7</td>
<td>6.6</td>
<td>8.1</td>
</tr>
<tr>
<td>Regional average annual growth</td>
<td>6.2</td>
<td>7.6</td>
<td>8.7</td>
</tr>
</tbody>
</table>

5. The Norconsult study highlights that, in the short term, Thailand will continue to be the principal market in the region - accounting for about 67 percent of demand in GMS in 1997. Its share is expected to fall to about 40 percent by 2020 as power demand in Vietnam, Myanmar, and Cambodia will begin to increase. There is evidence that load growth supplied by the major utilities in Thailand may slow down, as the country faces increased competition from its neighbors regarding manufacturing exports and as private generators offer co-generation facilities to serve the new industrial estate market.

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\(^1\) This study focused on the optimal development of EHV transmission networks to exploit hydro resources in Lao PDR, Myanmar, and Yunnan Province, as required to meet shortfalls in Vietnam and Thailand. NEWJEC Inc. / MRC, Mekong Integrated Transmission System Study (Basin-wide), funded by JICA and published by MRC, September 1996.

\(^2\) This study concentrated on the energy demand and coal, hydro and gas resource development in the GMS. Norconsult International A.S., Subregional Energy Sector Study for the Greater Mekong Sub-region, funded and published by ADB, October 1995.

\(^3\) The Newjec/MRC Study forecasts higher consumption for 2020: 611 TWh (93 MW).

\(^4\) This is based on the forecasted values for both 1997 and 2020.
6. Demand in all other regions is mainly constrained by the lack of generation capacity (Myanmar, southern Vietnam), or by constraints (as exhibited by high system losses) in the transmission and distribution systems (Cambodia, Lao PDR, northern Vietnam, Yunnan Province). The prospects for growth in Vietnam and Cambodia are likely to improve significantly as they industrialize and expand their rural electrification programs. Power demand growth in the southern Chinese border provinces of Yunnan and Guangdong, and in Guangxi Zhuang Autonomous Region, is also expected to be high, which will be difficult to meet despite the fact that these regions are well endowed with resources.

7. If the countries of East Asia are grouped around the main load centers in the larger geographic power supply regions, the increasing importance of the South East Region’s power market is highlighted - its market share will grow most, from a 5 percent share in 1995 to 17 percent in 2020. This assumes that Malaysia/Singapore are likely to grow at about the same rate as Bangkok. The main load centers are North/North East Region (Myanmar, northern and northeastern Thailand and northern Vietnam), South East Region (Cambodia, southern and central Lao PDR and southern Vietnam), Bangkok, and the South Peninsular Region (Malaysia, Singapore, southern Thailand). (Table A1.3)

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>North/North-East</td>
<td>7%</td>
<td>4,534</td>
<td>7,083</td>
<td>10,153</td>
<td>14,006</td>
<td>23,818</td>
<td>21%</td>
</tr>
<tr>
<td>South East</td>
<td>10%</td>
<td>1,623</td>
<td>3,471</td>
<td>6,176</td>
<td>9,859</td>
<td>19,631</td>
<td>17%</td>
</tr>
<tr>
<td>Bangkok</td>
<td>5%</td>
<td>10,075</td>
<td>14,898</td>
<td>19,751</td>
<td>25,450</td>
<td>38,400</td>
<td>34%</td>
</tr>
<tr>
<td>Southern Peninsular</td>
<td>4%</td>
<td>10,902</td>
<td>13,898</td>
<td>17,047</td>
<td>21,190</td>
<td>32,448</td>
<td>28%</td>
</tr>
<tr>
<td>Total</td>
<td>6%</td>
<td>27,134</td>
<td>31,688</td>
<td>53,127</td>
<td>70,505</td>
<td>114,297</td>
<td>100%</td>
</tr>
</tbody>
</table>

8. In assessing the potential economic benefits associated with sub-regional power trade, the current study has used Norconsult’s base demand projection (Table A1.2) as a basis for its High Demand Growth scenario (para. 45). However, to reflect the impact that the current financial crisis in Thailand may have on these benefits, the current study has developed an additional electricity demand forecast for the sub-region, based on more pessimistic rates of growth. Under this projection, Thailand’s demand is assumed to stagnate in 1997, to increase by only 2 percent in 1998, and then to recover gradually and maintain a level of around 5.5 percent per annum from 2002 to 2020. This contrasts with Norconsult’s low demand forecast (Table A1.2), which has an average growth rate for Thailand of 6.4 percent per annum. Vietnam is also considered to be affected by the crisis, although Norconsult’s low demand forecast is assessed as satisfactorily denoting its impact. Yunnan Province is considered unaffected, and due to their small contribution to overall electricity consumption, the demand in Cambodia and Laos is left unchanged. These projections are combined to produce the current study’s Low Demand Growth scenario for the GMS, used in a sensitivity analysis of the benefits of power trade (paras. 48-52). Figure A1.1 compares the High and Lower Demand Growth scenarios for the sub-region.
Diversity of Resources among Countries

9. The GMS is well endowed with hydro and thermal resources. Most of the exploitable resources are locally concentrated. Hydropower capacity is largely in southern China, Lao PDR, and Myanmar, and most of the thermal resources are in China.5

Thermal Generation

10. In China, there are abundant coal resources in Yunnan (23,452 mt of proved recoverable coal), enough to fuel 125,000 MW for 30 years. Guangxi Zhuang Autonomous Region and Guizhou Province have an additional 6,000 mt of coal. Other major coal resources are in Lao PDR, Thailand, and Vietnam. Gas is a competing option, and likely to be the fuel of choice until the offshore reserves are depleted. Although only a small portion of regional oil capacity has been exploited to date, oil resources are likely to be reserved for export.

11. Outside China, the largest coal fired thermal generation source is located at the Mae Moh lignite mine site in northern Thailand. Despite problems in dealing with the high sulfur content, EGAT plans to double the capacity of the site to 5,300 MW by 2005. Vietnam’s coal resources include high quality anthracite which would be suitable for export if its Haiphong port facilities were adequate. Three old thermal power plants are now shut down or on reduced capacity due to lack of demand in the north. The country has tried to export surplus power from the 440 MW Pha Lai plant to Guangxi, but has yet to accept pricing in incremental terms. Power prices in China are already very low and Vietnam would have difficulties in competing if it tries to recover the full costs of development of the old power plants.

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5 The following analysis of the regional energy resources is based on the Norconsult and Newjce/MRC Studies.
12. A notable thermal export project will be built in Lao PDR in the Hongsa Chalyaburi Basin. Preliminary prospecting has indicated sufficient reserves to run a 1,800 MW plant for 30 years there. The sulfur content of the Hongsa Chalyaburi coal is much lower and less likely to cause the environmental problems experienced at Mae Moh. The developer has already signed a PPA with EGAT to supply 600 MW to the Thai grid for 25 years.

13. It is estimated that offshore gas supplies could be used to fire 18,000 MW of new generation by 2005 in the region. Most of the potential oil and gas development is located in the territorial waters of Myanmar, Thailand, Vietnam, and to a lesser extent, in Cambodia. Thailand’s gas consumption now is at about 1.4 bcf/year and is expected to rise to 2 bcf/year by 2000. The Yadana gas interconnection project will add 525 mcuft/day from Myanmar in 1998 to fuel 4,600 MW of new capacity in Thailand. A new project at Yedagun is expected to increase this by 200 mcuf/day by 2002.

**Hydro Power Potential of the Mekong**

14. The largest and most studied river basin system in the East Asian region is the Mekong, encompassing parts of East Asia and Yunnan Province in China. The basin covers a catchment area of over 795,000 km$^2$ with an estimated potential of 285 TWh, making it the twelfth largest in the world. The length of the river from the upper basin to the Laos border is about 2,100 km. The river is there characterized by steep gradient and few tributaries. This part feeds into the lower basin, meandering about 2,400 km into a relatively flat area frequently flooded by big tributaries. About 80 percent of the Mekong’s discharge is in the rainy season, with river levels changing by as much as 14 m in some locations. As the population in the Mekong basin reaches about 100 million, complex international, social and environmental aspects are associated with any development in this area.

15. Within China, Yunnan Province has identified 14 schemes on the Lacang (i.e., the upstream portion of the Mekong) totaling about 20,000 MW. Considerable investigative work is required to prioritize these developments, as many sites are inaccessible and far from load centers. Downstream, studies have also been carried out since 1970, identifying nine cascaded schemes in the lower Mekong, totaling about 18,000 MW. A combined development of run-of-river mainstream projects and storage tributaries is expected to be very feasible, but would require considerable cooperation agreements among the riparian countries. The first seriously considered development of was the 2,400 MW station at Pa Mong in Thailand. This was abandoned because of a need to resettle 250,000 people. The 1,350 MW Jing Hong currently is the main project being considered for development on the Lacang.

16. The other main river basins in the GMS besides the Mekong (Lacang) are the Jinsha (200 TWh), Thanlwin (137 TWh), Red River (41 TWh) and Ayeyarwaddy (39 TWh). (see Norconsult Study) Each basin stretches over more than one national territory. The total exploitable hydro potentials by country are: Cambodia 8,000 MW, Lao PDR 20,000 MW, Myanmar 25,000 MW, Thailand 10,000 MW, Vietnam 15,000 MW, and Yunnan Province 90,000 MW. Within Yunnan, the Jinsha basin has potential for about 40,000 MW in 12 schemes, about half of which could be developed for export.

17. Of the three countries with surplus hydro for export, Lao PDR has the most ambitious plans in place. It hopes to develop its hydro resources from an estimated potential of 13,000 MW in tributaries of the Mekong. Lao PDR plans to commission 3,000 MW from seven stations for export to Thailand by 2004. Cambodia has an estimated 3,000 MW in tributaries, but the country has limited financial resources to develop them, and studies are at a very early stage. It has no hydropower at present, even to serve its own needs, although plans are afoot to rehabilitate the 10 MW Kirirom station. The development of this resource is, therefore, unlikely to occur within this decade. Myanmar has lined up...
eight of its most promising sites (aggregate capacity 8,200 MW) for export to Thailand, although no discussions with specific outcomes have taken place.

Investments in Transmission

18. Thailand does not experience significant supply constraints; its transmission and distribution (T&D) systems are efficient and the country has achieved a high electrification ratio through its aggressive rural electrification strategy during the 1980s. Thailand is, however, expected to double the capacity of its transmission networks to provide about 1 million km of lines needed by 2010. This capacity expansion may be difficult to achieve due to increasing difficulties in obtaining right-of-way (ROW) access. The other significant market in need of new supplies is the Malaysia/Singapore grid. Its size is comparable to Bangkok, but it is about 1,000 km away. To compete in this market, exports from the northern hydro resources would require a major investment (about US$600 million) in an HVDC link, together with additional reinforcement of the Thai grid.

19. Investment requirements to bring the generation capacity of Myanmar and southern Vietnam, and the T&D systems of Cambodia, Lao PDR, northern Vietnam, and Yunnan, up to the standards of the Thai system are significant. Vietnam networks in particular, are in urgent need of repair and replacement. Approximately US$2 billion in investment between 1996-2000 would be needed for new T&D lines to double existing capacity and to ensure an adequate standard of service. Likewise, Cambodia needs significant new investment in T&D to access many existing load centers not currently receiving an adequate supply.

Design of a Power Trading Network

20. For historical reasons, most Asian countries have pursued energy strategies aiming to achieve self-sufficiency, even though in some cases there are long distances between in-country load centers (e.g., Yangon and Mandalay or Hanoi and Ho Chi Minh City), limiting the prospect for economic power transfer. In the case of Vietnam, rather than transmitting power from north to south, national energy demand could have been met at a lower cost by exporting surpluses in the north to Thailand, and importing the same amount from Lao PDR in the south.

