Lao People's Democratic Republic
Ministry of Energy and Mines

Data Collection Study (Preliminary Assessment) on Energy Sector in Lao People's Democratic Republic

Final Report
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JAPAN INTERNATIONAL COOPERATION AGENCY
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Abbreviations

3E	Energy Security, Economics and Environment
AAGR	the Annual Average Growth Rate
ADB	Asian Development Bank
APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Center
ASEAN	Association of South East Asian Nations
B10	Diesel fuel blended with 10% Bio-diesel
BAU	Business as Usual
bbl	barrel
BDF	Biodiesel Fuel
bil.	billion
BOO	Build-Own-Operate
BOT	Build-Operate-Transfer
BRICs	Brazil, Russia, India, China
BT	Build-Transfer
C. V.	Calorific Value
CA	Concession Agreement
CDM	clean development mechanism
CIF	Cost, Insurance and Freight
CO2	Carbon dioxide
COD	Commercial Operation Date
CPI	Consumer Price Index
DBMS	Database Management System
DEB	Department of Energy Business
DEM	Department of Energy Management
DEPD	Department of Energy Promotion and Development
DEPP	Department of Energy Policy and Planning
DODT	Department of Domestic Trade
DOE	Department of Electricity
DOM	Department of Mine
E10	Gasoline blended with 10% Ethanol
ECI	Electrical Construction and Installation
EdL	Electricite du Laos
EdL-Gen	EdL-Generation Public Company
EDMC	Energy Data and Modeling Center
EGAT	Electricity Generating Authority of Thailand
EGEDA	Expert Group on Energy Data and Analysis
EMS	Energy Management System
ESCO	Energy Service Company
ESSPA	Energy Supply Security Planning in the ASEAN
EWG	Energy Working Group
F/S	Feasibility Study
FAO	Food and Agriculture Organization
FS	Feasibility Study
GDP	Gross Domestic Product
GMS	Greater Mekong Sub-region
GNU	GNU's Not Unix!
GoJ	Government of Japan
GoL	Government of Lao PDR
GoT	Government of Thailand

GWh	Gigawatt hour
HH	house hold
IBRD	International Bank for Reconstruction and Development
ID	Identification
IEA	International Energy Agency
IEEJ	Institute of Energy Economics, Japan
IFC	International Finance Corporation
IMF	International Monetary Fund
IPP	Independent Power Producer
IPP(d)	Independent Power Producer for domestic supply
IPP(e)	Independent Power Producer for export supply
IREP	Institute of Renewal Energy Promotion
IRR	Internal Rate of Return
JICA	Japan International Cooperation Agency
JODI	Joint Organizations Data Initiative
ktoe	thousand tons of oil equivalent
kWh	kilowatt hour
Lao PDR	Lao People's Democratic Republic
Laos	Lao People's Democratic Republic
LDC	Least Developed Country
LECS	Lao Expenditure Consumption Surveys
LFGA	Lao Fuel & Gas Association
LHSE	Lao Holding State Enterprise
LIRE	Lao Institute for Renewable Energy
LNG	Liquefied Natural Gas
LNMC	Lao National Mekong Committee
LPG	Liquefied Petroleum Gas
LSB	Lao Statistics Bureau
LSFC	Lao State Fuel Company
LSX	Lao Securities Exchange
MAF	Ministry of Agriculture and Fisheries
MB	Million Barrel
MDGs	Millennium Development Goals
MEM	Ministry of Energy and Mines
MESD	The Strategy Plan For Developing the Energy and Mines from 2006 to 2020
METI	Minister of Economy, Trade and Industry
MHP	Micro/Mini hydropower
MIC	Ministry of Industry and Commerce
MIH	Ministry of Industry and Handicrafts
MNRE	Ministry of Natural Resource and Environment
MOIC	Ministry of Industry and Commerce
MOU	Memorandum of Understanding
MPI	Ministry of Planning and Investment
MRC	Mekong River Commission
Mtoe	Million tons of oil equivalent
MUSD	Million US Dolars
MW	Megawatt
NCD/LIBC	Name of Lao Private Company
NEDO	New Energy and Industrial Technology Development Organization
NLD	National League for Democracy
NPV	Net Present Value
O&M	Operation and Maintenance
ODA	Official Development Assistance
OECD	Organization for Economic Co-operation and Development
OJT	On-the-Job Training

P2P	Power to the Poor
PC	Power Conditioner
PDA	Project Development Agreement
PDCA	Plan-Do-Check-Act
PDEM	provincial government of Energy and Mine
PDP	Power Development Plan
PEA	Provincial Electricity Authority of Thailand
PF	plant factor
PMU	Project Management Unit
PPA	Power Purchase Agreement
PSC	Production Sharing Contracts
PTT	Petroleum Authority of Thailand
PV	Solar Photovoltaics
PV Oil	Petrovietnem Oil
PVEP	PetroVietnam Exploration Production Corporation
RE	Renewable Energy
REDS	Renewable Energy Development Strategy in Lao PDR
REF	Rural Electrification Fund
REP	Rural Electrification Program
REP 1	Rural Electrification Program Phase 1
REP 2	Rural Electrification Program Phase 2
SDC	Shlapak Development Company Contract Area
SEZ	Special Economic Zone
SHP	small hydropower
SHS	Solar Home System
SLACO	Sino-Lao Aluminum Corporation
SVC	Static Voltage Compressor
SVR	Static Voltage Regulator
T. M.	Total Moisture
T. S.	Total Sulfur
TA	Tariff Agreement
TD	Total Depth
TFEC	Total Final Energy Consumption
TPES	Total Primary Energy Supply
UC	Under Construction
UK	United Kingdom
UNTAC	United Nations Transitional Authority in Cambodia
US$	The United States dollar
USAID	US Agency for International Development
USD	The United States dollar
VOPS	Village Off Grid Promotion and Support
WB	World Bank
WS	WorkShop
WTI	West Texas Intermediate

Introduction

(1) Background to the Study

Total energy demand of the Lao People's Democratic Republic (Lao PDR) was 2.4 million tons of oil equivalent (Mtoe) in 2010, with an annual increment of 3 to 4% in parallel with stable economic growth. Therefore, it is estimated that total energy demand in 2025 will be 6.4 million tons, approximately 2.6 times current demand. In terms of sector-wise demand, the industrial sector accounts for about 31%, the transportation sector for about 29%, the residential sector for about 29%, the commercial sector for about 10%, and the agricultural sector for about 1%. Among these, the industrial sector and the transportation sector, in particular, show higher annual increases of 15% and 8%, respectively. These are sectors where remarkable growth of demand is expected.

Currently, the major energy supply sources are firewood/charcoal (about 47%), petroleum (about 19%), and hydropower (about 19%). However, in view of a sharp rise in energy consumption in the transportation and the industrial sectors, it is thought that the petroleum contribution of overall energy sources will be about 60% in 2025. In addition, the share of electricity is expected to grow substantially as the electrification rate increases from the current level of about 70% to 90% in 2020, and electricity consumption will increase sharply due to increasing use of home appliances.

The Government of Lao PDR is expected to establish institutions to secure energy efficiently by making reliable energy demand forecasts and formulating an appropriate energy policy and supply plan. To do so, the government needs to tackle the several issues listed below:

- Imbalance in power supply/demand
- Seasonal fluctuation
- Energy security
- International power trade
- Energy efficiency
- Renewable energy
- Institutional capacity

(2) Objectives of Study

As a preparatory step toward full-scale technical cooperation including assistance in preparing an energy master plan, the Data Collection Study on Energy Sector in Lao PDR (the Study) aims to acquire basic information on demand in the energy sectors in Lao PDR, analyze and identify the current capabilities of the organizations concerned, assess the potential for domestic fossil fuels and renewable energy sources, forecast energy demand, review present scenarios, and propose an outline energy supply and development scenario and database.

(3) Study Areas

The entire territory of Lao PDR (literature search also includes neighboring countries)

(4) Counterpart Organization
The Ministry of Energy and Mines of Lao PDR

(5) Schedule of Study
From January 2012 to August 2012

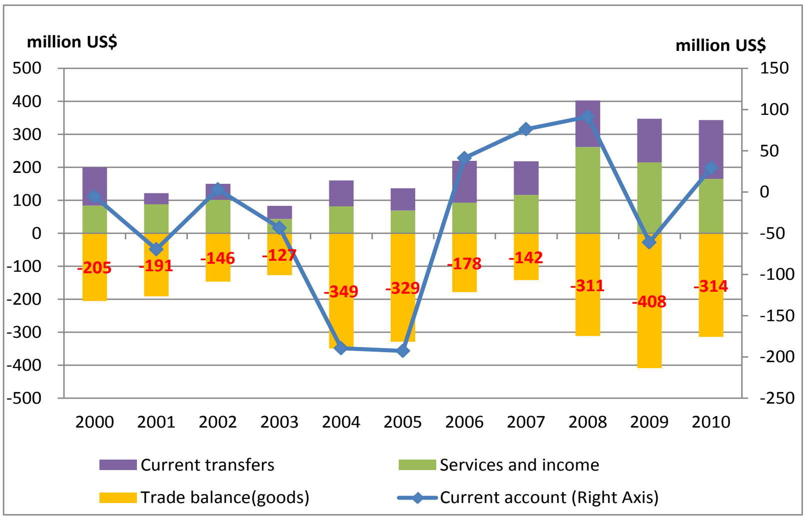
1 Current Situation of Energy and Economy

1.1 Economic situation

1.1.1 Aiming for a transition to a market economy and ASEAN regional integration

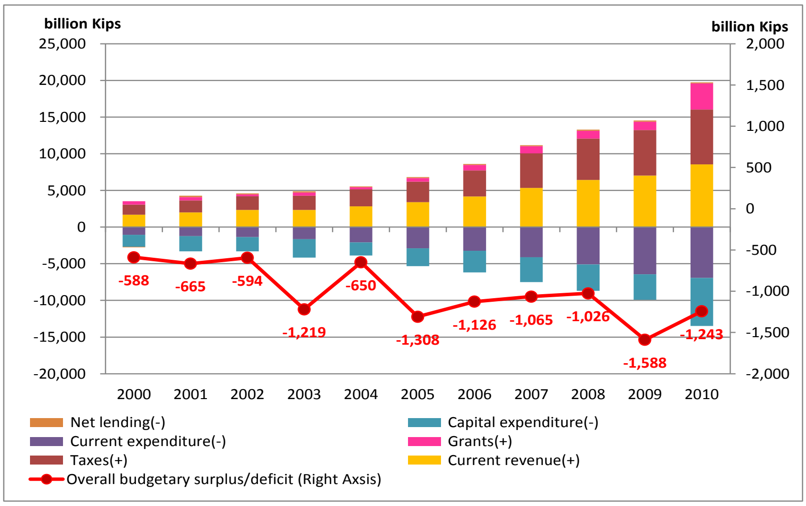
Lao People's Democratic Republic (Lao PDR) was established in 1975 as a result of the abolition of the monarchy. Since then, Lao PDR has promoted economic development with support from socialist countries such as the Soviet Union. In 1986, Lao PDR launched a new economic policy, Chintanakan Mai, to move away from a centrally controlled planned economy. However, suffering from a critical foreign currency supply situation due to a sharp drop in aid from the Soviet Union and Eastern Europe (collapse of the Soviet Union and Eastern Europe starting with the fall of the Berlin Wall), Lao PDR made the choice to accept assistance from international organizations such as IBRD, IMF, and ADB. The condition for assistance at that time was to transition from a planned economy to a market economy. Despite strict conditions, Lao PDR decided to overcome these difficulties by becoming a member of ASEAN in 1997 and achieving economic independence and development within regional economic integration (market economy).

