

## 3.0 OVERVIEW OF LAO POWER SECTOR

### 3.1 Setting

#### 3.1.1 Development of the Power Sector

In Lao PDR, the power sector serves two vital national priorities:

- (i) It provides a reliable and affordable power supply to Lao society and industry. Inexpensive electricity promotes competitiveness in Lao commerce and brings social benefits to urban and rural communities.
- (ii) It earns foreign exchange from electricity exports. The country possesses abundant energy resources, principally hydropower but also coal, and the exploitation of these resources through electricity exports is at the heart of GOL's strategy for earning the revenues needed to fund the country's development.

Strategic planning of the sector will consider both objectives.

Currently about 41% of households in Lao PDR are electrified and GOL has committed itself to increasing this to 90% by 2020. One of the primary objectives of the PSDP is to determine the development requirements of the Lao power system to meet this objective.

In the early years of power sector development in Lao PDR, power systems evolved separately around the main centers of population. Investments tended to be small and decisions were intuitive. Power projects were planned on an individual project basis without the need for a coordinated plan to ensure optimality across the country. Projects were publicly financed through bilateral and multilateral development agencies and the orderly procedures of these agencies governed project selection and procurement processes.

With the growth of demand and expansion of power systems, intuitive *ad hoc* decision-making is becoming less reliable. Investments are typically larger and the consequences of sub-optimal decisions are now greater. Also, over the last decade power sector planning is being complicated by the changing way in which projects are financed and implemented.

A rational development plan is needed to guide development to the maximum advantage of the country, and to forecast the capital investment and revenue implications of this development. Several planning and strategy studies have been prepared in recent years but they have been fragmentary and contradictory. The PSDP draws on this previous work, updates and reconciles conflicts, and outlines a development path for the period from 2005 to 2020.

### 3.1.2 Planning and Financing Lao Power Projects

Planning and financing of projects are interdependent. In Lao PDR, a clear distinction has been drawn in the past between EdL-owned, publicly planned and financed power projects for domestic supply and privately owned, project financed export-oriented projects. Reasons for this distinction include:

- **Physical infrastructure:** Transmission networks have evolved within national boundaries and have not had the trans-national links to support free transfer between surplus and deficit areas with the region. The proposed development of an ASEAN/GMS grid will facilitate energy trading by providing the means and reducing the cost of moving energy to a willing buyer. It will also act as a catalyst in establishing an institutional framework to manage trades;
- **Size of project:** In the past, the ideal capacity increment was less than 100 MW for the Lao system but greater than 100 MW for EGAT and EVN. As demand increases and EdL's grids combine, optimal capacity increments will become larger;
- **Financing of Projects:** The reduction in the availability of ODA for domestic generation projects and the improvement in EdL's financial position is encouraging private investors and lenders to consider national supply as well as export markets.

The principal features of each category is outlined:

(i) EdL-owned projects for domestic supply:

EdL-owned projects have been financed in the past by multilateral agencies (e.g. World Bank, ADB) and bilateral agencies (e.g. JBIC, NORAD) on concessional terms. They have been planned and implemented in accordance with the agencies' procedures resulting in an orderly project selection process based on least-cost principles.

In the early days of sector development, demand for electricity was low and the capital needs were manageable. Demand growth, though, has been rapid and the availability of concessional funds and grants is not keeping pace with the increasing capital requirements of the sector. Also, a shift in policy of development agencies towards social and governance objectives has seen an abrupt decline in support for power generation investments. Transmission, distribution and off-grid projects continue to receive direct concessional lending.

The financing vacuum left by the withdrawal of the development agencies has been filled for the moment by non-traditional sources of finance, notably the China Exim Bank. Finance from these sources appears to be abundant and the financing model is effective in accessing loans, but it is new and the associated procurement practices are weak.