21. A significant regional energy trading market may evolve in the region over the next 20 years. This will probably take place in the form of a 500 kV (the voltage of choice in most East Asian countries) integrated power transmission network within East Asian countries. HVDC transmission links will be needed, primarily to separate larger grids for stability purposes, but also to provide adequate transfer capacity, security and control over inter-regional power flows. The first such link is expected to be a 600 MW HVDC back-to-back tie between Thailand and Malaysia. A subsequent HVDC link is envisaged for the Bangkok-Jing Hong connection, which would link the system northwards into the southern China's 500 kV integrated network. In the longer-term, HVDC links by submarine cable would be used to connect Sumatra and Java 500 kV networks, as well as HVDC links to connect the Sabah, Sarawak, Brunei, and the Kalimantan (Indonesia) markets.

22. The export of power from Lao PDR is expected to increase to about 3,000 MW as a result of several new hydro projects coming on line within the next ten years. Such developments will give Lao PDR an opportunity to build a 500 kV grid to aggregate the energy production for each plant, thereby maximizing the benefits of coordinated hydro production. This grid would eventually be integrated into the 500 kV/HVDC transmission system among Cambodia, southern China, Thailand, and Vietnam.
23. The situations in Lao PDR and Cambodia present special cases. Because of Lao PDR’s central location, the provision of transmission wheeling services through Laos to China, Vietnam, and Thailand is an attractive way of financing Lao PDR’s transmission needs. These services would be in addition to providing wheeling services to in-country BOT hydro exporters. There are three potential wheeling arrangements: (i) transferring power from Jing Hong to Thailand; (ii) transferring northern Vietnam surplus (coal/hydro) to Thailand; and (iii) using the proposed MPEX system to stabilize the Vietnam grid and, thereby, increasing the north-south transfer capability. In Cambodia, it is unlikely that the existing, largely diesel-based generation capacity would be in use beyond 2005. By 2010, all future large plants will probably comprise combined cycle or coal fired plants located around Sihanoukville. They would probably use imported fuel unless large scale gas supplies can be developed offshore. Hydro generation may also be possible, although the implementation of major Mekong based schemes is unlikely because of social and environmental reasons. In the short-term, Cambodia may be better off building a high capacity transmission line between Thailand and southern Vietnam to permit power trade between the two countries, while tapping off its own needs en route.

Power Development Plans

24. The Newjec/MRC Study also includes details of the Power Development Plans (PDPs) for each country. Aside from Thailand, where EGAT has an indicative plan to 2011, and Myanmar, where MEPE has completed a planning document for 1995 until 2015/16, none of the other countries forecast beyond about 2002. EGAT, however, is the largest player in the market for the time being and its high thermal expansion plans will indubitably be the focus of interest for exporting countries like China, Lao PDR, and Myanmar. Malaysia, Singapore, and Thailand are developing an open access environment, which may eliminate the need for prescriptive planning in East Asia. Although it may continue to be used to provide a baseline for examining alternatives, a competitive market approach, however, will require that the design and operation of the transmission system be sufficiently robust and flexible concerning wide variations in generation pattern - superimposed on the general requirement, due to increasing north-south bulk power transfers.

Alternative Trading Options Analyzed in Recent Studies

25. As there is a considerable mismatch between each country’s energy resources and its forecasted demand up to 2020, the question arises of how increasing demand could be met in the future. The Norconsult and Newjec/MRC Studies compare self-sufficiency in each country with trading. In particular, the Norconsult Study compares (i) national self-sufficiency (including imports of gas, coal and oil); (ii) interconnections limited to reduce investment in peaking; and (iii) unlimited regional power trade. The focus of the following introduction to the results of recent studies is on the Norconsult Study. Its self-sufficiency case is hereafter referred to as the Reference Scenario and the unlimited power interchange, hereafter referred to as the Trade Scenario. In general, the main focus of power trade studies has generally been on the utilization of vast hydropower resources in some countries to meet the electricity demand in GMS; another focus has been the expanded exploitation of natural gas.

Reference Scenario

26. The Reference Scenario in Table A1.4 assumes that there is no interconnection among grids and medium demand. Overall renewable energy sources decline from 26 percent in 1993 to 20 percent in 2020, while nonrenewable sources correspondingly increase to 80 percent. On a country basis, Thailand has the largest gross increase in energy consumption. Thailand would satisfy this increase with some
small additional hydropower developments and a large increase in domestically produced coal and gas sources. Due to declining coal and gas resources, Thailand is in the unenviable strategic position of having to import oil or other fuels from outside the region to meet its generation demand.

Table A1.4: Reference Scenario - Energy Sources, 2020 Medium Demand

<table>
<thead>
<tr>
<th>Country</th>
<th>Power Generation (GWh)</th>
<th>Share of Sub-region</th>
<th>Renewable % of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hydro</td>
<td>Coal</td>
<td>Gas</td>
</tr>
<tr>
<td>Cambodia</td>
<td>1,554</td>
<td>2,924</td>
<td>0</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>2,719</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Myanmar</td>
<td>6,841</td>
<td>0</td>
<td>7,610</td>
</tr>
<tr>
<td>Thailand</td>
<td>5,590</td>
<td>201,571</td>
<td>108,174</td>
</tr>
<tr>
<td>Vietnam</td>
<td>38,194</td>
<td>45,846</td>
<td>8,940</td>
</tr>
<tr>
<td>Yunnan Province</td>
<td>61,646</td>
<td>10,688</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>116,544</td>
<td>261,029</td>
<td>124,724</td>
</tr>
<tr>
<td>Fuel Mix</td>
<td></td>
<td></td>
<td>21%</td>
</tr>
</tbody>
</table>


Trade Scenario

27. In the Trade Scenario (Table A1.5), a reduction in the amount of power produced from nonrenewable sources is achieved. It drops from 80 to 67 percent, while total power produced remains the same as in the Reference Scenario at 597,298 GWh. Three countries/provinces would export power - Lao PDR, Myanmar, and Yunnan Province - while Thailand and Vietnam would import power. The bulk of the imports would be absorbed by Thailand.

Table A1.5: Trade Scenario - Energy Sources, 2020 Medium Demand

<table>
<thead>
<tr>
<th>Country</th>
<th>Power Generation (GWh)</th>
<th>Share of Sub-region</th>
<th>Renewable % of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hydro</td>
<td>Coal</td>
<td>Gas</td>
</tr>
<tr>
<td>Cambodia</td>
<td>1,554</td>
<td>3,157</td>
<td>0</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>21,550</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Myanmar</td>
<td>41,884</td>
<td>0</td>
<td>7,750</td>
</tr>
<tr>
<td>Thailand</td>
<td>5,590</td>
<td>172,014</td>
<td>108,000</td>
</tr>
<tr>
<td>Vietnam</td>
<td>39,378</td>
<td>39,447</td>
<td>8,940</td>
</tr>
<tr>
<td>Yunnan Province</td>
<td>85,346</td>
<td>10,688</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>195,302</td>
<td>225,306</td>
<td>124,690</td>
</tr>
<tr>
<td>Fuel Mix</td>
<td></td>
<td></td>
<td>21%</td>
</tr>
</tbody>
</table>

28. Under both the Trade and Reference Scenarios for 2020, Thailand would still heavily depend on coal, and would be required to produce approximately 50 percent of its electrical energy from this source. (Tables A1.4 and A1.5) Thailand’s total annual production from coal, however, declines from 201,571 GWh in the Reference Scenario and to 172,014 GWh in the Trade Scenario, as generation from coal would be replaced by imports from hydropower.

29. Both the Norconsult and Newjec/MRC Studies show that there should be a significant transfer of power from the northern resource rich areas of Lao PDR, Myanmar, and Yunnan Province to the southern population centers in Bangkok, Ho Chi Minh City, and Phnom Penh over the long-term. There may be a demand for exports to Kuala Lumpur and Singapore, requiring an increase in the north-south transfer capacity to make up for displaced energy from Thai thermal sites. The timing for the link to be upgraded to full capacity will probably depend on the rate of depletion of offshore gas resources in Myanmar, Thailand, Vietnam, and possibly, Cambodia.

### Economic Benefits of Interconnection

30. In general terms, the benefits from regional power system integration stem from:

- **Reduced or postponed costs.** Lower operation costs due to economic power exchange; postponed and lower investments in generation plants due to least-cost development of regional energy resources; reduced spinning reserve costs.

- **Improved conditions on the supply-wide.** Reduced coincident peak load of the region as compared to the sum of the individual peak loads for each country, mutually utilized generation reserves for interconnected systems, increased robustness of power supply to meet unexpected events, like load growth above forecast and/or delayed commissioning of generation/transmission projects, increased system reliability.

31. In sum, power trading may lead to lower capital investment requirements over time and reduced system operational costs. In addition, there may be benefits from reduced transmission losses, and postponement of transmission investment. This would, however, depend on the specific details of each interconnection project, as losses may not necessarily go down, and interconnections will require additional transmission investment.

### Previous Economic Assessments of Trade

32. Both the Norconsult and Newjec/MRC Study, evaluated the economic benefits of interconnection and then derived the future energy sources. (Tables A1.4 and A1.5) Norconsult quantified the benefits due to reduction in the coincident peak and in economic power transfer through the replacement of thermal power by hydropower under the Trade Scenario. The Trade Scenario assumes that gas turbines will serve peak load and that investment costs of gas turbines (including interest during construction) are US$625/kW, a saving in required installed capacity of 2,865 MW (about 3.1 percent of forecasted total load), equivalent to an estimated investment reduction of US$1.791 billion over the period 1995-2020. A net benefit of at least US$400 million between 1995 and 2000 results, given an estimated cost for limited interconnection of around US$190 million.

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6 Note that this value should be revised downward given current gas turbine capital costs (see Table A1.6).
33. Norconsult also assesses the gains due to economic power transfers. For hydropower-dominated systems in cooperation with thermal-based systems, substantial savings may be achieved. Surplus hydropower with minimal marginal costs may replace thermal power, based on oil or coal, characterized by high operating cost at either peak or base load. Norconsult ranked potential hydropower projects in the region against typical thermal plant costs on the basis of levelized cost. The Study noted that the ability of hydropower projects to cope with variations in system loads (i.e., provision of base and peaking service) justifies higher costs per unit of energy than the equivalent cost of coal-fired thermal plants for base load coverage. Such an advantage, however, is difficult to quantify without performing a full system optimization study.

34. The best prospects for economic hydropower transfers are identified by Norconsult as being: (i) replacement of more expensive hydropower in Vietnam and of thermal power in Thailand by inexpensive hydropower from Lao PDR (where not rendered uneconomic when accounting for transmission costs); (ii) replacement of thermal power in Thailand by hydropower from Yunnan Province (via transmission links through Lao PDR in particular), as it is considered to be a viable option depending on future market coal prices at Bangkok; and (iii) use of a number of hydropower projects in northern Vietnam and southeastern Myanmar, which can compete economically with coal-fired plants in supplying Thailand.

35. The Norconsult Trade Scenario develops a related plant investment schedule based on the inclusion of the most economic hydro projects, and the subsequent deferral or exclusion of a number of potential thermal projects, aiming for a system-wide and individual country reserve margin of 15 percent (allowing for exports/imports). The annual cost savings (accounting for the cost of transmission) from the Trade Scenario over the Reference Scenario are estimated to be up to US$1.54 billion (assuming that all economic hydropower projects have been commissioned).

36. The Newjec/MRC Study focuses on ranking potential hydropower projects and running system optimizations with and without specific interconnections. Of the three key interconnections examined, involving links between central and southern Lao PDR to Thailand and Vietnam, the total net benefit for those specific interconnections (i.e., accounting for the cost of transmission) is around US$670 million over the period 1996-2005.