Various reforms have been undertaken with foreign support during the last 25 years. The problem, however, is that Lao PDR has had twin deficits in trade (Figure 1.1-1) and budget (Figure 1.1-2) for 25 years, and it seems to be difficult to resolve this problem and appropriately adjust the macro-economy. Until now, these deficits have been reduced or mitigated by financial inflows from other countries, particularly foreign grant aid such as ODA. But, considering that regional economic integration will be accelerated in various ways: for example, tariff abolition within the ASEAN region by 2015, Lao PDR will inevitably be forced to improve its macro-economic situation by clearing the twin deficits as soon as possible. Myanmar, a neighbor of Lao PDR, which has a population of about 64 million and large natural gas and petroleum reserves, is not only geopolitically important, but is also rapidly democratizing. Myanmar is expected to appear in the international market as a major player in the region, thus foreign capital flows in this region are likely to change significantly. In this connection, Lao PDR has to promote economic reforms to achieve an independent economy and economic growth, while paying more attention to the behavior of its neighbors.



Source: Key Indicators for Asia and the Pacific 2011 (ADB)

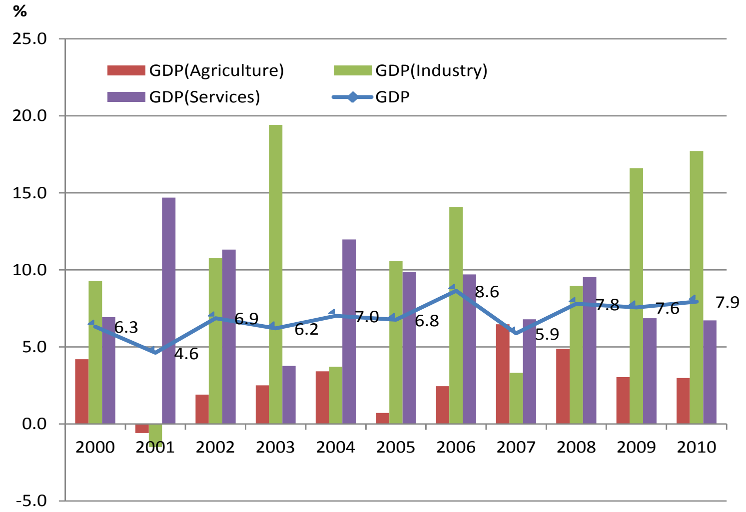
Figure 1.1-1 International Trade Balance



Source: Key Indicators for Asia and the Pacific 2011 (ADB)

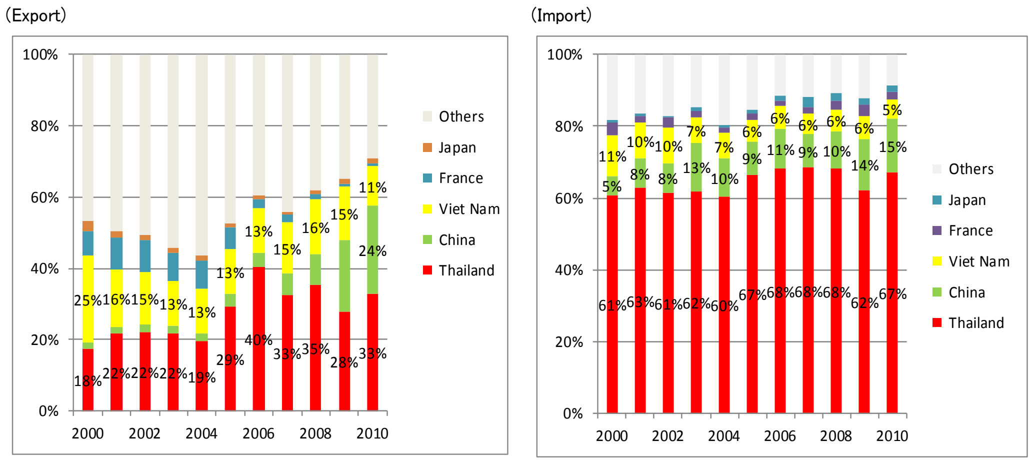
Figure 1.1-2 Financial Balance

The country faced a severe economic situation during the Asian financial crisis in 1997 such as a weak currency and accelerated inflation, but since then has launched various reforms. Although some reforms have not been progressing well, the country's economy has been growing significantly, i.e., 7.5% average (real) GDP growth rate during the past five years as shown in Figure 1.1-3 (2006: 8.6%, 2007: 5.9%, 2008: 7.8%, 2009: 7.6%, and 2010: 7.9%). Such high growth rates owe a lot to the industry sector, which has achieved over 12% growth during the past five years. The core industries are power generation development, which uses the abundant water resources in the Mekong region, and mining development such as gold and copper mining.



Source: Key Indicators for Asia and the Pacific 2011 (ADB)

Figure 1.1-3 GDP Growth Trends



Source: Key Indicators for Asia and the Pacific 2011 (ADB)

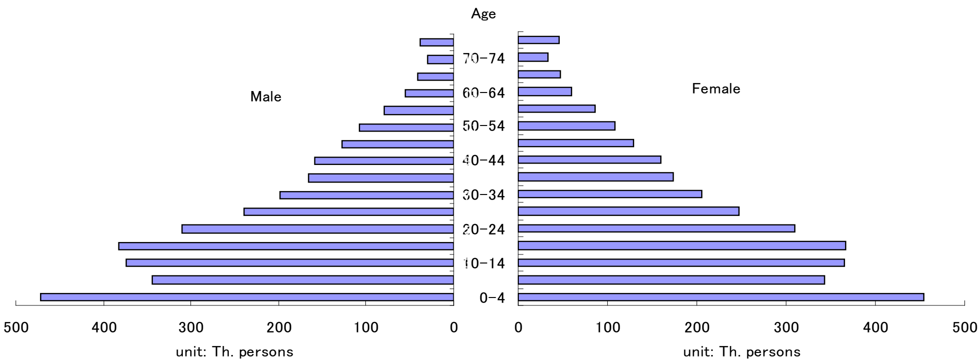
Figure 1.1-4 Trade Volume (exports and imports) by Country[1]

As exports increase in parallel with economic growth as shown in Figure 1.1-1, imports such as raw materials (including energy) and intermediate goods (capital assets) will increase at a higher level. As a result, the trade balance deficit increases. Trade volume by country, on the other hand, shows a significant change (Figure 1.1-4). Thailand and Vietnam were the largest and second largest export markets in 2000, accounting for about 40% of total export volume, but in 2010, rapidly growing China replaced Vietnam as the second largest importer, accounting for about 24%. This means China has greatly increased its importance to Lao PDR

[1] International trade balance statistics are calculated based on the transfer of property rights for products whereas trade statistics (direct trade) are based on custom clearance. Therefore, indirect trade, for example, raw materials exported from Country A, processed in Country B, and then exported to Country C, is deducted.

in recent years. Thailand is the largest source of imports, accounting for 60-70%, followed by China in second place (about 10%) and Vietnam in third place (about 5%). This order has not changed during the period, but here again China has been increasing its share gradually.

The population of Lao PDR has been growing at an annual average of about 2% since 2000, and the population cohort aged 15-65 accounted for 59% in the population pyramid in 2010. This large labor population is expected to make a substantial contribution to the future economic development of Lao PDR but, at the same time, the country needs to provide sufficient employment opportunities for this population. The industrialization strategies set forth by the Lao government will, therefore, pose an important policy challenge.



Source: Statistical Yearbook 2010, Ministry of Planning and Investment

Figure 1.1-5 Population Pyramid of Lao PDR

1.1.2 The Seventh Five-Year National Socio-Economic Development Plan (2011-2015)

The targets and directions of "The Seventh Five-Year National Socio-Economic Development Plan (2011-2015)" have four main aspects.

(a) Sustain high economic growth in harmony with society with a minimum target of 8% for the annual GDP growth rate and GDP per capita of more than USD 1,700.

(b) Achieve Millennium Development Goals (MDGs) by 2015 and introduce technologies and environments that enable the country to graduate from least-developed country status (LDC) by 2020.

(c) Achieve economic growth and at the same time make efforts to preserve culture, society, natural resources, and environment to secure sustainable development.

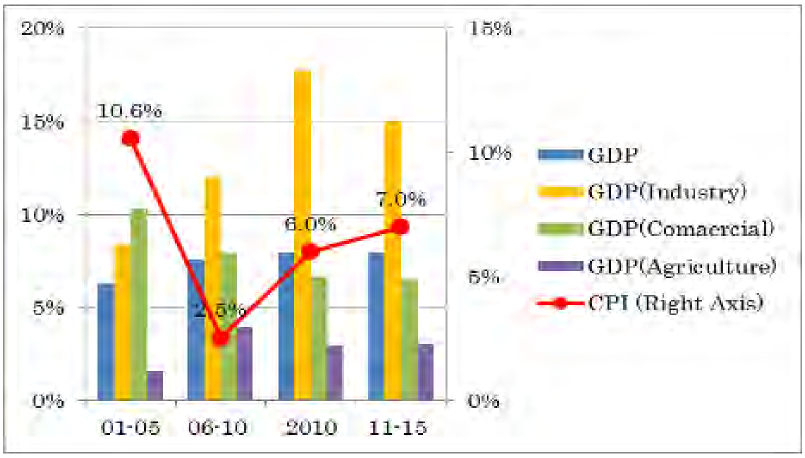
(d) Secure political stability, peace, and a society with public order.