(ii) Privately financed projects for export markets:

GOL signed MOUs with the governments of Thailand and Vietnam for the export of about 3000 MW over the period up to 2010. The private sector responded vigorously to the opportunities these agreements offered and about 24 project MOUs were signed with private developers between 1991 and 1997 based on the BOT model.<sup>1</sup>

Promotion of IPP projects in Lao PDR begins with an unsolicited proposal from a sponsor and, from this, an MOU is drawn up and a concession ultimately negotiated. Concessions are awarded in the absence of competition after the sponsor has completed technical and environmental studies of the proposed project.

The Lao IPP program met with initial success and two hydropower projects, Theun Hinboun and Houay Ho, were implemented. The Asian Economic Crisis and problems among key international power sector investors exposed many weaknesses in private financing models in use throughout the region. This has seen a downturn in private sector interest and no IPP projects in Lao PDR have been financed since the Theun Hinboun loans were closed about a decade ago.

The recent signing of the Nam Theun 2 PPA and advances in the development phases of the Nam Mo, Xe Kaman 3, and Theun Hinboun Expansion projects signal a recovery, but fundamental problems in the planning and procurement of private power projects remain.

The development of the PSDP is an important step towards establishing rational sector planning but there is a parallel need for compatible financing and procurement models to complement the plan by facilitating the implementation of power sector projects, whether EdL or private, in accordance with the PSDP. Aspects that need strengthening include the following:

- Selection of projects, being based on unsolicited proposals, tends to be *ad hoc* and sub-optimal;
- Selection of developers does not effectively discriminate between opportunistic adventurers and reputable, experienced sponsors. This has been a contributing factor in the difficulties developers have encountered in securing lender commitment;
- PPAs are negotiated project-by-project. EGAT and EVN have the advantage in such negotiations because they are not as dependent on a single project as the developer and their commitment is therefore weaker. Compromises by developers on tariff reduce tax and royalty entitlements;

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<sup>1</sup> All but two of the MOUs were for hydropower projects – the exceptions being a lignite-fired plant (Hongsa) and a transmission project (Southern Laos Transmission Project).

- Transparency in concession negotiations is lacking and leaves GOL vulnerable to unreasonable risks and harsh commercial terms. GOL is particularly vulnerable to unfair determination of a project's capital cost;
- The development and financing of projects are attended by great uncertainty.
- Engineering and environmental standards are not clearly specified and enforced.

### 3.1.3 Future Trends

The power industry globally and regionally has undergone great changes over the last decade. Cooperation between ASEAN/GMS countries is increasing, 500 kV international grid interconnections are planned, and in the longer term competitive markets may emerge. While the trend towards regional integration is now well established, the pace at which it will happen and the timing and scope of specific initiatives is still open.

The PSDP is therefore prepared against an uncertain and changing backdrop and, if it is to be effective and relevant, it must be in harmony with the direction of sector development in the GMS/ASEAN region. Much of the uncertainty in power sector investment planning concerns the following:

- Extent of private sector involvement and the private power procurement models used to mobilize participation;
- Pace of integration of the GMS/ASEAN power systems and, in particular, the timing of transmission interconnections;
- On-going development of the legal, institutional and regulatory environment in Lao PDR;
- Strengthening of the institutional capacity in Lao PDR and improvements in the commercial position of EdL;
- Setting of wholesale and retail tariffs in Lao PDR and neighboring countries.

A number of trends are evident in the power sector of Lao PDR, although it is too early to say where they are leading. The opening of the sector to new financing models is fundamentally changing the way in which projects are planned and implemented.