Dispatch Modeling of the Current Study

37. The current study extends the previous work by assessing the generation mix that would occur in each year between 1995 and 2020 of both the Norconsult Reference and Trade Scenarios, and hence, allows the distribution of annual investment and operation costs to be evaluated. Such an annual cost analysis is not included in the Norconsult Study. That study has, however, been used as the basis of the current study because it presents a more transparent investment program than is provided by the Newjec/MRC Study. Furthermore, the Newjec/MRC Study focuses on specific interconnections, rather than on unlimited power trade.

38. A dispatch model is used in the current study to determine the GWh production from each block of generation plant (i.e., base and peak hydro; coal; gas turbines, running on gas or distillate; boiler fired on fuel oil; diesel units running on fuel oil; and combined cycle plants running on gas or distillate),

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7 The ranking of hydropower projects in the Newjec Study is very different from that of the Norconsult Study.
assuming the investment programs for both Norconsult scenarios as given, but adjusting them to ensure that there is no unserved energy and that the reserve margins are always greater than 15 percent. The current study also updates the values for capital costs as well as operational unit costs (i.e., fixed; variable operation and maintenance, O&M; fuel). The most significant assumptions relating to the Trade Scenario are that (i) the system is completely interconnected; (ii) power flow is unconstrained; and (iii) losses are independent of dispatch as well as of the interconnection layout. Thus, the resulting cost savings of the generation system can be considered as the upper bound to the actual potential.

39. The dispatch model carries out a full systems analysis, by dispatching the different power plants according to the forecasted load requirements. It comprises four components: (i) a demand component, which incorporates the assumptions on long-term electrical load growth; (ii) a supply component, which details the generation plant available in each year, and the associated technical and cost parameters; (iii) a dispatch component, which determines the level of generation for each plant in each year, using a merit order based on marginal cost (with the exception that hydro plant is used for both base and peaking service in order to dispatch all available hydro generated energy), and by placing blocks of plant under the system load duration curve (LDC); and (iv) a cash flow component, which determines the present value cost of investing in and operating the entire generation system by collating the capital costs of new generation (including interest during construction) with the fixed and variable operating costs for both new and existing plants.

40. Power plant characteristics and fuel prices of the various plant types used in the dispatch model are shown in Table A1.6. These characteristics were taken from recent Bank estimates. The fuel costs are derived from the recent review of alternatives to the Nam Theun II project in Laos (using Thai prices) without application of a differential for the economic cost of fuel for plants in different countries. All these parameters have been significantly revised since the Norconsult Study, in particular, the capital costs of thermal plants, which have reduced considerably. Capital costs for hydropower plants have been taken from the Newjec/MRC Study (where available) or from the mid-point of the general cost bands provided for hydro projects in the Norconsult Study.

Table A1.6: Technical and Economic Characteristics of New Plants (Current Study)

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Availability (%)</th>
<th>Capital Cost (US$/kW)</th>
<th>Annual Fixed Cost (US$/kW/yr)</th>
<th>Fuel Cost (US$/mmBtu)</th>
<th>Efficiency (%)</th>
<th>O&amp;M Cost (c/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal Dry FGD</td>
<td>85%</td>
<td>1,150</td>
<td>28.75</td>
<td>1.80</td>
<td>35%</td>
<td>0.17</td>
</tr>
<tr>
<td>Boiler (FO)</td>
<td>80%</td>
<td>800</td>
<td>20</td>
<td>2.45</td>
<td>30%</td>
<td>0.14</td>
</tr>
<tr>
<td>CC (Gas)</td>
<td>85%</td>
<td>700</td>
<td>17.5</td>
<td>2.70</td>
<td>50%</td>
<td>0.40</td>
</tr>
<tr>
<td>CC (Distillate)</td>
<td>85%</td>
<td>700</td>
<td>17.5</td>
<td>3.89</td>
<td>50%</td>
<td>0.40</td>
</tr>
<tr>
<td>GT (Gas)</td>
<td>85%</td>
<td>450</td>
<td>11.25</td>
<td>2.70</td>
<td>24.5%</td>
<td>0.40</td>
</tr>
<tr>
<td>GT (Distillate)</td>
<td>85%</td>
<td>450</td>
<td>11.25</td>
<td>3.89</td>
<td>24.5%</td>
<td>0.40</td>
</tr>
<tr>
<td>Diesel (FO)</td>
<td>80%</td>
<td>500</td>
<td>12.5</td>
<td>2.45</td>
<td>34%</td>
<td>0.40</td>
</tr>
<tr>
<td>Hydro</td>
<td>Location Dependent</td>
<td>Location Location</td>
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<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

41. In the dispatch model, a self-sufficiency case (here referred to as the Self-supply Case) and an unlimited power interconnection case (here referred to as the Cooperation Case) were developed. These cases primarily relied on the Norconsult Reference and Trade Scenario, respectively, but the Newjec/MRC Study was used, where there were gaps and/or inconsistencies, and modified as noted above to ensure no unserved energy requirement. The determination of the Self-supply Case effectively involved running the model for six separate sub-cases, each relating to a particular country (or province,
in the case of Yunnan) under the High Demand Growth scenario. Although the dispatch model yields a reasonable approximation to the optimal dispatch of generating plants required to meet this demand, it does not optimize the investment program. In both cases, there may be alternative investment options with a lower present value cost.

42. In the dispatch model’s Self-supply Case, the Reference Scenario’s 30-150 MW of base load, targeted to be exported from Lao PDR and imported into Thailand, was modeled with an availability of 60 percent, which corresponds to the 1995 level. This results in a flow between 150 and 800 GWh per annum from Lao PDR to Thailand. The 300 MW backup supply between Malaysia and Thailand, and exports from Yunnan Province to Guangdong Province have been ignored, as these are considered common to the self-supply and Cooperation Case, and as such, will have little effect on the analysis. In the Cooperation Case, since the system is modeled as fully interconnected, imports/exports are not explicitly constrained or identified.

Changes in the Dispatch Model and Investment Program Ensuring Supply/Demand Balance

43. The Norconsult Study provides load duration curves (LDCs) for the individual countries and the combined system under its Trade Scenario. The load factors corresponding to each curve, however, are not consistent with the load factors implied by the Norconsult energy power demand forecasts. To reconcile this, the dispatch model of the current study used the approximate shape of each LDC resulting in load factors which are closer to those found in the section of the Norconsult Study on demand forecasting.

44. The investment programs used in the Reference and Trade Scenarios aim for a target reserve margin of at least 15 percent, and hence, concentrate on serving power demand rather than on energy demand. To ensure that the focus of the current study is on energy demand, assumptions regarding the firm capacity and availability of the various types of plants are made. For hydro plants, availability is taken, where specified, directly from the adjusted installed capacity and capability figures in the Norconsult Study; otherwise availability is assumed to be 40 percent. The availability values for thermal plant types are given in Table A1.5. When combining the firm capacity and availability values with the Norconsult investment programs, the dispatch model leads to small blocks of unserved energy for individual countries in the Self-supply Case and also for the combined system in the Cooperation Case in some years. To ensure a satisfactory reserve margin and no unserved energy in the current study, the investment programs were slightly adjusted.

Cost Comparisons in the Dispatch Model

45. Figure A1.2 shows the combined annual investment and operation cost of the GMS generation system as found from the dispatch model for the Self-supply and Cooperation Cases under the High Demand Growth scenario. The large increase in cost in both scenarios in the year 2014 is primarily due to the new investment required to offset a large number of thermal plant retirements in 2013. The annual total costs for the Cooperation Case are lower than for the Self-supply Case, with the exception of some of the earlier years. This is because, although the Cooperation Case has lower annual operating costs after 2002 (Figure A1.3), Norconsult’s Trade Scenario brings forward the required investment in capital-intensive hydro plant. Hence, the cumulative costs shown in Figure A1.4 do not begin to show a significant advantage under the Cooperation Case until after 2010.
46. The cumulative reduction in generation investment and operating costs for the Cooperation Case over the Self-sufficiency Case reaches US$13.7 billion by 2020 neglecting generation investment prior to 2000. Of this total, the majority (US$13.4 billion) is attributable to savings in operating costs. The reduction in generation investment and operating costs due to power trade in the Cooperation Case must then be compared against the investment needed in transmission to achieve such trade. With regards to interconnection costs, the Norconsult Study concluded that a net benefit of at least US$400 million between 1995 and 2000 would result from power interconnection - given an estimated cost for limited interconnection of around US$190 million.

47. If full and unconstrained interconnection were to ensue immediately, the present value of the stream of annual reductions in generation investment and operating costs from 1997 to 2020 due to power trade in the Cooperation Case is estimated to be US$4.1 billion. A more realistic time frame for full interconnection would be around 2010. By 2010, neglecting sunk investment prior to that year, the present value of annual reductions in generation investment and operation costs until 2020 is projected to be US$7.4 billion. This is higher than the present value for 1997, since, as mentioned above, significant hydropower investment is required before 2010. As the model assumes unconstrained interconnection, it means that this model's results are an upper bound to the benefits, which may be realized.

Figure A1.2: Annual Total Cost of GMS Generation System, High Growth

<table>
<thead>
<tr>
<th>Year (Year)</th>
<th>Self supply</th>
<th>Cooperation</th>
</tr>
</thead>
<tbody>
<tr>
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<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>1998</td>
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</tr>
<tr>
<td>2020</td>
<td>16,500</td>
<td>16,500</td>
</tr>
</tbody>
</table>

As the model assumes unconstrained interconnection, it means that this model's results are an upper bound to the benefits, which may be realized.

---

8 Assuming immediate interconnection, the cumulative generation cost savings between 1997 and 2000 would be US$2 billion of which US$1.7 billion would be attributable to capital cost savings.
Figure A1.3: Annual O&M Cost of GMS Generation System, High Growth
(US$ million)

Figure A1.4: Cumulative Investment and Operation Cost of GMS Generation System, High Growth
(US$ million)
Sensitivity Analysis: Lower Demand Forecast

48. As yet, it is unclear what impact the recent financial crisis in Thailand will have on the growth in electricity demand within the GMS. However, the crisis provides a strong incentive for investigating the sensitivity of the economic benefits of sub-regional power trade to significantly reduced demand growth. Hence, both the Self-supply and Cooperation Cases have been reevaluated using the Low Demand Growth scenario discussed earlier. (para. 8 and Figure A.1)

49. Under this Low Demand Growth scenario, the investment programs in the dispatch model have been modified, although not optimized, to minimize the amount of excess installed capacity in Thailand and Vietnam for the Self-supply Case, and on an overall sub-regional basis for the Cooperation Case. The installed capacities in both the Self-supply and Cooperation Cases have been revised downward by reducing the amount of generic coal-fired plant included in the investment programs of Thailand and Vietnam. The effect that this has in the Cooperation Case is to increase the percentage of hydro-produced energy in the generation mix from up to 37 percent in 2015 under the High Demand Growth forecast, to as much as 49 percent in the same year under the Low Demand Growth forecast.

50. Although a minimum reserve margin of 15 percent has again been applied, the reserve margin for the Cooperation Case needs to be considerably higher than this minimum for the lower demand conditions. This is because hydropower typically has less than half the average availability of thermal plant, and therefore, a greater installed hydro capacity is required to produce the same amount of energy as a thermal plant. Since the proportion of hydro generation increases significantly under the Low Demand Growth scenario, the total sub-regional installed capacity in the Cooperation Case exceeds the combined installed capacities of each country (or province) for the Self-supply Case.

51. This result negatively affects the economic benefits of power trade, as the investment program from 2000-2020 has an additional capital cost of US$3 billion in the Cooperation Case over the Self-supply Case. However, as under the High Demand Growth scenario, the benefits of power trade from applying the Low Demand Growth scenario mainly stem from savings in generation operating costs, which from 2000-2020 amount to US$14.5 billion. There is further a dissaving of US$4.1 billion related to capital investment. Hence, the net cumulative saving in generation costs due to power trade is still positive, and equates to US$10.4 billion. The operational cost savings under the two demand forecasts are of similar order, because the magnitude of hydro-based energy dispatched does not markedly change with the lower growth rate assumption. The main change in dispatch is due to the decreased installed capacity of coal-fired plant. Again, this saving can be seen as an upper bound to the potential cost savings, and it should be emphasized that these revised investment programs, as under the High Demand Growth scenario, have not been optimized.