The Development Plan sets the following major quantitative targets for macroeconomic indicators.

(a) Achieve at least 8% average annual GDP growth: at least 3% in the agriculture sector (23% of GDP), at least 15% in the industry sector (39%), and at least 6.5% in the service sector (38%).

(b) Stabilize the inflation rate at below the economic growth rate, and keep exchange rate fluctuations of the national currency, kip, at not more than 5%.

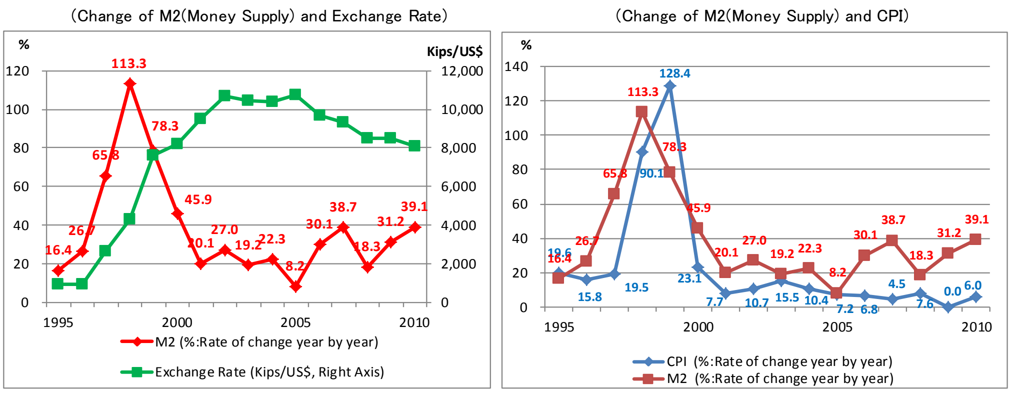
(c) Keep the annual financial deficit at less than 3-5% of GDP.



Source: ADB Macro Indicators

Figure 1.1-6 Economic Growth Rate by Sector

One concern about achieving the above targets is a steep rise in prices as a result of a weakened exchange rate and sharp increase in the money supply due to increasing pressure from expanding budget and trade deficits, which could be induced by expanded government expenditure and increased imports (capital goods and energy). As good economic performance during the Sixth Five-year Plan (2006-2010) was largely due to controlling prices and successfully stabilizing currency exchange rates through the government's budgetary and financial policies, as shown in Figure 1.1-7, stabilizing prices and currency exchange rates is considered to continue to be vital.



Source: ADB Macro Indicators

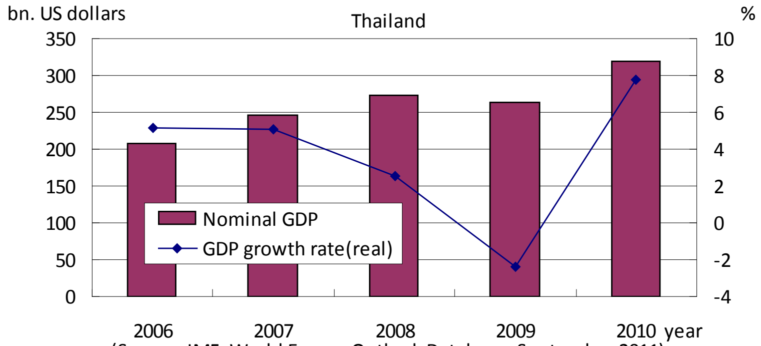
Figure 1.1-7 Exchange rates (against USD), M2 Fluctuation Rate, and Consumer Price Index

1.1.3 Economic situations of Greater Mekong Sub-region (GMS) countries

Lao PDR shares its borders with five countries, namely Thailand, Cambodia, Vietnam, Myanmar, and China, which form a region called the Greater Mekong Sub-region (GMS)[2]. Among these, Thailand, which is the top runner among ASEAN countries, and Vietnam, as a country that is also transitioning from a planned economy to a market economy, are models for Lao PDR, which is working towards economic development. The economic situations of Cambodia and Myanmar, as well as Thailand and Vietnam are explained briefly below as the development of Lao PDR depends greatly on close economic cooperation with GMS countries.

(1) Economic situation of Thailand

Thailand, which is one of the founding members of both ASEAN (1967) and APEC (1989), has maintained high economic growth through industrialization. The country has achieved high economic growth since the 1980s through economic stabilization and foreign capital inflows, and export demand under a fixed exchange rate. It recorded 9% annual economic growth during the 10 years from 1985. Despite a temporary contraction of the economy due to the transition to a floating exchange rate system after the Asian financial crisis in 1997, Thailand recovered to achieve high growth again as a result of attracting foreign capital and expanding exports. While the country's economic growth rate in 2010 was higher (7.8%) than those of Vietnam and the Philippines, the rate for 2011 is expected to be 1.5% due to extensive damage caused by catastrophic floods in the same year. The National Economic and Social Development Board of Thailand estimates the economic growth rate in 2012 will be 4.5-5.5% as the country recovers from damage caused by the floods and experiences an upswing. The IMF provides a similar projection of 4-5% for economic growth in the coming five years.



(Source: IMF, World Energy Outlook Database, September 2011)

	2006	2007	2008	2009	2010
Nominal GDP per capita (U.S. dollars)	3,296.1	3,917.9	4,300.0	4,151.3	4,992.4
Population (million persons)	62.8	63.0	63.4	63.5	63.9

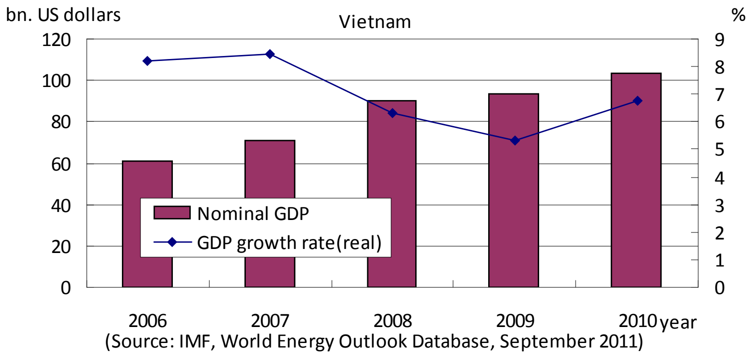
(Source: IMF, World Economic Outlook, September 2011)

Figure 1.1-8 GDP (nominal) and GDP Growth Rate (real) of Thailand

[2] GMS comprises countries located in the Mekong River basin, i.e., Thailand, Vietnam, Cambodia, Lao PDR, Myanmar, and China's Yunnan Province and the Guangxi Zhuang Autonomous Region (not in the basin).

(2) Economic situation of Vietnam

In 1986, Vietnam adopted the Doi Moi (Renovation) policy and introduced a market economy system as a socialist country. The economic growth rate has risen gradually since then, and the country became the first socialist member of ASEAN in 1995, and also maintained its growth even during the Asian financial crisis in 1997. Due to industrialization, the share of agriculture, forestry, and fisheries sectors in GDP has been declining, and has stood at about 20% in recent years. Vietnam achieved high economic growth of about 7% during the period 2006-2010. The GDP growth rate in 2011 is expected to be 5.8%, and the IMF estimates economic growth of about 6.0-7.5% until 2016.



(Source: IMF, World Energy Outlook Database, September 2011)

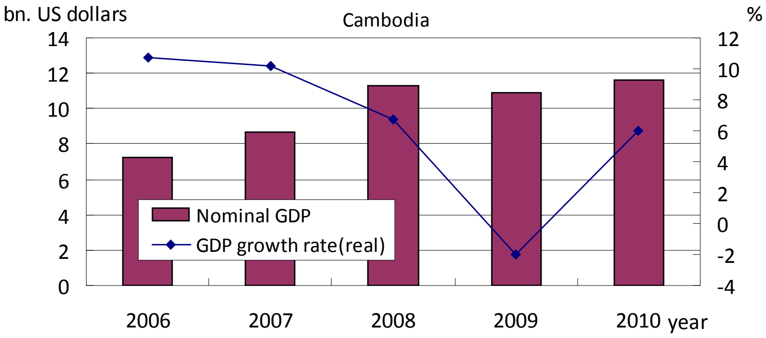
	2006	2007	2008	2009	2010
Nominal GDP per capita (U.S. dollars)	724.0	835.1	1,047.9	1,068.3	1,173.5
Population (million persons)	84.2	85.2	86.2	87.2	88.3

(Source: IMF, World Economic Outlook, September 2011)

Figure 1.1-9 GDP (nominal) and GDP Growth Rate (real) of Vietnam

(3) Economic situation of Cambodia

The Cambodian economy was been battered by civil war since 1970. With the launch of the United Nations Transitional Authority in Cambodia (UNTAC) as a turning point, however, the country achieved steady economic growth through large volumes of aid and promulgation of the investment law. Cambodia also had high economic growth during the 2000s, achieving 10.8% GDP growth rate in 2006 and 10.2% in 2007. While the major industries are agriculture, fisheries and forestry, manufacturing industries such as textiles and shoemaking, as well as tourism have recently been growing. Cambodia experienced a sharp drop in its GDP growth rate to -1.9% in 2009 when the global financial crisis occurred, because the economy largely depends on exports to the United States etc. In 2010, however, its growth rate recovered to 6.0% following the revival of the global economy. According to a projection by the IMF, high economic growth at about 6.0-7.5% is expected until 2016.