An increasing convergence between domestic and export projects is likely. New models will evolve to better capture the benefits of system integration but it is not yet clear what form they will take. Possibilities include:

- Establishment of a regulator to set domestic retail tariffs and negotiate wholesale export tariffs. This would mean tariffs could be pre-set before

bidding power generation concessions and bidding would therefore be on some other criterion, perhaps the highest royalty payments;

- Creation of a centralized Lao power purchasing agency or cooperative that could competitively bid power concessions within Lao PDR and could sell the off-take from some or all Lao projects to domestic and/or foreign power purchasers. The agency (perhaps the regulator) could negotiate cross border trades from a position of greater strength because of the amount of MW it brings to the market;
- Development of models tailored to the demands of the capital markets with risks shared between IPPs, GOL, EdL and MLAs according to market tolerance – e.g. capping of unforeseen conditions exposure, sharing of hydrological risk (e.g. through a capacity charge for availability), etc.
- In the longer term, establishment of a competitive power market within the region and the emergence of merchant plants.

The PSDP covers the period to 2020 and there is a need to regard the Lao power system in a regional context in preparing development plans and to look beyond the present distinction between domestic and export markets.

## 3.2 Power Sector in Lao PDR

### 3.2.1 Status of Power System

The status of Lao power sector development is summarized in Table 3.1 and Figure 3.1. It is divided into four principal unconnected supply areas, and a number of smaller supply areas. In addition, off-grid village and household systems provide electricity to remote and isolated communities. Thus, electrification is provided through the following six supply areas:

- Northern Supply Area (EdL)
- Central C1 Supply Area (EdL)
- Central C2 Supply Area (EdL)
- Southern Supply Area (EdL)
- Isolated Supplies (EdL/Provinces)
- Off-grid electrification (Provinces/Private)

#### (i) Northern Supply Area

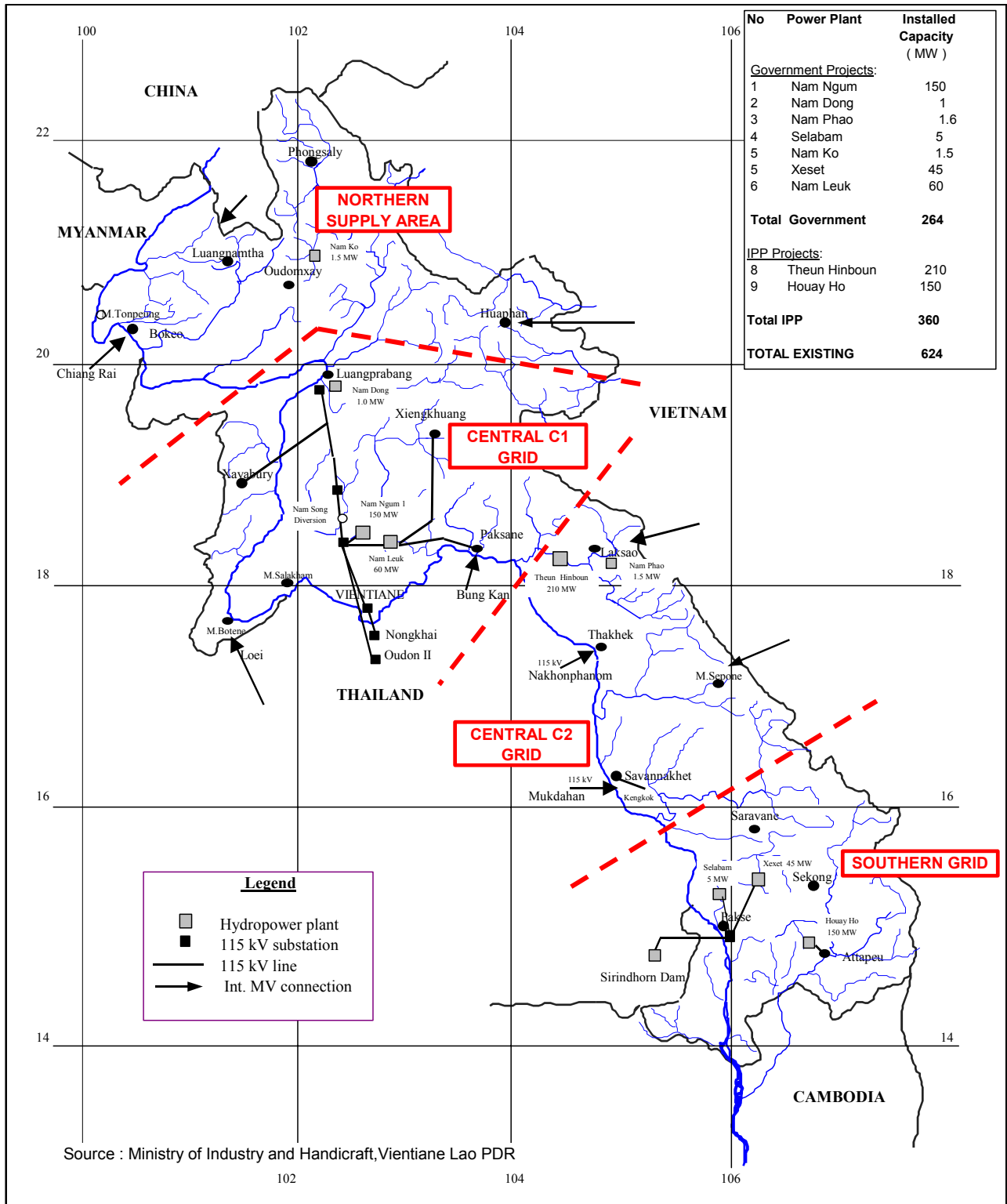
No HV grid has yet been established in the northern part of Lao PDR. Two of the main towns, Pongsaly and Luang Nam Tha, now have MV connections to the Chinese grid, but the tariff is high. A more permanent solution will be provided by a 115 kV transmission extension of the C1 grid from Luang Prabang to the three north-eastern provinces of Oudomxai, Pongsaly and Luang Nam Tha. This line is being financed by ADB under the second phase of its Power Transmission and Distribution Project (PTD2) and will be completed by 2007.