52. Figure A1.5 shows the cumulative investment and operation cost of the Mekong generation system for the Self-supply and Cooperation Cases under the Low Demand Growth scenario. The main effect of the reduced demand is to delay the onset of benefits due to the lesser operational costs from sub-regional power trade, and it is not until 2014 that the Cooperation Case begins to show a significant advantage. Nevertheless, a general principle can be drawn from this sensitivity analysis. Once hydro investment is sunk, there are significant benefits to be gained through a reduction in the operational costs of generation, and these benefits are fairly insensitive to the rates of demand growth. Furthermore, these benefits will continue to be viable long after the planning horizon of this study, particularly since hydro plants generally have a significantly greater plant life than thermal units.
Summary

53. Power demand in East Asia has been growing at a high rate for the last several years, and the power demand in the countries of the GMS is forecasted to grow rapidly within the time frame of the study - until 2020. Irrespective of any impact from its current financial crisis, Thailand will continue to be the principal electricity market. On the supply side, the region is well endowed with diverse energy resources like coal, gas, and significant hydro power potential.

54. The question to be raised is which supply options would ensure a satisfaction of the GMS's future power demand given that there has been a mismatch between each country's energy resources and its forecasted demand. A dispatch model is developed contrasting the Self-supply Case and the Cooperation Case (power trading). It evaluates the generation mix that would occur in each year between 1995 and 2020. The model draws from a Norconsult Study, but updated capital and operational costs, and also adjusted investment programs to ensure realistic reserve margins and that no energy remains unserved.

55. The result of a cost comparison between the Cooperation Case and the Self-supply Case shows significant economic benefits of power trading over self-sufficiency. The annual total costs for the Cooperation Case are lower than for the Self-supply Case, with the exception of some of the earlier years in which capital-intensive hydro plant investments are required. The cumulative reduction in generation investment and operating costs for the Cooperation Case over the Self-supply Case reaches US$13.7 billion by 2020, neglecting generation investment prior to 2000 and assuming a growth rate for electricity demand which appeared realistic prior to the current financial crisis in Thailand. However, the impact of lower rates of demand growth primarily seems to delay only the benefits of power trade, as it takes more years for the additional capital costs of hydro investment to be offset by the significant savings to be realized from reduced operating costs.
Annex 2: ENVIRONMENTAL BENEFITS AND POLICY ISSUES RELATING TO REGIONAL POWER TRADE

1. The development of a regional power market within the Greater Mekong Sub-region, through selective interconnection of the transmission systems of each individual country, would allow increased utilization of the region's hydro resources, and subsequently, would produce significant reductions in generation system investment and operation costs. (Annex 1) This cost reduction is projected to mainly result from Thailand meeting a significant proportion of its future energy needs from imports of hydro-based power generated in Lao PDR, Myanmar, and Yunnan Province in China, rather than from local coal-fired plant, as would be the case if countries in the region remained primarily self-sufficient in electricity supply.

2. Apart from these economic benefits, there are also clear environmental benefits which would stem from a reduction in coal-fired generation, particularly due to the ensuing decrease in emissions of greenhouse gases (especially \( \text{CO}_2 \)) and also of pollutants (i.e., NOx, \( \text{SO}_2 \) and particulate matter). However, hydropower development is itself not without potentially significant environmental impacts, and projects require careful design and implementation of impact mitigation programs on a case-by-case basis. This annex quantifies some of the environmental benefits of power trade due to a reduction in thermal plant emissions, which supports the discussion in Chapter 2, but also identifies some of the wider environmental issues relating to increased hydropower development and to the promotion of regional power trade. This latter discussion contributes to the power trade strategy outlined in Chapter 5.

Environmental Benefits and Impacts of Regional Power Trade

Emissions from Thermal Generation Plant

3. In Annex 1, two sets of power generation investment programs for GMS in 2020 are examined (Tables A1.3 and A1.4), with and without regional transmission interconnections, using data presented in a 1995 study by Norconsult. By 2020, without interconnections (Norconsult's Reference Scenario), hydro generated energy is forecasted to meet 20 percent of the total regional demand forecast of 597,300 GWh. Introducing transmission links between the countries in the region to allow power trade (Norconsult's Trade Scenario) is projected to allow an increase in the share of hydropower to 33 percent. Consequently, coal-fired generation is forecasted to supply 44 percent of energy demand under the Reference Scenario, but only 38 percent under the Trade Scenario, and the corresponding decrease in oil-fired generation is from 16 to 9 percent. The difference in gas-fired generation between the scenarios is negligible.

4. Table A2.1 shows the emissions of \( \text{CO}_2 \), \( \text{SO}_2 \), NOx and particulate matter (PM) associated with the generation forecasts of Reference and Trade Scenarios for 2020, and contrasts this with the current study's estimates of emissions from the region for 1997 and 2010. The 68 percent higher levels of hydropower generation in 2020 for Norconsult's Trade Scenario compared to the Reference Scenario, allows for 16 percent lower levels of thermal generation, resulting in a significant reduction in emissions. Under the Trade Scenario, there is 17 percent (74,743,000 tons) less \( \text{CO}_2 \) and 31 percent (262,000 tons) less \( \text{SO}_2 \) - \( \text{SO}_2 \) emissions determined assuming coal plants are conventional pulverized coal boilers with flue gas desulfurization - than under the Reference Scenario by 2020. In addition, the Trade Scenario is associated with 17 percent (163,000 tons) less NOx and 18 percent (32,000 tons) less PM. Although estimating the benefits of emission abatement is somewhat problematic, using environmental cost values
of US$240/ton for SO₂, US$577 for NOx and US$85 for PM, the benefit from reducing non-greenhouse
gas emissions for the year 2020 would be around US$160 million. The estimated benefit from
greenhouse gas reduction, which, at a valuation of US$20 per ton of carbon emitted (i.e., US$5.44 per ton
of CO₂), would be up to US$400 million per annum by 2020. The corresponding total environmental
cost reduction for 2010 is US$243 million, of which just under 80 percent is attributable to CO₂.

Table A2.1: Summary of Total Power Generation and Emissions for Reference and Trade Scenarios

<table>
<thead>
<tr>
<th>Generation (TWh) based on</th>
<th>Emissions (000 tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hydro</td>
</tr>
<tr>
<td>1997</td>
<td>32.3</td>
</tr>
<tr>
<td>2010 Reference</td>
<td>62.7</td>
</tr>
<tr>
<td>2010 Trade</td>
<td>101.9</td>
</tr>
<tr>
<td>% Difference (Trade/Reference)</td>
<td>+63%</td>
</tr>
</tbody>
</table>

| 2020 Reference           | 116.5 | 261.0| 124.7| 95.0| 597.3 | 20%  | 80% | 432,128| 840 | 1,379 | 180 |
| 2020 Trade               | 195.3 | 225.3| 124.7| 52.0| 597.3 | 33%  | 67% | 357,385| 578 | 1,216 | 148 |
| % Difference (Trade/Reference) | +68% | -14%| 0% | -45%| 50%  | 17%  | 31% | -12% | -18% |


5. A breakdown of thermal emissions by country (Table A2.2) indicates that Thailand and Vietnam
are the major sources of thermal generation and emissions in both scenarios. However, for 2020, under
the Trade Scenario, Thailand and Vietnam emit 18 percent less CO₂ relative to the Reference Scenario,
33 percent less SO₂, 13 percent NOx, and 19 percent less PM.

6. It also appears that with no increase in thermal generation in Yunnan and only slight increases in
Cambodia and Myanmar, the major generators, Thailand and Vietnam, show significant declines that pull
the overall percentages for generation and emissions down. The 68 percent increase in hydropower
generation for the Trade Scenario is largely supplied by Lao PDR, Myanmar and Yunnan Province,
bringing the total renewable generation up to 33 percent of the mix by 2020. The 16 percent decline in
thermal power for the Trade Scenario is experienced largely by Thailand and Vietnam, contributing to
67 percent of the mix for the GMS sub-region.

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1 These environmental cost estimates are from the World Bank for China (1994), and do not reflect all of the damages that are
cau by local pollutants such as soil acidification effects of SO₂ emissions. Although these estimates are indicated as being
lower bound estimates, costs are highly dependent on local conditions. For instance, recent Bank estimates for the Philippines
account for prevailing wind conditions and result in even lower costs for NOx and SO₂. On the other hand, a widely quoted
study by Pace University (1990), “Environmental Costs of Electricity” has considerably higher estimates, being US$4,260 per
ton for SO₂, US$1,760 for NOx and US$2,500 for PM. Although the Pace study considers these estimates to be conservative,
these costs are affected by using a “willingness-to-pay” more appropriate to industrialized countries.
Table A2.2: Emissions by Country for Reference and Trade Scenarios

<table>
<thead>
<tr>
<th>Year/Scenario</th>
<th>Generation (GWh)</th>
<th>Emissions (000 tons)</th>
<th>CO₂</th>
<th>SO₂</th>
<th>NOx</th>
<th>PM</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020 Reference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cambodia</td>
<td>2,924</td>
<td>3,406</td>
<td>14</td>
<td>13</td>
<td>2</td>
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<tr>
<td>Lao PDR</td>
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<td>0</td>
<td>0</td>
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<tr>
<td>Myanmar</td>
<td>7,610</td>
<td>3,348</td>
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<td>Thailand</td>
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<td>355,577</td>
<td>693</td>
<td>1,085</td>
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<td>Vietnam</td>
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<td>12,452</td>
<td>25</td>
<td>48</td>
<td>6</td>
<td></td>
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<tr>
<td>Total</td>
<td>480,754</td>
<td>432,128</td>
<td>840</td>
<td>1,379</td>
<td>180</td>
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<tr>
<td>2020 Trade</td>
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<td></td>
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<tr>
<td>Cambodia</td>
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<td>49,889</td>
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<td>Yunnan Province</td>
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<td>12,452</td>
<td>25</td>
<td>48</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Total</td>
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<td>357,385</td>
<td>578</td>
<td>1,216</td>
<td>148</td>
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</tr>
</tbody>
</table>


7. Not surprisingly, contrasting emissions per unit of generation indicates that there are more persons exposed to more emissions in both the Trade and Reference Scenarios for 2020 than currently. (Table A2.3) By 2020, Thailand and particularly Vietnam are forecasted to have the greatest population densities, 168 and 337 persons/km², respectively. Thailand and Vietnam, likewise, receive the largest increases in distribution of SO₂, NOx and PM.

8. Although the figures are national averages, if power plants are located in areas of medium to high density, exposures will be higher. In addition to power plant emissions, there are other contributions to a decline in air quality already in existence in urban and suburban locations, from other stationary sources like industrial plants and from non-stationary sources like vehicles. Environmental impacts would, therefore, be concentrated in those locations.

Table A2.3: Local Distribution of Emissions for Reference and Trade Scenarios

<table>
<thead>
<tr>
<th></th>
<th>Emissions (kg/km²)</th>
<th>Population Density (pers/km²)</th>
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</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>22</td>
<td>79</td>
</tr>
<tr>
<td>Lao PDR</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Myanmar</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Thailand</td>
<td>38</td>
<td>1,362</td>
</tr>
<tr>
<td>Vietnam</td>
<td>8</td>
<td>49</td>
</tr>
<tr>
<td>Yunnan</td>
<td>7</td>
<td>40</td>
</tr>
</tbody>
</table>


Sensitivity of Emissions to Drought and Flood Conditions

9. Thermal emissions have been estimated for the current study assuming both drought and flood conditions. (Table A2.4) Drought and flood generation figures were constructed as follows: for drought conditions, hydropower production was decreased by 35 percent and that fraction was divided into 75 percent added to coal production, 10 percent added to gas production and 15 percent added to oil production; for flood conditions, hydropower production was increased by 35 percent, of which 75 percent was diverted from coal production, 10 percent from gas production and 15 percent from oil production.