(Source: IMF, World Energy Outlook Database, September 2011)

	2006	2007	2008	2009	2010
Nominal GDP per capita (U.S. dollars)	526.4	626.7	805.1	768.4	813.8
Population (million persons)	13.8	13.9	14.0	14.1	14.3

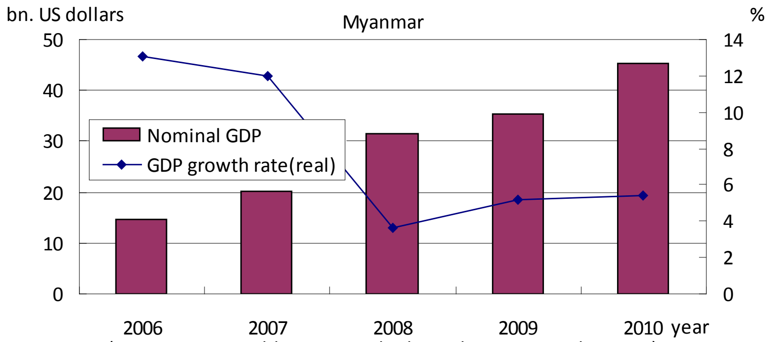
(Source: IMF, World Economic Outlook, September 2011)

Figure 1.1-10 GDP (nominal) and GDP Growth Rate (real) of Cambodia

(4) Economic situation of Myanmar

Myanmar achieved a high economic growth of 10% or more between 2000 and 2007. However, nationwide demonstrations by monks against the military government in September 2007 and repressive actions by the military government against these demonstrations incurred strong international criticism, which resulted in stricter economic sanctions by the United States and the European Union. Due to the global financial crisis, in addition to these sanctions, GDP growth rates during and after 2008 slowed to 3-5%.

In November 2010, Ms. Suu Kyi was released from house arrest, and a general election was held after an interval of about 20 years. As a result, the military political administration was replaced by the new administration in March of the following year. In a by-election of the Myanmar Federal Parliament held in April 2012, Ms. Suu Kyi and her party, the National League for Democracy (NLD), won a landslide victory. Based on this result, economic sanctions are expected to be further eased by various countries. The GDP growth rate during the period 2010-2012 is expected to be about 5.5% due to factors in recent years such as: development needs of the new capital Naypyidaw; development needs for construction of an expressway connecting the capital and Mandalay; and, economic recovery of neighboring countries that import food products and natural gas from Myanmar. IMF estimates economic growth of about 5-6% until 2016.



(Source: IMF, World Energy Outlook Database, September 2011)

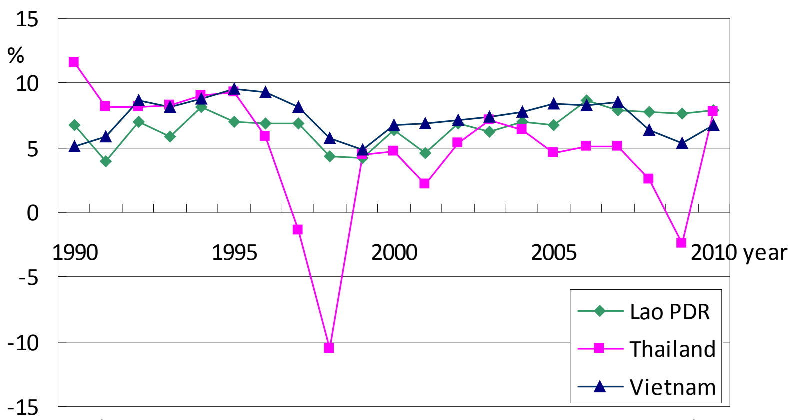
	2006	2007	2008	2009	2010
Nominal GDP per capita (U.S. dollars)	256.7	350.1	533.5	587.3	742.4
Population (million persons)	56.5	57.6	58.8	60.0	61.2

(Source: IMF, World Economic Outlook, September 2011)

Figure 1.1-11 GDP (nominal) and GDP Growth Rate (real) of Myanmar

(5) Medium- to long-term projection for the Lao economy

Tracing the history of economic development of neighboring countries, particularly Thailand and Vietnam, is important from the viewpoint of the flying geese pattern of development theory when considering the medium- to long-term economic growth of Lao PDR. Thailand's GDP per capita is already over USD 5,000, which is equivalent to the BRICs level, marking its emergence from being a developing country. Vietnam's economic development, on the other hand, is somewhat ahead of Lao PDR, aiming to transition from a planned economy under a socialist regime, as with Lao PDR, to a market economy. Although the environments of the two countries are not necessarily the same as Lao PDR—they have large populations and extensive energy resources such as petroleum, natural gas, and coal—their economic data are important leading indicators when considering the Lao economy in 10 or 20 years.



(Source: IMF, World Economic Outlook Database, September 2011)

Figure 1.1-12 Real GDP Growth Rate

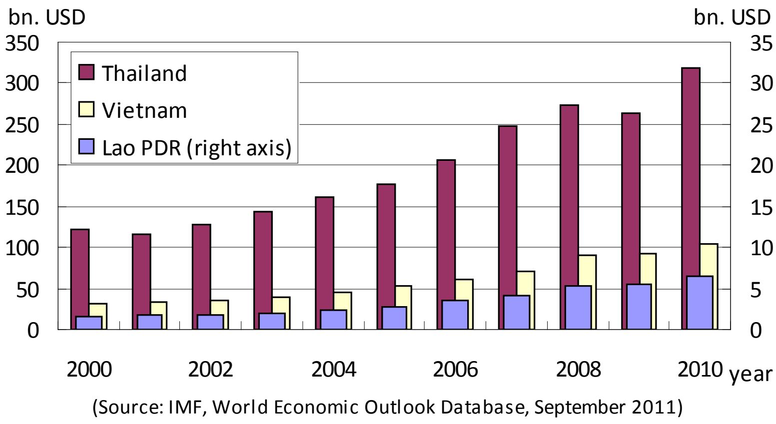


Figure 1.1-13 Nominal GDP

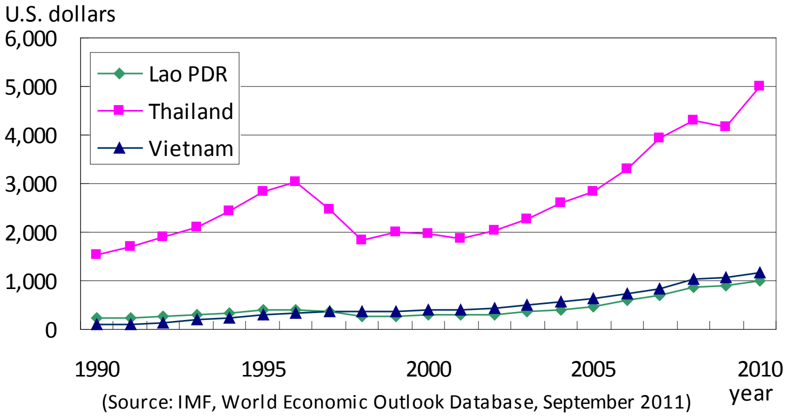


Figure 1.1-14 GDP per Capita

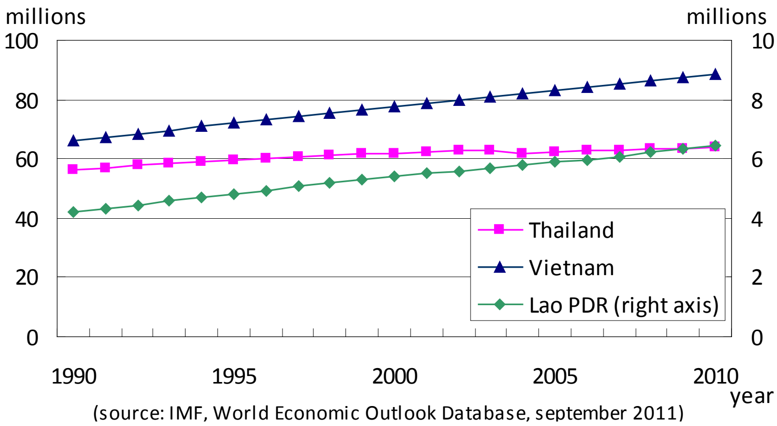


Figure 1.1-15 Population

1.2 Current situations of energy demand and supply

1.2.1 Energy outlook of Lao PDR

The most important aspect of the energy outlook of Lao PDR is that the country is a net exporter of electricity generated from hydropower using abundant water resources from the Mekong River and its tributaries. The net export volume in 2010 was more than double domestic electricity consumption. It is also said that the country has extensive coal resources, which are expected to cover almost all domestic demand for coal with the exception of a small volume of imports. However, detailed exploration for coal, with the exception of some coal deposits, has not been conducted. On the other hand, it has few petroleum resources, so all petroleum products are imported.

The largest share of energy sources of total final energy consumption is mainly fuel wood and charcoal by households, accounting for about 61% of total final energy consumption in 2010. The second largest is petroleum products such as light diesel oil and gasoline, which are mainly used in the transportation sector (26%), followed by electricity (8%) and charcoal (5%) in the commercial, industrial, and household sectors.

Comparing Lao PDR with Vietnam and Thailand based on comparable data for total primary energy supplies and total final energy consumption since 1990 provides us with the following findings. Vietnam achieved high growth (11% or more as an annual average) during the period 2000-2009 both for total primary energy supply and total final energy consumption. Total primary energy supply and total final energy consumption of Lao PDR, on the other hand, remained at about 5% as an annual average, which is nearly as low as Thailand. This finding for energy consumption is not necessarily balanced with the annual growth rate of nominal GDP during the same period, i.e., the growth rate of Lao PDR was 15%, which was higher than those of Vietnam and Thailand. This probably indicates differences among the countries in the progress of development such as motorization, along with economic development levels. In Lao PDR, which is still at the initial stage of development, explosive growth of energy demand from motorization is yet to be observed in data, whereas sharp growth of energy demand is observed during the same period in Vietnam, which is in the next development stage, and moderate growth is seen in Thailand, which is achieving further development ahead of Vietnam.