**Table 3.1: EdL Generation Plant**

Plant	Province	Grid	Capacity		Average Energy (GWh/a)	First Year of Operation
			Units (MW)	Total (MW)		
<b>HYDROPOWER</b>						
Nam Ngum (incl. Nam Song)	Vientiane	C1	2 x 15	30.0	1021	1971
			2 x 40	80.0		1978
			1 x 40	40.0		1984
Nam Dong	Luang Prabang	C1	3 x 0.336	1.0	3.0	1970
Nam Leuk	Vientiane	C1	60	60	249	2000
Nam Phao	Bolikhamxay	C1	3 x 0.5	1.5		1995
Selabam	Champassak	South	3 x 0.668	2.0	30	1969
Xeset 1	Saravane	South	1 x 3	3.0	180	1994
			2 x 3	6.0		1991
			3 x 13	39.0		1991
<b>Hydro Sub-total</b>			<b>263</b>	<b>263</b>	<b>1473</b>	
<b>DIESEL PLANT</b>						
<b><u>Region: C1</u></b>						
Sokpaluang	Vientiane		8.00		Operation 3hrs/day	1971
Sanakham	Vientiane		0.24		-	1993
Luangprabandg	Luang Prabang		1.64		-	1991-92
Phongsaly	Phongsaly		0.30		0.33	1994
Luangnamtha	Luangnamtha		0.32		0.35	1992
Xiangkhuang	Xiang Khuang		0.48		0.53	1995
Xayabury	Xayabury		0.78		1.53	1994
Oudomxay	Oudomxay		0.25		0.27	1978
Bokeo	Bokeo		0.48		0.53	1992
<b><u>Region: C2</u></b>						
Savannakhet	Savannakhet		1.00		-	1971
<b><u>Region: Southern</u></b>						
Pakse	Champassak		0.28		-	1970/85
Saravane	Saravane		0.40		-	1985
Attapeu	Attapeu		0.24		0.26	1993
<b>Diesel Sub-total</b>			<b>14.11</b>		<b>2.8</b>	

Source: Ministry of Industry and Handicraft

**Figure 3.1: Existing EdL System (Hydro generation and 115 kV Transmission)**



Sam Neua (Houphan Province) and Houayxai (Bokeo Province) are supplied as isolated supplies (refer (iv) below). Sam Neua will be connected to the C1 grid at Xieng Khouang through the construction of a 115 kV line under the third stage of the ADB's Power Transmission and Distribution Project (PTD3).