10. Drought conditions would increase thermal emissions since more thermal generation would occur relative to flood conditions. The drought conditions, therefore, are more crucial in evaluating the environmental benefits of increased hydropower development. In absolute terms, the emissions under drought conditions are less for the Trade Scenario than for the Reference Scenario since 126,946 GWh of hydropower generation would still remain. The loss in hydropower generation would be made up by thermal generation, since the Trade Scenario contains a 68 percent increase in hydropower generation. Consequently, under drought conditions for the Reference Scenario there would be a 10 percent increase for all emission totals, and for the Trade Scenario there would be around a 20 percent increase for CO₂, a 21 percent increase in SO₂, a 20 percent increase in NOₓ and a 23 percent increase in PM.

<table>
<thead>
<tr>
<th></th>
<th>Emissions (000 tons)</th>
<th>CO₂</th>
<th>SO₂</th>
<th>NOₓ</th>
<th>PM</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Drought Flood</td>
<td>Drought Flood Drought Flood Drought Flood Drought Flood</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2020 Reference</td>
<td>Hydro 75.8 157.3</td>
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<td>0</td>
<td>0</td>
<td>0</td>
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<td></td>
<td>Coal 291.6 230.4</td>
<td>339,739</td>
<td>268,458</td>
<td>414</td>
<td>327</td>
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<tr>
<td></td>
<td>Gas 128.8 120.6</td>
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<td>Oil 101.1 88.9</td>
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<td>68,439</td>
<td>496</td>
<td>436</td>
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<tr>
<td></td>
<td>Total 597.3 597.3</td>
<td>474,275</td>
<td>389,981</td>
<td>913</td>
<td>765</td>
</tr>
<tr>
<td>2020 Trade</td>
<td>Hydro 127.9 263.7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Coal 276.6 174.0</td>
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<td>202,756</td>
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<tr>
<td></td>
<td>Gas 131.5 117.9</td>
<td>57,871</td>
<td>51,856</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Oil 62.3 41.7</td>
<td>47,935</td>
<td>32,145</td>
<td>306</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>Total 597.3 597.3</td>
<td>428,014</td>
<td>286,757</td>
<td>701</td>
<td>454</td>
</tr>
</tbody>
</table>

Sensitivity to a Lower Demand Forecast

11. Given the recent financial crisis in Thailand, Annex 1 presented a second set of generation investment programs based on a more pessimistic view of future electricity demand growth in the sub-region. However, under this Low Demand Growth forecast, the magnitude of hydro-based energy dispatched annually would be practically the same as under the High Demand Growth forecast. (Annex 1, para. 51) Hence, although a reduction in electricity demand will clearly decrease the overall magnitude of thermal plant-based emissions, the absolute difference in emissions given self-supply or cooperation would be similar in either scenario.
Impacts of Hydropower Development

12. Developing and implementing successful impact mitigation programs, for hydropower projects on a case-by-case basis, will be critical to minimize adverse environmental consequences. Aspects are:

- **Reservoir sizing.** Lowering the elevation of the take-off may provide significant benefits in terms of relocation and effects on specific habitats without sacrificing too much power.

- **Multi-purpose reservoirs.** Reservoir design for purposes other than storage can spread the benefits. Examples are flood control, water supply (domestic and irrigation), fish farming and recreation. Optimizing the design, given the competing objectives of multi-purpose development, is important.

- **Watershed management.** Control of land use patterns is required to maintain the integrity of the soil, forests and agricultural land. Resettlement of people should avoid stressing the watershed that provides run-off to the reservoir.

- **Bank stabilization.** Stability of the banks of the reservoir and the stream below the dam with vegetation, rocks, rip-rap, gabions and other means should be ensured.

- **Innovation.** Opportunities like the creation of terraces for specialized agriculture along banks of reservoirs that experience substantial and long-lasting drawdowns; creation of parks and nature preserves in watersheds to prevent development and to enhance wildlife should all be explored.

- **Monitor waterways.** Waterways should be monitored to ensure that diseases are kept under control, reservoir water quality remains acceptable and to assess the effects of upstream activity.

- **Successful resettlement.** Resettlement should consider financial stability, cultural integrity, and that people are not placed in environments, which are either harmful to the hydropower project and/or of less suitable for economic and social lifestyle.

Policy Issues

13. Due to the magnitude and complexity associated with a power trade strategy for the GMS, there are a number of issues which should be identified, explored, and ultimately, resolved before related projects should go forward. These include: coordinated regulation, evaluation of environmental institutions, analysis of environmental externalities, clarification of the involvement of the private sector, establishment of baseline conditions, optimization of the power system, consideration of sustainability of the power sector, survey on sub-regional watershed management, and development of a energy resources plan. The first four issues should be incorporated into an initial agreement among the respective countries.

Coordinated Regulation

14. **Issue.** To avoid a situation in which one country would bear the environmental burden resulting from relatively lax environmental regulation so that some or all of the other countries can have "clean" power, the countries of the sub-region would need to define a common environmental denominator. This should take place independently of each country’s different approaches to (environmental) legislation and regulation.
15. **Recommendation.** As a basis for discussing a compatible environmental approach regarding legislation and regulation, an analysis of existing and planned legislation and regulation which affect power generation and trading, should be executed. A plan coordinating legislation and regulation should be developed. This step should be taken regardless of the extent of power trading, as trans-boundary movement of pollutants may become an issue. Changes in the legal, regulatory and financial framework may include: (i) development of (realistic) emission standards through legislative and regulatory means and development of enforcement mechanisms to ensure compliance; (ii) development of economic incentives that reward polluters for deploying cost-effective abatement schemes, i.e., pollution tax (a tax rate per unit of pollutant discharged) or emission trading; (iii) government sponsorship of energy technology demonstrations; (iv) enhanced utilization of natural gas by promoting seasonal gas use for control of NOx, and commercialization of high-efficiency gas technologies; and (v) intensification of the use of renewable technologies by promoting the integration of resource planning.

**Evaluation of Environmental Institutions**

16. **Issue.** The electric utilities will be particularly challenged in implementing a project of this magnitude. The MRC would probably play an important role in coordinating the utilities. Other governmental organizations and ministries will also need to work together. A major shortcoming in some of the sub-regional countries is the absence of environmental units in electrical utilities, the absence of a national environmental policy, at least where energy is concerned, and in some cases, the absence of an Environmental Protection Agency or even a Ministry of Natural Resources. In some cases, it may be necessary to create an environmental institutional infrastructure, and in other cases, to modify the institutions’ coordination.

17. **Recommendation.** An initial evaluation of the environmental institutions within the participating countries should be carried out to determine capabilities and to develop means of coordination.

**Assessment of Externalities**

18. **Issue.** The question over which concerns should be factored into a power project’s economic evaluation, and which factors are external to the project and should, therefore, not be included, is difficult to answer. For example, the following questions may be raised in a power context: (i) whether and which environmental consequences are attributable to the project; (ii) which fuel development and transportation are (environmental) externalities; (iii) how a project is treated if it uses the same fuel source as other related thermal projects; (iv) which social costs are be factored into hydropower projects; or (v) how externalities are considered when the power system is very large and is composed of a mix of technologies, countries and environments.

19. **Recommendation.** An initial assessment should be made of the potential externalities and their impact on the costs and benefits of the power strategy for the GMS. The assessment should also clarify how costs and benefits change over time as well as which indirect costs and benefits of the interconnected system.

**Establishment of Baseline Conditions**

20. **Issue.** In the case of energy development, determining baseline data is critical for evaluating economic feasibility as well as environmental impacts of a power strategy. Baseline data may include
resource availability, sector demand, current system operations (transformer efficiencies, line losses, available capacity), local and regional economic conditions, and social structure - all of which have an impact on the environment. Sufficient and accurate baseline data for planning a power strategy may, however, be difficult to source.

21. **Recommendations.** A concerted effort should be made to identify, collect, and analyze existing data sources in order to find gaps and suggest measures of filling those gaps. This effort may initially be carried out by the MRC until the institutional structure for the strategy is in place.

**Optimization of the Power System**

22. **Issue.** For a power system as complex as that envisaged in this paper to achieve economic and environmentally acceptable operation, comprehensive optimization will be required. A strategy is needed that satisfies demand as well as considers supply constraints (e.g., resource and technological constraints) and environmental impacts while ensuring an economically efficient result. In the course of the optimization, international and systematic operation rules for not only the generation and transmission of power, but also for other potential uses, like irrigation, flood control and wildlife, are required. User conflicts are to be avoided, and public participation is essential.

23. **Recommendation.** An optimization of the power system should be performed that considers environmental impacts for all design options. The optimization should balance losses and gains, and ultimately, support a power system that can survive economically, socially and environmentally.

**Sustainability of the Power System**

24. **Issue.** Thermal power plants are generally only sustainable for 10, 15 or 20 years. To ensure sustainability in energy development, high levels of renewable resources in addition to demand management are necessary. The power trade strategy for the GMS may be a step in this direction for two reasons. First, by combining and sharing renewable resources in a regional cooperative venture, the results may be more sustainable than if each country developed their own projects. Second, there is momentum generated for additional resource development from a sustainable perspective, like water resources within the GMS.

25. **Recommendation.** The institutions involved in the power trade strategy for the GMS should ensure that the implementation maximizes sustainability in an economic, social, technological and environmental sense.

**Sub-regional Watershed Management**

26. **Issue.** Planning concerning watersheds, which supply the run-off for power plants, will become crucial. This assumes that significant hydropower development will take place as power trading increases. In particular, regional watershed planning becomes necessary as the Mekong watershed includes all of the countries and several of its tributaries run through more than one country.

27. **Recommendation.** A survey should evaluate the status of watershed planning and management in the sub-region. Existing information regarding watershed planning, supplemented by field work, should be used to evaluate the current and future land use patterns along the Mekong and its tributaries,
and natural and man-made characteristics of all watersheds. To manage the watersheds of the GMS, a framework for coordinated decision-making may be needed.

**Plan for Energy Resources Mix**

28. **Issue.** Based on the economic and environmental evaluation, regional power trade would be more favorable than self-sufficiency. Assuming power trade, nonrenewable resources will become less utilized in electrical energy production. To compensate the latter and to satisfy increased demand, more renewable energy in the form of hydropower will need to come on line. Natural gas, although a nonrenewable resource, will, however, be the most favored nonrenewable supply option in terms of heat efficiency, emissions and availability in the sub-region.

29. **Recommendation.** As part of the strategy implementation, a plan aimed at an expansion of particular energy resources within the sub-regional resources mix should be developed. The plan should ensure that identified, longer-term, renewable and nonrenewable energy resources, which are the most economically and environmentally desirable resources, go on line. The plan should include location, magnitude, energy potential of resources, as well as a schedule for the plan implementation.

**Summary**

30. If regional power trade is developed on a least-cost development basis, taking advantage of the relative cost-advantages of the region’s hydropower resources, an interconnected power system would have significant environmental benefits. These would mainly stem from a substantial reduction in greenhouse gas and pollutant emissions caused by the substitution of hydropower generation for a large proportion of coal-fired and oil-fired generation. By 2020, thermal generation is forecasted to be around 16 percent lower under a regional power trading regime than would be the case if countries in the region remained primarily self-sufficient in electricity supply. The resultant reduction in emissions is projected to be up to 31 percent for \( \text{SO}_2 \), as much as 12 percent and 18 percent for NOx and particulate matter, respectively, and 17 percent for \( \text{CO}_2 \). Although valuing the benefits of such reductions in monetary terms is problematic, environmental cost estimates suggest that power trade could result in emission abatement benefits of up to US$160 million per annum by 2020.