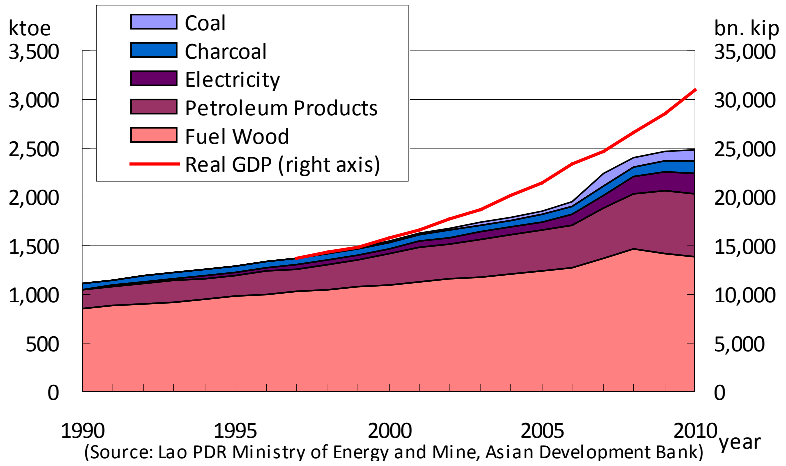


Figure 1.2-1 Total Final Energy Consumption by Energy Source

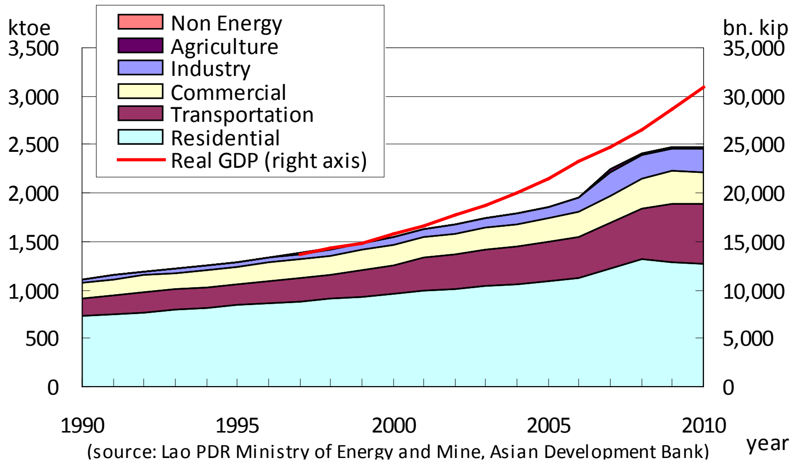


Figure 1.2-2 Total Final Energy Consumption by Sector

As mentioned earlier in this section, Lao PDR is a net exporter of electricity generated from abundant water resources. Although electricity is an important source of national revenue, the country occasionally imports electricity from its neighbor Thailand depending on the season and area. This is caused by fluctuations in water resource volumes in the rainy and dry seasons and bad connections between domestic power line systems in the northern, central, and southern regions. Such conditions force the country to make the choice to export electricity to Thailand from the region with surplus production of electricity (e.g. southern region) and import electricity to the region lacking electricity (e.g. central region) at higher rates for an excess amount compared with export one. To overcome this situation, power-line connections have recently been strengthened in the central and southern regions, and a central load-dispatching center is being established. Besides, coal thermal power plants, which are not affected by water volumes, are being constructed by IPP. It is expected that using part of the electricity generated by thermal power plants for domestic demand will be one measure to overcome the current situation.

Electricité du Laos (EdL) covers retail sales of electricity in Lao PDR, while IPP mainly exports electricity overseas, although it also supplies domestic consumers through EdL. EdL, which is responsible for all domestic retail sales, needs to estimate the future growth of domestic electricity demand, expand power generation facilities, and negotiate long-term contracts with IPPs. EdL, however, failed to accurately predict the sharp growth of electricity demand due to recent rapid economic growth. EdL did not satisfactorily meet domestic demand, and has been importing more electricity from Thailand than it exports since 2007. Such a situation was natural in a sense because EdL did not want to incur economic losses from overestimated electricity demand and signing large long-term electricity procurement contracts with IPP. It is, however, crucial for EdL, and moreover to improve the electricity situation of Lao PDR, to accurately forecast demand growth and secure the proper quantity of electricity.

1.2.2 Energy outlook of Greater Mekong Sub-region (GMS) countries

(1) Energy outlook of Thailand

Energy demand of Thailand has grown in parallel with rapid economic growth since the 1980s, and continued growing in general due to steady economic growth, although there were setbacks due to the Asian currency crisis and the global financial crisis. Aiming to improve energy intensity, the Thai Government is promoting rationalization and energy savings in the transportation sector, use of renewable energy, and development of domestic energy resources.

On the supply side, domestic resources are being tapped but cannot cover expanding demand in the country, thus Thailand is a net importer of petroleum and natural gas. The latest data show that the country imports just under 70% of petroleum demand, about 80% of which relies on imports from the Middle East. Natural gas demand was previously covered by domestic supplies, but recently about 30% of natural gas demand has been imported from Myanmar through pipelines. Thailand is relatively rich in coal resources and the reserve-production ratio is about 70 years. The government also promotes development of petroleum and gas resources under international bidding to promote domestic resource development; and at the same time, expansion of LNG imports is also being planned to respond to increased gas demand in the future.

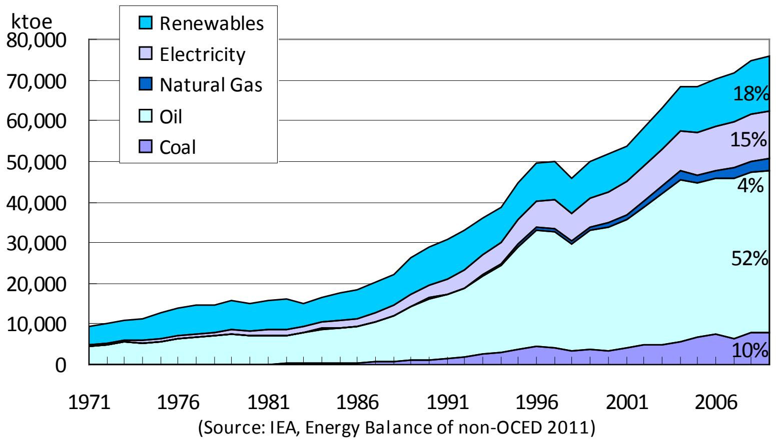


Figure 1.2-3 Total Final Energy Consumption (Thailand)[3]

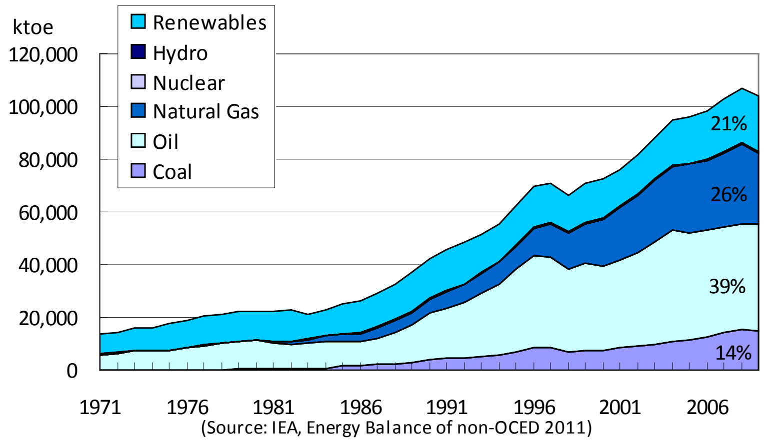


Figure 1.2-4 Total Primary Energy Supply (Thailand)

(2) Energy outlook of Vietnam

Energy demand of Vietnam has been increasing steadily in parallel with steady economic growth since 1990, when the country adopted the Doi Moi policy. Increases have been substantial in the industrial and transportation sectors due to industrialization in progress, but more than half of total demand still comes from the household sector, which is expected to continue to grow steadily.

On the supply side, Vietnam has relatively abundant domestic resources, and about 70% of coal and more than 90% of crude oil produced in the country have been exported since 1990. On the other hand, only a little natural gas is exported, with more than 80% of natural gas produced consumed by the power generation sector. Until 2008, the country had exported the majority of its crude oil, and in turn imported all petroleum products. It is expected that this situation will change in the future as domestic petroleum refineries have started operation

[3] Renewables include traditional biomass such as charcoal and firewood.

since 2009 and with a shift to full-scale development of a petroleum refinery in the country.

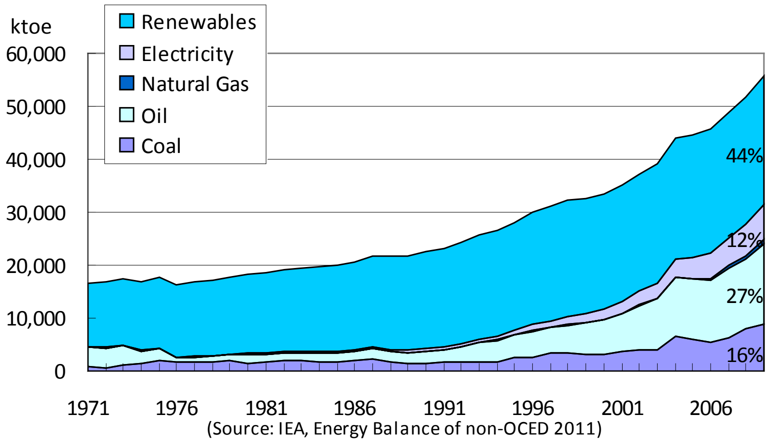


Figure 1.2-5 Total Final Energy Consumption (Vietnam)

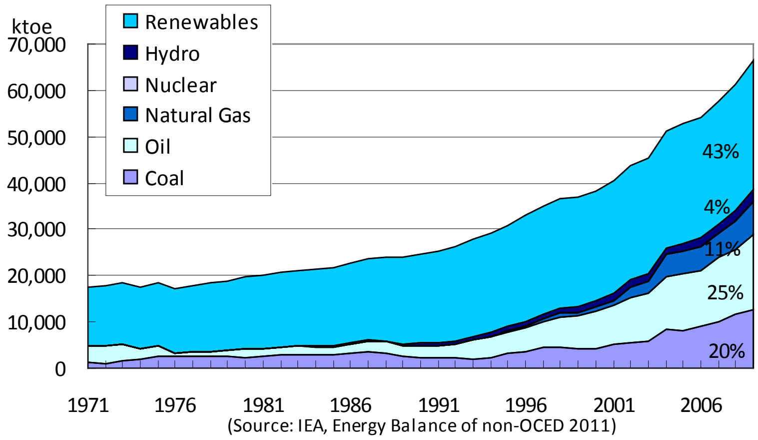
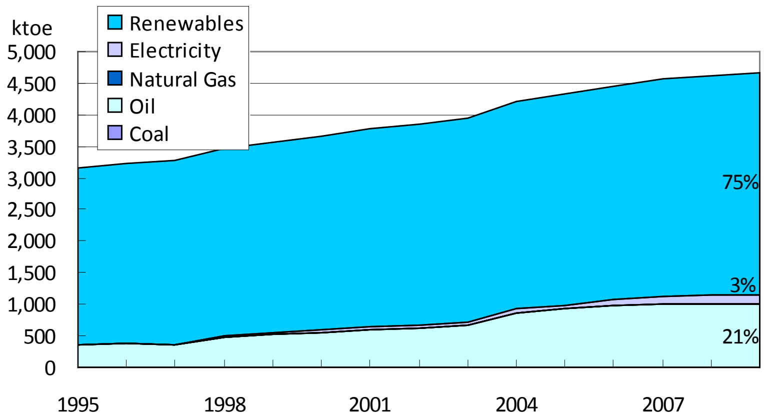