(ii) Central C1 Supply Area

Historically, the load in Lao PDR occurs predominantly in the Central C1 Grid which comprises a 115 kV transmission system connecting Vientiane, Luang Prabang, Vangvieng, Pakxan, Xieng Khouang and Sayaburi. 115 kV interconnections link the C1 and EGAT grids at Phontong (Nam Ngum 1), Thanaleng (Vientiane) and Pakxan.

Hydropower generation for the C1 Grid is provided by Nam Ngum 1 (150 MW, with Nam Song and Nam Leuk diversions to augment energy), Nam Leuk (60 MW) and Nam Dong (1 MW). In addition, there is limited diesel capacity including 8.2 MW at Sokpaluang (Vientiane) and 1.6 MW at Luang Prabang. The Nam Mang 3 hydropower project will contribute a further 35 MW when it is completed in 2005.

(ii) Central C2 Supply Area

The Central C2 area includes two separate networks, emanating from Thakek (C2.1) and Savannakhet (C2.2), each supplied by 115 kV interconnections with the EGAT grid. Under successive World Bank projects, i.e. the Provincial Grid Integration (PGI) and Southern Provinces Rural Electrification (SPRE 1) projects, these networks are radiating out, electrifying villages and towns in rural areas of Khammouane, and Savannakhet provinces. SPRE 1 includes about 52 km of 115 kV transmission line.

Under the current PPA between EdL and EGAT, EdL imports from Thailand at a premium on its export price, effectively a transmission charge for wheeling energy from the Nam Ngum/Nam Leuk plants through the EGAT system to the C2 grids.

(iii) Southern Supply Area

The Southern Grid services areas of Champassak and Saravane. The grid is supplied principally from three sources: from Xeset 1 (45 MW) and Selabam (5 MW) (both run-of-river), and from imports from EGAT. Xeset 1 is connected to Pakse and Ubon Ratchathani (Thailand) by a 115 kV line and to Saravane by a 22 kV line.

The town of Attapeu (Attapeu Province) has an isolated supply with generation provided by the Houay Ho IPP project.

As with the Central Supply Area, the PGI and SPRE 1 projects have extended the Southern Grid further into rural areas of Saravane and Champassak and this work will continue under the new SPRE 2 loan.



(iv) Isolated EdL Supplies

EdL is also responsible for the reticulation of electricity in a number of areas isolated from the main supply grids. Some centers import supplies across international borders through MV feeders.

Sam Neua and Vieng Xai (Houphan Province) are supplied by 35 MV feeders from Vietnam and Houay Xai (Bokeo Province) is supplied at 22 kV from Thailand.

Other towns receiving isolated cross border supplies include Xe Pon (Savannakhet) from Vietnam grid and Mouang Kenthao (Sayabury) from Thailand. More cross border connections are planned. Wholesale import prices for these supplies vary; Thai imports are at the PEA price for a large industrial customer while imports from EVN are charged at 6 ¢/kWh. Retail sales in areas supplied from cross border connections are largely to domestic customers and the EdL domestic tariff is currently below wholesale purchase prices.

Isolated hydropower and diesel generators electrify other centres, e.g. Mouang Xai from Nam Ko hydropower plant (1.5 MW) and Laksao from Nam Phao hydropower plant. The township of Attapu is supplied from the Houay Ho IPP project. Sometimes EdL is responsible for providing isolated supplies (e.g. Laksao, Attapeu) but in the majority of cases it is the relevant provincial, district or village authority.