31. The benefits from reduced emissions must be contrasted with the impacts from increased hydropower development and additional transmission lines. Environmental issues should be addressed through a regional approach to resolve conflicts between regions/countries, coordinate regulation, and incorporate environmental issues into overall planning. Also, impact mitigation programs will need to be developed for each hydropower project on a case-by-case basis, and should consider: resettlement issues, appropriate reservoir size, multi-purpose and innovative uses for the reservoir and affected areas, reservoir stabilization, and watershed management and monitoring. Wider environmental issues associated with a regional power market include the need for: coordinated regulation, evaluation of environmental institutions, assessments of externalities, establishment of baseline conditions, power system optimization and sustainability, and regional watershed management. Any initial agreement among the respective countries regarding power trade should consider the first four issues in particular.
Annex 3: PRIVATE POWER GENERATION INITIATIVES

1. While private sector participation already exists in power generation in the GMS, the level varies by country.

Thailand and Lao PDR

2. Private power developments are rapidly moving ahead in Thailand and Lao PDR. In 1995, EGAT conducted a public solicitation seeking proposals from the private sector to build independent power projects with a capacity up to 4,100 MW to be constructed by the year 2002. This would take place in two phases: Phase I of 1,300 MW by 2000 and Phase II providing the balance of 2,800 MW. More than 59 proposals have been received, mostly for plants using natural gas or imported coal. EGAT is negotiating long-term build-operate-own (BOO) contracts and is signing power purchase agreements with selected developers. Six projects were selected for Phase I. All IPP contracts must be approved in Thailand by the National Energy Policy Council and the Cabinet of the Thai Government. Prices seem to be very attractive to EGAT, at about 4 to 5 US cents/kWh; an indication that - under the competitive process - successful developers have been forced to cut their margins sharply. In the future, EGAT is expected to seek about half of its new capacity needs within Thailand from IPP sources. A second request for proposals will be issued in early 1998 for an additional capacity of 2,000 MW.

3. In addition to local IPP proposals, EGAT is seeking to buy power from Lao PDR under an MOU signed in 1993 in which Thailand agreed to buy up to 1,500 MW from Lao PDR by the year 2000. Under a second MOU signed in 1996, Thailand agreed to purchase an additional 1,500 MW by 2006. EGAT is negotiating to buy power from BOT developers in Lao PDR on the basis of 20-25 year agreements. Lao PDR has drafted procedures outlining how investors should seek to implement and obtain government approvals for IPP projects.

4. So far, two power purchase agreements (PPAs) were signed between EGAT and Lao IPPs. The first PPA was with a Thai developer, MDX Power, which commenced construction of the 210 MW Theun Hinboun project. Sixty percent of this project is sponsored by EDL, and 40 percent by MDX Power and Nordic Hydropower. Project costs are estimated to be about US$280 million. About US$110 million of the financing will be in the form of equity and the balance will be borrowed from commercial lenders and export credit agencies. EDL's equity share of US$60 million is funded through an ADB credit. The second PPA comprises the 126 MW Houay Ho hydro project. Its construction has already been started by Daewoo (Korea), with the Lao Government and Loxley Public Company Limited, a publicly listed Thai company, as joint venture partners. Construction of the dam has been completed. The developer is also building a 230 kV transmission line from the power station to the Lao border with Thailand. This is expected to be completed by 1998.

5. The Nam Theun II hydro project in Lao PDR, which the Bank has been asked to support through a partial risk guarantee, is being reviewed. The goal of the review is to evaluate the project's viability, to assess the optimal configuration in terms of project size, and to minimize the environmental impact. Although a price agreement was signed for this project, construction is now delayed while this review is being undertaken.
6. In Lao PDR, the construction of a 600 MW lignite-fired plant - Hong Sa - is also planned for construction by about 2002. The plant would be located in Lao PDR near the border with northern Thailand. This would be not far from existing EGAT plants in the Mae Moh region.

7. The Shlapak group (USA) is quite advanced in the preparation of the 650 MW Nam Ngum 2 hydro project in Lao PDR. MDX Power of Thailand has expressed interest in constructing the 400 MW Nam Ngum 3 hydro project. This project would be a joint venture with the Lao Government; 55 percent owned by MDX and 45 percent by the Lao Government. A feasibility study for Nam Ngum 3 was completed by the Snowy Mountains Engineering Corporation and construction is planned to start once a PPA has been signed with EGAT. Transmission investments for Nam Ngum 2 and 3 need to be coordinated to avoid potential duplication. Both projects are expected to be commissioned in 2002.

8. EGAT plans to construct 500 kV transmission links to the Lao border to transfer power from various Lao projects to Bangkok. The timing of the construction of these lines will depend on when the Lao projects are likely to be commissioned.

China

9. In China, the Yunnan Provincial Electric Power Bureau (YPEPB) is planning a joint venture with MDX Power to develop the 1,500 MW Jing Hong hydro project - about 90 km from the Lao border. A feasibility study is being undertaken by EGAT and Kunming's Hydro Electric Power Investigation and Design Institute. Electricity (about 80 percent of the plant’s output) would be exported 1,200 km into Thailand. This would possibly take place through a HVDC transmission line through Lao PDR via Luang Nam Tha (being reviewed under an ADB-financed study). The construction of the Jing Hong hydro project could begin in 1998. Full commissioning of five 300 MW units would then be expected in 2005. The developers expect the cost of power to be about 5 US cents/kWh at the border with China. Since the cost of transmission lines to Bangkok is estimated to be about US$1 billion, the cost of power delivered to EGAT may be relatively high compared to other alternative sources, like IPPs and projects in Lao PDR.

10. Jing Hong would be the first power project in China to be developed for the export of electricity. The concept of developing the Jing Hong hydro project for export purposes seems to be supported by the South-East China Electric Power Corporation (SCEP), although the corporation is not directly involved in the project. YPEPB expects that the State Planning Committee will meet with Yunnan government officials, at a time to be agreed, to firm up the details of this cooperation with Thailand. So far, there is no formal agreement between the Governments of China, Lao PDR, and Thailand to cooperate for this purpose and no PPA has been drafted with EGAT. There are many issues to be discussed and resolved by the respective parties before arrangements can be finalized. The Chinese authorities have not yet formulated their position on key policy issues, like government support and participation, risk sharing, guarantees, taxation, incentives for developers, and royalties.

11. YPEPC is interested in the upstream 4,500 MW Nuozhadu hydro project and the 4,200 MW Xiaowan project - both on the Lancang (Mekong) River. Nuozhadu would not be built before about 2010. It would be connected to the Yunnan grid, which could make a connection of Jing Hong to the Yunnan grid possible.
Vietnam

12. In Vietnam, consultants have been appointed to assist the Ministry of Industry to develop Phu My 2-2 as an IPP. The Bank/IDA is financing these services, which will support the selection of a suitable developer on the basis of competitive bidding. This project will be the first competitive bidding for an IPP in Vietnam. The Government is also interested to develop several other IPP projects and is seeking World Bank support for at least one of these, including: Ban Mai hydro project (300 MW), Qong Ninh thermal (300 MW), and Ba Ria (200 MW).

13. Vietnam is interested in purchasing up to 2,000 MW of hydro capacity from Lao PDR by 2010. A MOU was signed for this purpose and feasibility studies on the development of Sekong 4 and 5 are in progress (supported by ADB). If one of these sites were to be developed, a transmission line would be built to Pleiku in southern Vietnam. Other projects might be considered in central Lao PDR to develop and to transmit supply further to the north at Vinh in central Vietnam.

Myanmar, Cambodia, and Malaysia

14. In Myanmar and Cambodia, other possibilities exist for developing projects to export to Thailand. However, no firm plans have been agreed upon. A developer in Malaysia, YTL, has obtained approval to build an IPP near the Thai border. This would be a gas fired combined-cycle plant. The power would be sold to TNB, who would in turn sell it to EGAT. Malaysia has recently canceled plans for building a 2,400 MW hydro complex at Bakun in Sarawak as an IPP: About 80 percent of the output would have been sent to Peninsular Malaysia via a 1,300 km HVDC connection, including 600 km of submarine cables. Power produced from Bakun would have been purchased by TNB.
Annex 4: POWER TRADING POOLS

1. The development of a regional electricity market requires sufficient and appropriate interconnections among the different national networks, technical and institutional coordination, as well as compatible regulatory procedures and transparent rules governing commercial and financial activities. In particular, the question arises: What structure should the power market of the GMS adopt? Potential alternatives are provided by other regional power trading arrangements.

Examples from Other Countries

2. It would be too ambitious to forecast a specific long-term structure for the GMS electricity market. All options should remain open to facilitate the step-by-step evolution of the present situation toward a more active and mutually beneficial structure and joint arrangement. Several regional electricity markets which are already operational worldwide, however, may provide useful examples.

3. In Europe, the Union of Producers, Transporters and Distributors of Electricity (UCPTE), which basically regroups the countries of the European Union, trades about 10 percent of the electricity consumed in the region every year. The organization is very loose and is mainly composed of a series of coordinated bilateral contracts either on a long- or short-term basis in order to provide capacity, economy energy or mutual reserve supports.

4. In the Scandinavian region, Norway and Sweden have set up a very active competitive structure composed of a spot market for physical delivery hedged by a financial stock market. The market is in the process of being extended to Finland and Denmark as soon as their respective national power sector structures are compatible with the requirements of the Norway-Sweden market. In North America, the U.S. and Canada have several bilateral structures for different types of "electricity products". One of the most interesting pools which could be used as an example for the GMS is the Mid-Atlantic Power Pool (MAPP).

5. In southern Africa, twelve countries of the SADC region (Southern African Development Commission) are in the process of implementing a well coordinated "loose pool" structure (the Southern African Power Pool - SAPP) with a coordinating center which will play the role of central dispatching center of information among the different national dispatch centers of the region. This coordinating center will circulate the information on different national requirements, and the availability of the different plants and lines. It will also be the central point to set up transactions and, if necessary, arbitrate disputes. The SAPP was established under a series of Memoranda of Understanding, sanctioned by the respective governments and the chief executives of the power utilities of the twelve countries in the region. The MOUs are supported by an Agreement Between Operating Members and Operating Guidelines (similar to a regional Grid Code). The SAPP has specific objectives of (i) coordinating and cooperating in the operation of their systems to minimize costs while maintaining reliability; (ii) recovering their full costs; and (iii) sharing equitably the resulting benefits. The benefits are considered to include reductions in the required generating capacity, reductions in imported fuel costs, and improved use of hydroelectric energy.
6. In sum, the following lessons may be drawn from regional power markets:

- **Organizational framework.** Experience shows that all existing regional power markets have been set up under the umbrella of some recognized organization for economic development such as mentioned above: the European Economic Union or the SADC. Such organizations provide the initial forums required to launch the dialogue and to facilitate communication among interested parties. Specific issues linked to the development and implementation of a power market, however, have to be discussed among specialized experts later on. Two conditions of extreme importance in setting a regional power poll are: trust and confidence between partners and an agreed procedure to resolve disputes.

- **Compatibility.** Development of regional power markets is facilitated by three basic rules: (i) the compatibility or similarity of the structures of the different national power sectors; (ii) the compatibility of the regulatory systems; and (iii) the possibility of wheeling electricity between countries. The optimal structure for power sectors is the full unbundling among production, transmission and distribution, which allows the buyers (the distributors or the large consumers) to buy electricity wherever they want. The compatibility of regulatory systems ensures that the rules, especially for the setting of prices both at generation and transmission levels, are transparent and compatible. The wheeling or third parties access releases the purchasers and the sellers from the constraints created by integrated transmission companies and allows the cross-border energy trade.