Figure 1.2-6 Total Primary Energy Supply (Vietnam)

(3) Energy outlook of Cambodia

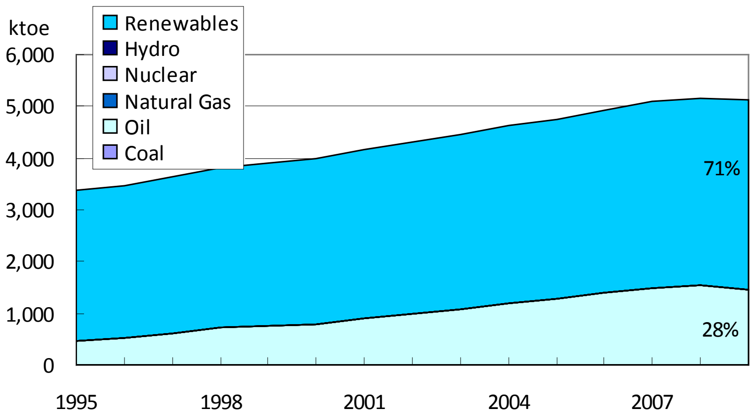
On the demand side, Cambodia's total final energy consumption increased from 3,153 ktoe in 1995 to 4,665 ktoe in 2009 at an annual rate 2.8%. The growth of demand for petroleum products and electricity has been particularly significant, recording 7.6% for petroleum products and 22.4% for electricity during the same period. Statistics shows no consumption of coal and natural gas yet, with only consumption of petroleum. The domestic electrification rate is still very low, which indicates that the above-mentioned current levels of demand will continue to grow.

On the supply side, no coal, petroleum, and natural gas are produced currently in Cambodia. Total primary energy supply reached 5,193 ktoe in 2008 from 3,373 ktoe in 1995, but remained almost at the same level in 2009 as the previous year (5,182 ktoe) because of the influence of economic stagnation due to the global recession. More than 50% of the increase in total primary energy supply during the same period has come from petroleum, which contributed to the high growth of petroleum (annual average 8.3%) within total primary energy supply (annual average 3.1%). Petroleum and other renewable energy accounted for 28% and 72%, respectively, of total primary energy supply in 2009, and the share of non-commercial energy use of total consumption in Cambodia is the largest among GMS countries.



(Source: IEA, Energy Balance of non-OCED 2011)

Figure 1.2-7 Total Final Energy Consumption (Cambodia)



(Source: IEA, Energy Balance of non-OCED 2011)

Figure 1.2-8 Total Primary Energy Supply (Cambodia)

(4) Energy outlook of Myanmar

On the demand side, Myanmar's total final energy consumption increased at 2.4% annually from 7,135 ktoe in 1971 to its peak of 14,146 ktoe in 2005. Consumption, however, then gradually decreased in parallel with economic decline due to political instability etc., recording 13,803 ktoe in 2009. Looking at growth by energy source, annual demand for natural gas and electricity grew significantly at as much as 15.2% and 6.8%, respectively, until 2009. The shares of total final energy consumption in 2009, however, remain low (14% and 3% for natural gas and electricity, respectively), while energy used in the household sector such as biomass accounts for the majority at more than 70%.

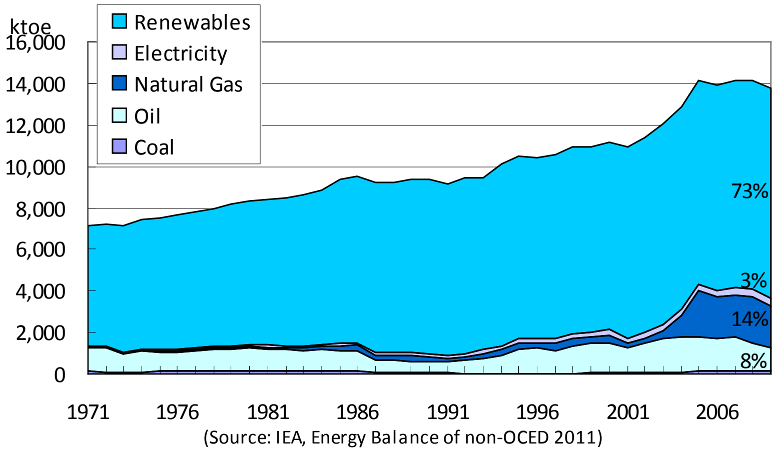


Figure 1.2-9 Total Final Energy Consumption (Myanmar)

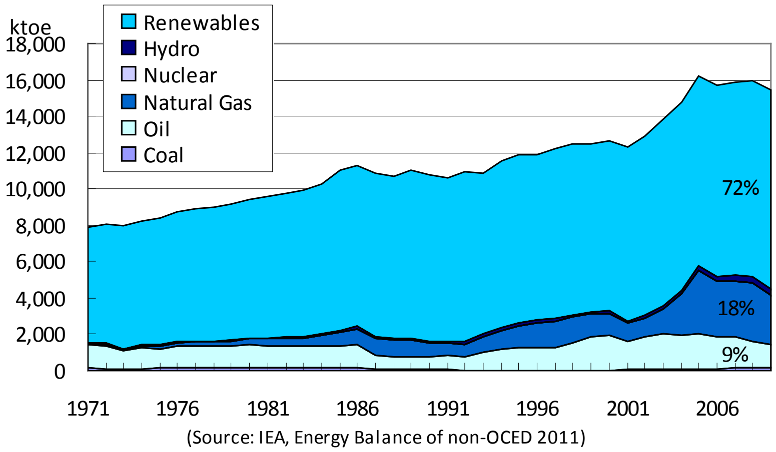


Figure 1.2-10 Total Primary Energy Supply (Myanmar)

On the supply side, total primary energy supply reached its peak at 15,968 ktoe in 2005 from 7,882 ktoe in 1971, and then decreased to 15,062 ktoe in 2009. The expansion of total primary energy supply until 2005 was mainly covered by natural gas, which grew at as high a rate as 13% as an annual average, while total primary energy supply grew at 2.2%. Yet, the share of fossil fuels within total primary energy supply in 2009 was still about 30% (coal: 1%, petroleum: 9%, and natural gas: 18%), and non-commercial energy such as biomass accounted for as much as 70%. Energy supply per capita is the lowest among GMS countries.

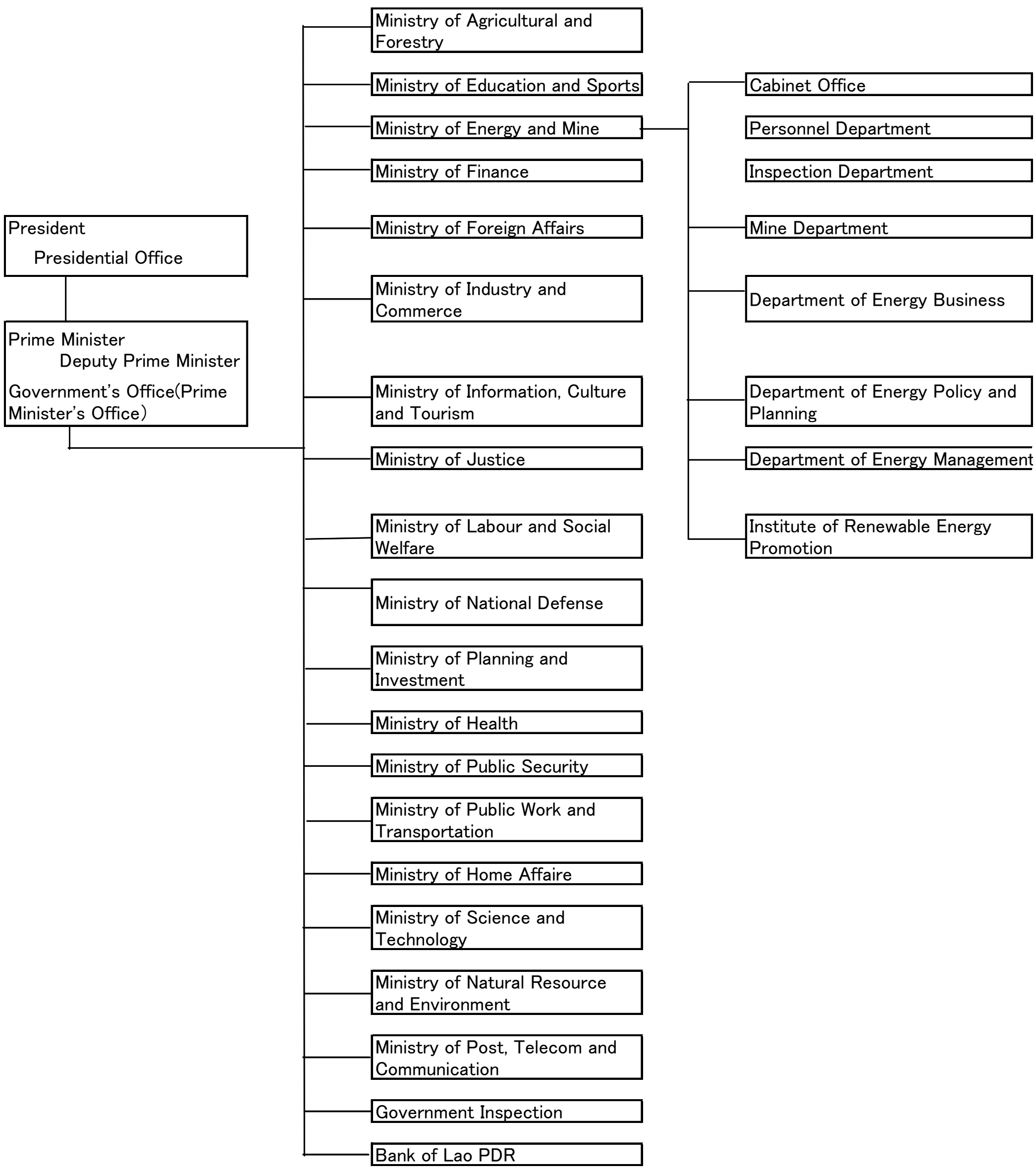
2 Current Situation and Issues concerning Energy Policy and System

2.1 Outline of Energy Policy and System

2.1.1 Political regime

The political regime of Lao PDR is a people's democratic republic with the president as head of state. The president is elected by the national assembly and the term of office is five years. The prime minister and cabinet ministers are appointed by the president with the approval of the national assembly.