(v) Off-Grid Supplies

Much of the country lies beyond the economic reach of the EdL's grids and off-grid development provides the only prospect of electrification for many isolated rural communities. The Rural Electrification Department of DOE is responsible for a program of off-grid electrification at a village and household level using micro- and pico-hydro, diesel and solar technologies. Subsidy funding is mobilized from GOL and donor sources and there are plans to establish a Rural Electrification Fund to coordinate and channel contributions. A system of licensing enterprises to provide off-grid services is being introduced.

Approximately 5,000 household installations have been completed or are planned under this program. This is expected to grow to 150,000 by 2020.

### 3.2.2 Electricity Trade with Neighboring Countries

Electricity trading between Lao PDR and its neighbors is carried out at several levels:

- (i) Committed exports are made under project-specific PPAs that set out strict conditions (including penalties) governing delivery of capacity and

energy. At present, PPAs have been signed only with EGAT (Theun Hinboun, Houay Ho and Nam Theun 2), although negotiations are in progress with Vietnam in respect of two other proposals, the Nam Mo and Xe Kaman 3 projects.

- (ii) Under a blanket PPA between EdL and EGAT, EdL can freely export surplus energy without committing to the quantity or timing of either. Electricity exports from Lao PDR began in 1971 with the commissioning of Nam Ngum 1. In the period since, the trade has provided a significant source of foreign exchange but it is tapering off as local demand absorbs surplus energy and periodic tariff negotiations erode price.
- (iii) As outlined in the previous section, there is opportunistic power trading with Lao PDR's neighbors for least-cost supply to border areas. EdL's PPA with EGAT allows EdL to import capacity and energy at the PEA large customer tariff and several important border towns have been supplied in this way. Similar arrangements are in place allowing localized MV imports from China and Vietnam to supply towns near those borders.

While electricity trading has been an important feature of the sector's development to date, its role in future sector development is potentially profound. Given the country's location between populous and growing neighbors, the Lao power system is likely to take on an increasingly regional dimension.

### **3.2.3 EdL System Development**

Expansion of the EdL grid has been rapid and this has brought electricity to many rural towns and villages.

In the past, EdL relied primarily on multilateral and bilateral finance for transmission and distribution projects with the ADB playing a central role in the north and the World Bank in the south. Despite re-focusing their resources in recent years, the World Bank and ADB continue to support grid extension projects. Bilateral funds from Japan and India also contribute to the development. Grid expansion as well as economic development is fuelling the high rates of growth in domestic demand.

Generation expansion has not kept pace with demand growth. The funding gap left by the withdrawal of MLAs from generation is being partially filled by loans from the China Exim Bank.

### **3.3 Review of Past Studies**

#### **3.3.1 Summary of Key Studies**

The PSDP draws on the extensive work of others in its formulation. A large number of studies and documents related to the Lao power sector have been prepared over the last decade and this body of work provides a useful foundation on which to base the integrated planning of the Lao power sector. Many previous studies are narrow and project-specific in nature and add only to our understanding of a particular site or basin. Collectively, though, these project studies extend our knowledge of the county's commercially exploitable energy resource base and provide useful data for evaluating and ranking projects. The objectivity of some of project studies can be questioned and the information is used with care. (There is evidence in some cases of commercial interests of project sponsors influencing content and conclusions.)

Other studies take a broader planning perspective and explore optimal development directions and sequences. The PSDP overlaps and duplicates much of this material.

Studies of particular relevance to the PSDP are listed in Table 3.2). Wherever this work is current, correct and relevant, it is adopted without duplication.