**A Potential Structure - Pooling**

7. A crucial prerequisite to the success of regional trading is that benefits are shared (see Chapter 2) and that an appropriate structure, like a “loose pool,” is developed. At the international level, the “loose pool” principle is probably more appropriate and much more flexible that the tight pool structure. Loose pools emphasize gaining the maximum economic and reliability benefits from trading within the parameters of maximum system autonomy. These pools do not employ central dispatch, as in tight pools, and tend to be characterized by long-term bilateral contracts for the supply of electricity between generators and customers. These are supplemented with offsetting short-term contracts and other deals under the overall agreement framework.

8. Loose pools may provide central services such as data gathering and provision - including continuous real time data to match generation and demand, producing indicative expansion plans, and implementing emergency procedures. Loose pools also establish detailed common design and operational standards to ensure system security and reliability, and to facilitate trade. The U.S. experience shows that loose pools are flexible, and can evolve from a structure characterized by cooperative trading arrangements between largely integrated utilities into one marked by increased levels of competition when the power sector structures are unbundled and prepared for competition.

9. If a regional pool structure is put in place in the long-term future, it will be necessary to define a set of terms. Exemplary terms are listed in Table A4.1.
<table>
<thead>
<tr>
<th>Terms of a Regional Pool Structure</th>
<th>Content of Terms</th>
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<tbody>
<tr>
<td>Terms of an agreement</td>
<td>Effective and termination date, relationship to earlier agreements and law, transitional provisions, procedures for amendment, force majeure clauses.</td>
</tr>
<tr>
<td>Membership</td>
<td>Initial members, arrangements for membership change, provisions regarding transfer of rights and obligations to successor bodies of original pool participants, status and rights of IPPs.</td>
</tr>
<tr>
<td>Structure for pool management</td>
<td>Roles of different management bodies, their membership, appointment of key staff, voting arrangements, notice of meetings, budgeting and source of funds.</td>
</tr>
<tr>
<td>Valuation of capacity and energy</td>
<td>Procedures by which capacity and energy are valued and are paid.</td>
</tr>
<tr>
<td>Settlement of payments</td>
<td>Arrangements on metering, billing and settlement.</td>
</tr>
<tr>
<td>Transmission facilities, pricing, and access issues</td>
<td>Unbundling of (transmission) price from electricity generation prices reflecting fixed and variable cost of transmission of electricity. Development and procedures for ancillary services.</td>
</tr>
<tr>
<td>Dispute resolution</td>
<td>Provisions on informal and formal dispute resolution, procedures for arbitration.</td>
</tr>
</tbody>
</table>
Annex 5: PROPOSED STRATEGY

1. The question arises whether recognizing economic and environmental benefits of power trading is enough to open the power sector to power trading. To facilitate and enable power trading among the GMS countries, existing policy, technical, institutional, and commercial/financial barriers to cross-border trading would need to be overcome. A strategy addressing these barriers will, therefore, be introduced in this annex. The strategy should be considered as a process and its individual components as benchmarks, whose achievement helps to ensure an efficient (regional) power market.

Policy Measures

National Priority

2. Each country should recognize and endorse international trading in electricity to be an integral part of its policies to strengthen its electricity sector.

3. It appears that the governments of Lao PDR and Thailand recognize the benefits of cross-border trading. Both recognize the potential for economic savings or for increased revenues, which can result from win-win transactions. These same benefits are available to all of the countries within the region. Countries should not reject a pro trade policy unless they are willing to incur the increased costs which may result.

4. While national security concerns are understood and acknowledged, the cost of self-reliance, when more economic production is available for import, should also be considered. This is a matter which should be considered by individual governments. Each government should determine the value of potential trading arrangements. It is likely that an objective analysis will show significant benefits. In some instances, the benefits may primarily accrue to one region within a country. For instance, Yunnan Province may enjoy greater benefits from cross-border trading than other regions of China. If benefits can be identified, the country should formulate a policy statement. It should state that the country’s policy is to encourage international trade in electricity and that all agencies and corporate entities within the country should take appropriate action to implement the policy.

Regional Coordination

5. An ad hoc group with no formal structure should assume responsibility for developing the regional protocols and early planning for regional integration.

6. The recently established GMS Experts Group (EG) is aimed at assisting the GMS countries in: (i) promoting the development of the regional transmission network; and (ii) facilitating the expansion of cross-border power trade. Accordingly, its terms of reference establish that the EG is responsible for initiating and overseeing studies necessary to meet the above objectives. In particular, the group is expected to undertake, through bilateral and multilateral technical assistance, studies to develop strategies and basic rules, and to reach consensus on transmission links. These include studies to update the Mekong Integrated Transmission Development Plan and to determine the institutional and legal arrangements to develop and manage the interconnected network.
7. It is expected that the EG exert clear leadership in taking the next steps towards the creation of a protocol and to initiate the required momentum to keep the process going. It is recommended that this should be a temporary arrangement until a permanent organization is formally established by the proposed policy protocol.

**Regional Protocol**

8. A formal regional cooperation agreement and permanent organization for coordination of planning, development, and operation should be established. Permanent organizations would include an entity to coordinate operational procedures of the different national dispatching centers and, in the long-term, a regional agreement and legal structure for a power pool.

9. Governments in the region should develop a protocol which recognizes the long-term benefits of regional trading. The document should encourage each of the countries to plan and develop generation and transmission jointly. In addition, it should promote opportunity trading for the mutual benefit of the parties. The protocol should also establish a permanent organization to administer the agreement and to coordinate planning, development, and operation of generation and transmission within the region.

10. This recommendation is not intended to convey central planning; rather, it should consider providing for the coordination and compatibility of individually developed plans and their adoption in an efficient manner. Each of the countries within the region will retain its own decision making autonomy.

11. An issue might arise as to whether the initial agreement should be bilateral or multilateral. Bilateral agreements already link Lao PDR to Thailand and Vietnam, although their scope is limited. Since Lao PDR is a party to both agreements and has a strong national interest in regional trade, it may develop recommendations for discussion at the next meeting of the regional EPF. One possibility would be to draft a three party agreement which could be then expanded to include additional countries in the region.

12. A policy protocol could include, inter alia, the following components:

- Statement of objectives. For instance, starting with an establishment of legal rights and obligations of all parties, to a promotion of greater competition and private participation, as well as building the required infrastructure.
- Statement of principles. Principles ruling the agreement, like competition, gradually, reciprocity.
- Definition of a regional power market. Basic principles for its functioning (definition of participants, rules for entry and exit, type of pool aimed), definitions.
- Establishment of permanent organizations. For instance, an entity responsible for the coordination of operation and dispatch of the regional grid and/or the regulation of the regional market.
- Sections on governments’ obligations, the resolution of controversies, agreed incentives, etc.
Flexibility in Laws, Regulations, and Contracts

13. All countries within the region should examine the compatibility of legislation, regulations, and contracts to ensure that they permit the required flexibility necessary to allow the regional market to expand.

14. Currently, the countries are at various stages in the development of new structures for the electricity sector. Each of the instruments, which is required to introduce and operate the electricity sector should be reviewed from the perspective of regional electricity trade. For instance, it needs to be analyzed whether provisions are included that could act as a barrier to future market development. As noted in Chapter 4, there is a concern that PPAs may include provisions which would not allow development of a secondary market in sales of capacity, energy, or both. To avoid this, provisions should be included, which allow reassignment of portions of the capacity provided that the purchaser meets stated minimum financial criteria.

Transmission Ownership

15. Each government in the region should establish a clear policy of which entity will own and operate the transmission assets within its boundaries.

16. There should not be any uncertainty as to who will be permitted to own and operate transmission facilities. Thailand has clearly stated that the transmission arm of EGAT will be the sole operator of transmission in that country. This unambiguous position helps all potential developers of generation, either inside or outside of that country, to determine where the responsibility and the risk for that aspect of their projects will reside.

Open Access Transmission

17. Policies of open access to the transmission network for wholesale competition should be established by each government.

18. An open access, non-discriminatory environment is essential for establishing a favorable trading electricity environment. A typical method for obstructing trade is to bundle transmission with generation, and to use the bundled “fence” to keep potential competitors from potentially selling to load within the area, which is served by the generation/transmission entity.

19. Thailand’s proposals for restructuring illustrate how open access may be offered without also introducing retail competition. Retail competition may be introduced at a later date. However, all potential developers, which are selling into Thailand’s single buyer market, are aware that they will be permitted non-discriminatory access to Thailand’s transmission system. An open issue remains as to whether one country may be permitted to wheel energy through Thailand’s system to another. Such an open access policy will be needed in order for generation in China to have access to Thai markets. Lao PDR has indicated its acceptance of such a policy in supporting the proposed Jing Hong hydro plant, which is planned for Yunnan Province in China.
Environmental Impact

20. Environmental issues should be addressed through coordinated regulation and a regional approach to resolve conflicts between regions/countries, strengthen institutions, and incorporate environmental issues into overall planning (e.g. assessment of externalities and development of energy resources mix in the Master Plan, establishment of baseline conditions).

21. Programs to mitigate environmental impact should be developed for each project on a case-by-case basis. These efforts should, however, be complemented by a regional strategy aimed at assessing cumulative impact, coordinating environmental regulation, strengthening involved institutions, and mounting joint efforts in watershed management. This would help ensure that the trade-off between environmental and economic objectives is fair and acceptable to all countries.

Technical Issues

22. The development of the transmission system within the GMS is following the experience of developed countries. For instance, first, self-supporting regional systems are developed, then these regions are linked in order to take advantage of diversities in loads and outages of facilities. These links enable sharing of generation reserves and provide significant savings in capital investment in achieving a given level of reliability.

23. Lao PDR is in a strategic geographical position to interconnect a number of potential trading partners within the region. As noted previously (see Chapter 2), plans are in various stages of development which could result in an inter-regional network. This would primarily result from construction of a north/south path within Lao PDR, which would operate in parallel with the Thailand and the Vietnam transmission. Such a transmission network would provide additional trading and operational flexibility.

Master Plan on Regional Transmission Expansion

24. A master plan for transmission to guide investment decisions should be developed. Information on plant locations and transmission development, which fits better within the regional transmission expansion plan, should be provided.

25. Development of a plan might be difficult because there is significant uncertainty with regards to many proposed generation projects. Decision analysis techniques should, therefore, be applied establishing a clear picture of a spectrum of possible transmission system configurations with a ranking of the possible plans according to the most probable.¹

26. The MRC paved the way and started to identify a series of priority transmission lines. Further and more detailed studies are required. In particular, it would seem interesting to investigate the viability of a “backbone” transmission line in Lao PDR which could link the Nam Ngum and Nam Theun Valleys in the north of the country with those of the Sekong Valley in the

¹ Transmission planners within the region may wish to investigate the work of England’s National Grid Company (NGC). Following the restructuring of the electricity supply industry in England and Wales, NGC has had to manage transmission expansion in an environment of considerable uncertainty.
south. In addition to this backbone, at least two east-west transmission lines to link with Thailand and Vietnam could be added. The possibility of linking the power line(s) coming from China with the central backbone could also be studied.

27. In order to produce plans and studies which have credibility, it is essential that the participating members contribute professional engineering expertise with in-depth knowledge of the existing power systems. Review by academics or international experts may be helpful, but the primary work should be performed by experienced engineers. However, such detailed work should be directed by a senior level staff person.

Regional Transmission Network Expansion

28. Each of the governments in the region should commit to the construction of specific transmission lines, which will ultimately form an efficient regional network.

29. It is recommended that transmission facilities be expanded where they are economic. However, to the extent that certain transmission projects can be identified, which are either marginally uneconomic, but would contribute to the establishment of a regional network, the construction of such lines should be considered. Also, if an additional increment of investment above that which is initially required for a generation project can be added to routes that could become part of a network, such investment should be undertaken. Planning, as described in the previous section, should identify those projects, which would represent a prudent risk and yield future returns in the form of regional trading.