The Administrative Organization Chart of Lao PDR is shown in Figure 2.1-1.



Source: developed by the Institute of Energy Economics, Japan based on materials acquired locally.

Figure 2.1-1 Administrative Organization Chart (Centered on MEM)

2.2 Implementation Structure of Energy-related Administration

2.2.1 Administrative organizations related to energy

(1) Outline of organizations related to electricity and their roles

The Ministry of Industry and Handicrafts (MIH) was formed from the Ministry of Energy and Mines (MEM) in 2006. The present minister of MEM is Soulivong Dalavong, who is in charge of the energy and mining sectors.

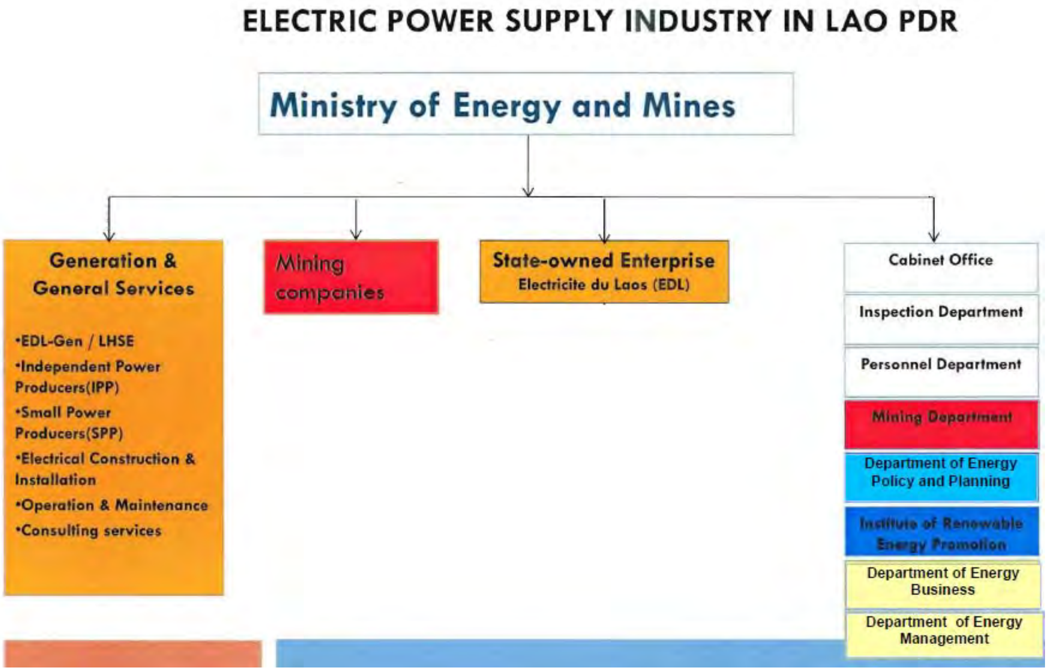
Organized under MEM, as can be seen above, are the Cabinet Office, Personnel Department, Inspection Department, and three electricity-related departments: Department of Energy Business, Department of Energy Policy and Planning, and Department of Energy Management. In addition, Mine Department and Institute of Renewable Energy Promotion were set up in April 2012.

The Electricity Law prescribes that MEM is responsible for making policy and strategy for the nation's electricity sector. MEM also has the responsibility to develop and implement laws and regulations, and to supervise the businesses of electricity companies.

Department of Energy Policy and Planning (DEPP) is under the jurisdiction of MEM. DEPP is in charge of policy-making and planning, and is responsible for energy policy-making, energy/electricity supply planning.

Department of Energy Promotion and Development (DEPD) changed its name to Department of Energy Business (DEB) under an organizational reform in 2012. DEB has taken over the responsibilities of DEPD, which include promoting and negotiating IPP development and in some cases arranging various agreements and monitoring construction and operation.

Figure 2.2-1 shows the electric supply industry in Lao PDR. Organizational structures of the energy/electricity industry were extensively reformed in 2012.



Source: MEM

Figure 2.2-1 Organization Chart of Electricity Power Supply Industry in Lao PDR

The following are the major differences after the structural reforms in 2012:

(a) EdL is divided into EdL-Generation Public Company: EdL-Gen and State-owned Enterprise Electricité de Laos (EdL). Transmission and Distribution sectors are owned and operated by the State.

(b) DOE (Departments of Electricity) was reorganized into Department of Energy Policy and Planning (DEPP), Department of Energy Management (DEM), and Institute of Renewal Energy Promotion (IREP) under MEM together with the Cabinet Office, Inspection Department, and Personnel Departments. DEPP is positioned at the center of energy-related policy-making.

Electricité du Laos (EdL) is Lao PDR's state-owned electricity enterprise, which is responsible for electricity transmission and distribution, import/export of electricity, etc. EdL-Generation Public Company: EdL-Gen, which was separated from EdL and became a publicly-held company, is responsible for power generation.

Electrical Construction and Installation (ECI) is a construction company handling the domestic and overseas electricity businesses of Lao PDR. The company is given authority to coordinate cooperation between local and overseas investors, develop energy resources (power sources) such as hydropower and solar power, and invest in the production of power utilities and equipment.

Lao Holding State Enterprise (LHSE) invests in IPP projects for power exports, representing Lao PDR.

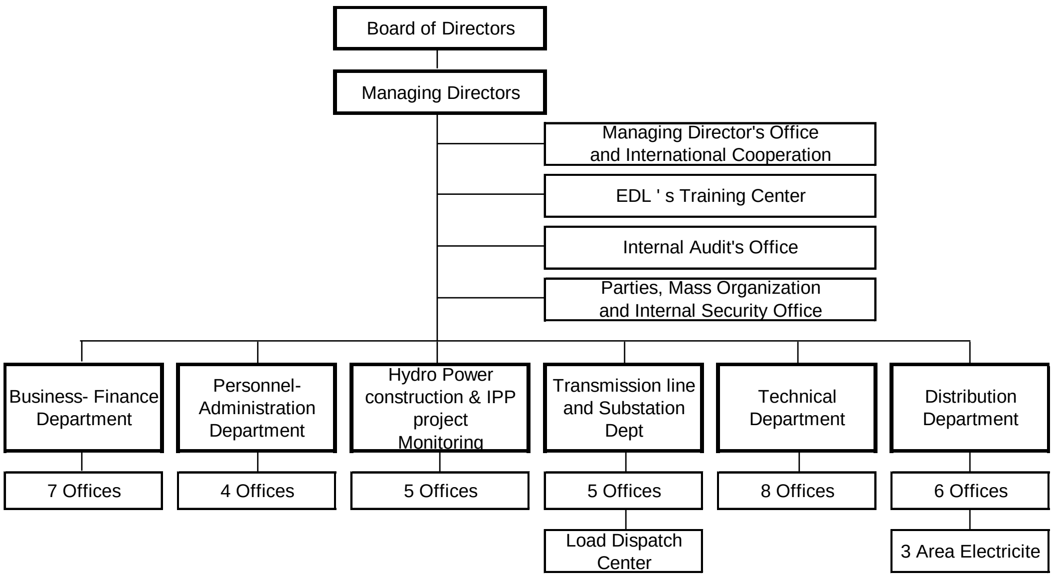
Ministry of Natural Resource and Environment (MNRE) plans, implements, and supervises environmental policies.

(2) Organization and roles of Electricité du Laos (EdL) and EdL-Gen

1) EdL

Electricité du Laos (EdL) is a state-owned electric power utility, supplying electricity to domestic consumers through its transmission and distribution lines. EdL also manages imports and exports electricity. EdL owns transmission lines and distribution lines for domestic supplies countrywide, obtaining electricity from EdL-owned power stations, EdL-Gen, IPP for domestic (IPP(d)), off-take from IPP for export (IPP(e)), power stations, and imports from neighboring countries.

EdL was established in 1959 as the electricity department of the Ministry of Public Utilities. EdL was a vertically integrated utility, which owned generation, transmission, and distribution facilities, and had functions to product, transmit, and sell electricity energy. In 2010, following directives from the Government of Lao on restructuring the electricity industry in Lao PDR, the function of electricity generation of EdL was taken from EdL and given to EdL-Gen Company. Figure 2.2-2 shows the current organization chart of EdL.



Source: Prepared by JICA Team based on information from MEM

Figure 2.2-2 EdL Organization Chart

2) EdL-Gen

EdL-Generation Public Company (EdL-Gen) was established on December 15, 2010 as the first publicly-held enterprise in Lao PDR listed on the Lao Securities Exchange (LSX). In January 2011, EdL-Gen increased its capital to 3,474 billion kip. As a result of the capital increase, 75% of the stock of EdL-Gen is held by EdL and the remainder is held by private investors.

The main objectives of EdL-Gen are as follows:

(a) To generate energy for EdL to wholesale, and in the future to export, which includes development of transmission lines and substations, as necessary.
(b) To invest in or set up joint ventures with other electricity generation projects.
(c) To provide management and maintenance services for other generation electricity projects.