**Table 3.2: Key References: Power Sector Planning Studies and Projects**

Study	Year	Funding	Focus
<b><u>Strategy Studies:</u></b>			
Power System Planning in the MIH	1997	ADB	Domestic hydropower (< 50MW)
Hydropower Development Plan for Lao PDR	1998	EU	Evaluation of projects > 50 MW
Nam Theun 2: Study of Alternatives	1998	WB	Export hydropower projects
Hydropower Development Strategy Study	1999	WB	Rank domestic & export projects
Power System Strategy Study	2002	ADB	Domestic and export projects
EdL PDP – PDP2002-12, July 2003 (draft)	2003	EdL	Power system expansion.
<b><u>Basin Development Studies/Projects:</u></b>			
Masterplan Study on Hydroelectric Power Development in the Sekong Basin	1995	JICA	Coordinated hydropower development in Xe Kong
Water Management Plan for the Nam Theun / Nam Hinboun, Lao PDR	1997	ADB	Coordinated water management in Nam Theun
Se Kong, Se San and Nam Theun River Basins Hydropower Study	1999	ADB	Hydropower dev. in 3 river basins
Nam Ngum River Basin Development Sector Project	2003+	ADB	Integrated water resources management of Nam Ngum
<b><u>Transmission Planning Studies:</u></b>			
Establishment of Lao National Grid Company	1997	ADB	Technical legal and commercial.
Lao National Grid Study (Lahmeyer)	1997	GOL	Development of national 500kV grid
Nam Ngum 500kV Transmission Project, Part A: Feasibility Study	1998	ADB	Technical planning of Nam Ngum 3 transmission line
Masterplan of Transmission Lines and Substation Systems	2002	JICA	Domestic grid development
Indicative Masterplan on Power Interconnections in GMS Countries	2001/2	ADB	GMS grid development
<b><u>GMS Power Demand:</u></b>			
Thailand: General Information EGAT Power Development Plan, (draft April 2003)	April 2003	EGAT	Plan for expansion of generation and transmission in Thailand
General Information: EGAT Power Development Plan (draft – April 2003)	April 2003	EGAT	Plan for expansion of generation and transmission in Thailand
North Eastern Thailand: Power Development Plan (PDP 2003)	2003	EGAT	Plan for generation and transmission expansion in NE Thailand
Thailand: Power Development Plan – (presentation Manila 16-17 June 2003)	2003	EGAT	Plan for expansion of generation and transmission in Thailand
Vietnam: PDP and Power Interconnection among Vietnam, Lao PDR and Thailand (presentation Manila 16-17 June 2003)	June 2003	EVN	Generation and transmission expansion Plan and interconnection with Lao PDR and Thailand
Myanmar: Developments in the Power Sector	Dec 2001	Min of Elec Power	Plan for expansion of generation and transmission in Myanmar
Power Generation Country Report (Myanmar)	2003	Min of Elec Power	Long term plan for expansion of generation in Myanmar.

### 3.3.2 Reconciliation of Study Differences

Inconsistencies exist between studies and an objective of the PSDP is to reconcile them. The inconsistencies derive from differences in:

- methodology
- level of detail and effort
- study objectives
- parameter values, constraints and other assumptions.

In most cases disparities can be traced to differences in assumptions and parameters. Agreement on appropriate values was reached at the Inception Workshop. This was held a few weeks after mobilization of the Consultant and it provided a formal forum for debating many of the divergent issues. The principal participants in the power sector, representing diverse and sometimes conflicting interests, were represented at the workshop and their views were influential in deciding assumptions and constraints to be employed in the formulation of the PSDP.

The two most recent and relevant studies to the PSDP are the Hydropower Development Strategy Study (HDSS) and the Power Sector Strategy Study (PSSS).<sup>2</sup> The more prominent disparities in the conclusions of the HDSS and PSSS are listed in Table 3.3. They are attributable in large part to the financing assumptions on which each is based. For the most part these are reconciled by adopting values agreed with stakeholders in the Inception Workshop and as otherwise advised by the Consultant's infrastructure financing specialist (refer Annex 4.1).

In the PSDP, investment recommendations are made on the basis of project rankings and system expansion plans determined using economic methodologies and a discount rate of 10%. Financing terms (and the availability of concessional financing) are not considered in the investment recommendations; the financing of investments is treated as a separate matter and is discussed in Section 9.