30. The lack of transmission facilities is the most immediate barrier to regional trading. Therefore, it is recommended that all opportunities should be identified and investment strategies investigated. Vietnam has already demonstrated what can be accomplished if there is sufficient political will. However, the commitment to build needed transmission must also be tempered by other requirements to strengthen the electricity sector. No government will be able to undertake or to strengthen all segments of its electricity sector at once. The desire to increase regional trade must, therefore, be balanced against local needs.

Regional Operations Protocol

31. The operators of transmission systems within the region should develop an operations protocol, which would establish procedures and processes as necessary to maintain reliable operation and to facilitate trading.

32. Once the countries within the GMS are interconnected, uniform operational arrangements will be required. These arrangements will establish the obligations of the respective parties, which are participating in regional trading. No system should be operated in a way as to expose a neighboring system to a risk of interruption.²

² This could occur, for instance, if one system were to operate with insufficient generating reserves. In such an instance, a sudden equipment failure could result in a loss of essential generating capacity. In such a case, it might be necessary to immediately sense the problem and to automatically open the transmission lines which interconnect the two countries.
33. Generally speaking, the operating protocol should encompass those areas which are included in Thailand’s Grid Code. At a minimum, the operating protocol should include planning, facilities design, system operations, and generation scheduling and dispatch. For instance, the protocol should include provisions for developing a regional plan for scheduling maintenance. By coordinating such outages, one system may be able to come to the assistance of another, provided that adequate reserve margins are established.

34. The regional operating protocols should recognize and address the real probability that the initial requirements will be substantially less than those which may be applied once there are adequate investments in facilities. The region does not have sufficient generation to meet stringent reserve criteria. Most areas of the existing transmission system within the region cannot be operated within the acceptable criteria of uninterrupted operation following a single contingency (N-1). The code must, therefore, be constructed to apply within the initial limited facilities, but also provide a road map toward a future system, which may be operated on a higher standard. These future standards should guide the intervening investment plans.

Institutional Issues

Leadership

35. A leading group who will accept responsibility for developing the regional protocols should be identified.

36. Leadership to be assumed by the recently established GMS Experts Group.

Independent National Regulators

37. Each of the countries should consider establishing an independent regulator.

38. The requirement for an independent regulator is not critical to cross-border trading. However, the increased certainty regarding regulated tariffs should assist developers in obtaining financing for transmission and generation projects. It is, therefore, recommended that each country gives serious consideration to establishing a regulator, and a system of regulations independent from public and private interest groups.

Commercial and Financial

Generation Tariffs and PPA

39. All generation tariffs and PPAs should be constructed on the basis of a capacity payment, which is a function of the amount of generating capacity available and the related fixed costs, and an energy payment, which is a function of the actual production and the variable energy cost.

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3 Thailand’s Grid Code is a third generation version of the arrangements which were first adopted by NGC for England and Wales, and which were subsequently modified for Northern Ireland’s single buyer market.
40. Some PPAs, which are being negotiated in Thailand are based on a two-part tariff. To the extent that such contracts permit a high degree of dispatchability, they will permit the purchaser to reduce output any time that less expensive energy is available from another source. The other source may be within the country or outside of the country. If the purchaser of the output of the plant is compelled, under commercial terms in the PPA, to accept a portion or all of the output of a plant, the output will act as a barrier to regional trade.

41. A two-part availability tariff for generation is designed to meet several criteria:

- Investment requirements for ensured revenue recovery to meet capital and fixed cost requirements including competitive return on investment;
- Operational requirements for scheduling and dispatch on the basis of variable cost comparison to other generating and purchased power resources; and
- Incentives and penalties to promote achievement of operational objectives such as compliance with dispatch instruction, efficiency gains and compliance with system maintenance schedules.

**Transmission Tariffs**

42. Each country should develop a system of transmission tariffs, which would provide a firm basis for expansion and operation of the network.

43. Uncertainties related to the price of transmission should be removed as soon as possible through development of a robust system of transmission tariffs. Further, it is desirable for the tariff methodologies to be consistent from one region to another.

44. Design principles for transmission tariffs should be established in order to provide adequate incentives for investment and also to provide pricing signals for the optimal location of generation with respect to networks or load centers. Pricing methodologies should then be developed and tested against a number of practical scenarios that have already been experienced in other countries. In general, the transmission charges should be based on demand, not energy, in order to avoid exposure to under-recovery of costs if energy deliveries fall below a predicted amount.

**Generation Risk**

45. Governments and agencies which are procuring generation should take all necessary steps to reduce the uncertainty as to which projects are most likely to reach successful financial closure and actually be brought on line.

46. Governments and agencies that are procuring generation have to take all necessary steps which are required to reduce the uncertainty of generation development. It is unsatisfactory and inefficient to pursue simultaneously many generation projects that are unlikely to reach financial closure.

47. Each government should identify the various risks which are associated with the development of generation. Responsibility for assuming these risks should be assigned to the party best able to manage the risk. The government or agency should solicit bids only from a limited list of well qualified bidders. It should assemble a team of experienced advisers, who are
acquainted with all aspects of finance, construction, and operation of a plant. Finally, each
government should continuously monitor each project and assign a probability of success as a
condition of having obtained governmental approvals, reached contracts with equipment
suppliers, reached financial closure, etc. Projects which are in the very early stages of
development (pre-financial closure) should be regarded as less probable than those which already
have financing.

48. It is imperative that the parties within the region take a realistic view of their ability to
complete generation successfully. There will be increased uncertainty and a reduction in
confidence of the government to undertake generation expansion and the developers to perform.

Transmission Planning and Construction Risk

49. Governments and utilities in the region should take measures so as to reduce the risks
associated with transmission planning and construction.

50. Many factors can contribute to delays in planning and constructing transmission. There
can be indecisiveness on the part of governments as to which agency should have the primary
responsibility. If multiple agencies are involved, there can be confusion - and delay. The need
for environmental approvals may not be addressed until it is too late. Procurement and delivery
of equipment and contract labor may be protracted.

51. Some countries within the region have demonstrated the ability to plan and construct
transmission in a timely fashion. However, other countries have very little experience with
planning and actually constructing transmission lines - especially lines, which are in the range of
400 kV. It is necessary for those governments to win the confidence of generation developers
that their projects will not be delayed because of late construction of transmission. Those
governments should, therefore, list adequate construction schedules, which can be met. Clearly
defined accountability for expeditious construction of projects must be assigned to a single
agency.

Taxes and Royalties

52. Governments should decide their policy and clearly communicate their policy on taxation
and royalties on exports of electricity, and communicate it clearly to all interested parties.

53. Taxes and royalties are actual barriers to generation development and should, therefore,
be eliminated. If governments believe that it is necessary to impose taxes or royalties on projects
which are developed for export, decisions should be taken as soon as possible. Uncertainty
concerning taxes and royalties on such projects likely discourages development, even when there
could be significant benefits. In determining such policies, the governments should consider the
competitive environment within the region, and set taxes and royalties at a level permitting the
projects to remain competitive with those being developed in other countries.
Annex 6: WORLD BANK SUPPORT - GUARANTEES

1. The question arises as to how the World Bank could be of assistance in supporting the private sector and Governments in their efforts to develop more extensive power trade in the GMS. The discussion in this annex, which draws substantially from a recent World Bank proposal for Central America,¹ is based on the assumption that most countries in the region are moving towards establishing a policy framework suitable for the development of private-based power trade. Consequently, World Bank Group support, including guarantees, would be aimed also at complementing or further encouraging the reform momentum.

2. The three agencies of the World Bank Group that could facilitate the participation of the private sector and power trading in the GMS are the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIGA), and the World Bank. IFC provides loans and equity capital to private sector entities, while MIGA offers political risk insurance to private sector investors. The World Bank can support private sector involvement directly through its guarantee program, or indirectly through technical assistance and credits/loans for public investments (particularly for transmission) aimed at complementing private sources. The following section discusses the guarantee, the only direct and potentially most versatile instrument to support private projects.

Examples of Guarantee Arrangements

3. Under this instrument, the World Bank guarantees to protect private lenders against non-fulfillment of government obligations concerning a project which causes a debt service default. The World Bank must also receive a counter-guarantee from the country or countries which the World Bank guarantees.

4. Three typical examples that may be candidates for a guarantee scheme relating to power trade can be foreseen, but there may be many other possibilities.

- Example 1: A private developer wishes to invest in the construction of a power plant in country A and then sell power in both country A and to a neighboring country B. This arrangement is typical of most projects that are, or will be, built in Lao PDR, where a small share of the production will be for local use and the large remaining part for export to Thailand. The main risk for the investor would be the lack of creditworthiness of country A due to weak regulation and the lack of a track record, as well as the political risks in each country (e.g., government interference, breach of contract, foreign exchange convertibility), and possibly, the seller’s lack of access to available transmission lines (e.g., in Thailand, EGAT may face difficulties in obtaining rights-of-way).

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- **Example 2:** A private developer wishes to invest in a new international transmission line between countries A and B. A possible future case is between Lao PDR and Thailand or Vietnam. The benefit would derive from the opening up or expansion of trade and the risk would principally relate to the non-fulfillment of government obligations in both countries.

- **Example 3:** A private developer wishes to invest in the construction of a power plant in country A and to sell the power both in country A and to country C which requires transmitting the power through a third country B. This arrangement is similar to the Jinghong project, that will be built in China, where 25% of production will be sold to China and the remaining 75% exported to Thailand through Lao PDR. In this case the risk would relate mainly to the non-fulfillment of government obligations in three countries.

5. Although the guarantee scheme of the World Bank was originally established for non-IDA countries, the policy has been revised and has been extended to enclave projects in IDA countries. An important issue, however, is how to structure the indemnity arrangements or counter-guarantees.

**Counter-Guarantee Options**

6. The World Bank’s articles require that a counter-guarantee be obtained from the country in whose territory the project is located. In addition, World Bank policy requires that a counter-guarantee be obtained from the country or countries whose obligations the World Bank is backing. This implies that, in the case of the cross-border examples, more than one counter-guarantee would normally be required. Three possible solutions could probably be viable: (i) a full unconditional counter-guarantee; (ii) a full conditional counter-guarantee; and (iii) a partial counter-guarantee. Under the first solution, the World Bank would receive a full and unconditional counter-guarantee from all the countries involved in the project. Each country would be liable to the World Bank for the full amount of World Bank guarantee debt. Suitable arrangements would need to be agreed in order to ensure that the World Bank collects only the amount due. The countries could also agree to settle between themselves their respective liabilities according to a jointly agreed formula, so that payments to the World Bank would always be sufficient to convert the amounts paid out under the guarantee.

7. Under a full conditional counter-guarantee, the World Bank would receive full counter-guarantees from each country, but these could only be invoked with respect to the obligations of each government. If the World Bank does not invoke the indemnity with a country and the country does not pay, the World Bank would exercise its standard remedies, as under World Bank loans. This option may be more attractive since countries are only liable to the World Bank for those obligations that are under their control. The location of the project and benefit area would also need to be determined in this case to ensure compliance with the territory provisions of the World Bank’s Articles.

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2 Countries with a GNP per capita less than US$800 per year.
8. Under the partial counter-guarantee, the World Bank would receive counter-guarantees from each country, equal to the amount of the private loan that is guaranteed by the World Bank in each country. Consequently, the amount counter-guaranteed by each country would not be for the full amount of the World Bank’s exposure. This case would apply to situations in which private developers in more than one country take loans from private creditors and the World Bank guarantees all of these loans.

9. In each case, achieving acceptable counter-guarantee arrangements will involve a precise definition of the projects and an alignment of the incentives for the countries. Differentiating the potential risks (e.g., government obligations) that could be covered by a World Bank guarantee and then allocating them to each country may be a complicated exercise which will require expert advice. This also applies to dispute resolution procedures.