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<sup>2</sup> *Hydropower Development Strategy Study*, Worley – Lahmeyer, World Bank (2000); and *Power Sector Strategy Study*, Electrowatt – PA Consulting, ADB TA 3374-LAO (2002).

**Table 3.3: HDSS and PSSS – Comparison of Conclusions**

	HDSS (2000)	PSSS (2002)
<b>Export Projects</b>	<p>In the current tariff regime, few projects are likely to meet the objectives of power purchasers, sponsors, lenders and GOL.</p> <p>Concession = 25 years from COD.</p> <p>Multilateral Partial Risk Guarantee (PRG) support for IPP projects is rationed. Also, PRG available only to projects providing demonstrable benefits to GOL. Under the current tariff regime, there are few projects technically capable of this.</p> <p>Assumptions regarding commercial loan terms and fees, and project development costs are more stringent than PSSS.</p> <p>IDA or ADB's ADF highly concessional finance cannot be relied on for GOL equity.</p> <p>Assumed limits to the number of project concurrently under development based on limited capacity of EdL and GOL to borrow money and to negotiate, monitor and implement projects.</p>	<p>In the current tariff regime, there are enough attractive projects to meet hurdle rates of return at avoided cost tariffs to ensure GOL's export commitments of around 4,000 MW are met.</p> <p>Concession = 30 years from COD.</p> <p>Assumes PRG support more widely available</p> <p>Less stringent assumptions regarding loan terms and fees, and project development costs.</p> <p>Concessional finance available for GOL equity. Theun Hinboun model adopted.</p> <p>GOL's institutional capacity and access to finance on reasonable terms do not constrain IPP development.</p>
<b>Domestic Supply</b>	<p>Financed with concessional IDA or ADF finance, domestic hydropower projects provide least cost source of generation. However, concessional lending for generation is becoming scarce. Without concessional loans, least cost supply is:</p> <p><u>Northern</u>: Either interconnection with main grid or domestic hydro (e.g. Nam Beng);</p> <p><u>C1 and C2 Grids</u>: Interconnect main grid with Central grids; 75 MW off-take from Nam Theun 2; if NT2 doesn't proceed, import from Thailand.</p> <p><u>Southern Grid</u>: Domestic hydropower (Xe Katam) or import from Thailand.</p> <p>Power system expansion planning takes stochasticity of hydropower plant into account</p> <p>Relied on domestic off-take only from NT2 because of the greater certainty of this project but otherwise regarded such sources opportunistically because of development uncertainties.</p>	<p>Financed with concessional IDA or ADF finance, domestic hydropower projects provide the least cost source of generation. Concessional lending will be available for all projects and on this basis, the least cost supply is:</p> <p><u>Northern</u>: Interconnection</p> <p><u>C1 and C2 Grids</u>: Interconnection of grids with development of Nam Ngum 5 and Nam Mang 3</p> <p><u>Southern Grid</u>: Domestic hydropower (Houay Lamphan Gnai).</p> <p>Comparison of development scenarios is based on annual average values for demand and supply, masking system reliability problems due to annual and seasonal hydrological fluctuations.</p> <p>Domestic off-take allocations form an integral part of domestic generation expansion planning.</p>

### 3.4 Overview of PSDP Planning Methodology

The following steps were used to identify the power system investments that meet forecast demand in Lao PDR and maintain minimum system security standards at least-cost:

1. Evaluate EdL's demand forecast and adjust as appropriate. The demand forecast derives from EdL's electrification plan scoped to achieve GOL's electrification target of 90% electrification by 2020.
2. Prepare a supply curve of attractive projects. Projects will be chosen not only for their suitability in supplying EdL's grids at least-cost, but also for their competitiveness in selling electricity into Lao PDR's target export markets.
3. Prepare an optimal generation and transmission development plan for the power sector. Transmission system development will link new power stations, interconnect grids and reinforce and extend the system to achieve the objectives of the electrification plan.