Table 2.2-1 Existing Generation Assets of EdL-Gen

Region	Name	Province	Installed Capacity (MW)	Annual Energy Production (GWh p.a.)	COD
Central	Nam Ngum 1	Vientiane	155	1,002	1971
	Nam Leuk	Vientiane	60	218	2000
	Nam Mang 3	Vientiane	40	180	2005
South	Xeset 1	Saravanh	45	180	1991
	Xeset 2	Saravanh	76	309	2009
	Xelabam	Champasak	5	21	1969
Total			381	1,910	

Source: Prepared by JICA Team based on information from MEM

The existing generating assets (six hydropower stations: Nam Ngum 1, Nam Mang 3, Nam Leuk, Xeset 1, Xeset 2 and Xelabam) were transferred from EdL to EdL-Gen. The total installed capacity of these power stations is 381 MW and annual energy output is 1,910 GWh.

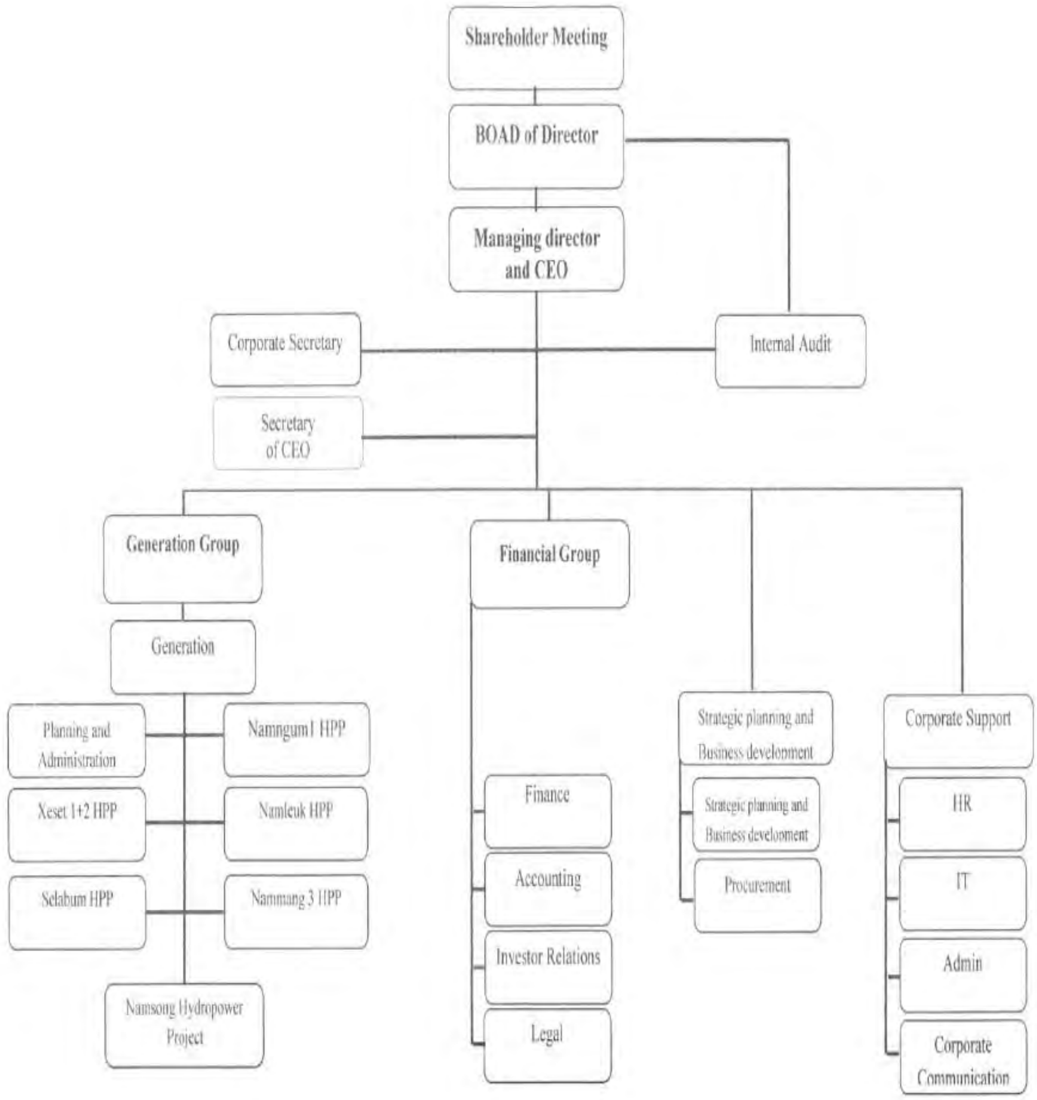
EdL-Gen entered into a Concession Agreement (CA) with the Government of Lao in December 2010. The validation period of the CA is 30 years and can be extended 10 years. At the end of the term or at termination of the contract, generating assets will be transferred back to the Government of Lao in accordance with the CA.

The Power Purchase Agreement (PPA) signed between EdL and EdL-Gen for each power station has the same duration of 30 years. The average tariff of EdL-Gen for supplying EdL set 413.89 kip/kWh as the initial price, and this will increase at a rate of 1% per year.

It is planned that EdL-Gen will acquire EdL's shares in IPP projects and EdL's hydropower stations under construction: Nam Kan2 and Houay Lamphanh Gnai.

According to the EdL-Gen annual report 2010, EdL-Gen expects to increase the install capacity of generation from 387 MW in 2010 to 2,238 MW in 2020 using capital from the shares issued and revenue from power generation. EdL-Gen expects to increase the installed capacity of generation over three periods: In 2011 - 2012, generating capacity is expected to increase from 387 MW to 757 MW, in 2013 - 2015 from 757 MW to 1,498 MW, and in 2015 - 2020 from 1,498 MW to 2,238 MW.

Two divisions and two groups are organized within EdL-Gen. Each division's roles and responsibilities are as follows (Figure 2.2-3).



Source: EdL-Generation Public Company ANNUAL REPORT 2010

Figure 2.2-3 EdL-Gen Organization Chart

(a) Division of Strategic Planning and Business Development:

Has functions to define the strategies of the company; manage analyses for developing business opportunities; manage relations with business partners in invested projects and customers; manage procurement of materials and equipment; and, manage all activities effectively and systematically.

(b) Division of Organizational Support Management:

Manages and develops administrative tasks in an effective and systematic manner; defines policies, rules/regulations, and work plan; directs and monitors human resources management and human resources development in accordance with line and business policies, as well as with planned work plan.

(c) Generations Group:

Has important roles and functions for managing electricity-generating operations/activities, effectively maintaining dams and hydropower plants (Machines Buildings); controlling and monitoring hydropower plants in order that machinery functions effectively and at an appropriate cost; and, generating electricity in accordance with planned goals and objectives such as production goals, quality goals, initial cost goals, and financial goals.

Preserving and implementing policies for the repair and maintenance of hydropower plants (machinery buildings) and equipment in order that machinery functions well, has an adequate useful life, and generates electricity effectively; and, controlling, inspecting, and monitoring electricity generating works in accordance with the laws of Lao PDR and rules and regulations of the Company, in areas such as security and environment.

(d) Financial Group CFO:

- Managing the planning of finances and budget;
- Effectively managing the procurement of capital sources and investment capital;
- Managing investments and business risks; and,
- Others

3) Holding State Enterprise (LHSE)

Lao Holding State Enterprise (LHSE) is a state-owned stock-holding enterprise established in 2005. The mission of LHSE is to hold and manage shares of IPP projects. Upon establishment of the company, LSHE invested in the Nam Theun 2 Power Company. LHSE holds shares in nine IPP projects, eight hydropower projects including Nam Theun 2, and Hongsa Thermal Power Project.

(3) Participation of private sector in power development business

The Lao Government has a basic policy of promoting exports of electricity to neighboring countries through power development using BOT or BT-style private capital (hydroelectric development by IPP). Electricity-generating equipment is expected to be transferred from IPP to the government over 20 to 30 years. Investments from other countries in Lao PDR are controlled by Ministry of Planning and Investment (MPI). MPI is a government organization that can grant licenses for power project development.

A memorandum of understanding (MOU) for project development is issued when the government accepts a proposal from a development investor. After issuance of the MOU, the investor evaluates, designs, constructs, and operates the project in a step-by-step manner.

As a policy for investing in electricity businesses, Article 26 of the Electricity Law requires the following methods for investing in businesses.

(a) Build, Operate, and Transfer (BOT);

(b) Build and Transfer (BT);

(c) Build, Own, and Operate (BOO);

(d) Operation by State-owned power company

2.3 Issues concerning Energy Policy and System

2.3.1 Current Situation Concerning Energy Policy and System

(1) Basic policies

An integrated energy policy has not been formulated.

However, from a presentation by MEM staff[4], the outline and direction can be understood.

According to the presentation, there are the five basic concepts for energy-related policies listed below.

(a) Maintain and expand power supply based on economic efficiency, reliability, and sustainability, in order to promote economic and social development.

(b) Promote electric power development and expand electricity exports, in order to secure finances targeted by the government.

(c) Develop and strengthen laws and regulations, in order to effectively develop the electricity sector through the government, the private sector, or partnerships between public and private sectors.

(d) Increase the nation's capabilities, while developing international-standard techniques, expertise, and experience.

(e) Achieve sustainable development by identifying impacts and responsibilities related to society and environment.

It would appear that generating power with economic efficiency and exporting electricity are the major targets, and there also seems to be no basic supply/demand plan for oil and coal, for which Lao PDR depends heavily on imports.

(2) Electricity policies

In 1994, Department of Electricity (DOE) was established within the Ministry of Industry and Handicraft (MIH), the organization formerly responsible for energy. DOE is responsible for management and planning in the electric power sector: managing the strategy of electric power sector, policies, and legal framework of electricity and power development plan. As a result of the structural reorganization of the government in 2006, MEM was established as a ministry to oversee the mining and energy industries. At that time, the Department of Energy Promotion and Development (DEPD) was established within MEM to promote and develop energy sources in the form of independent power projects (IPP).

The Government of Lao PDR defined the basic policy for the power sector as follows in the “Socio-economic Development Plan 2010-2015” in 2010. The main objectives of the power sector policy include.

(a) Earn foreign exchange through electricity exports to finance economic and social programs.

(b) Increase access to electricity through grid extensions and off-grid rural electrification.

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[4] From a speech by Mr. Phonepasong Sithideth, MEM DOE Technical staff, etc. (IEEJ, May 2011)

(c) Satisfy growing domestic demand.
(d) Maintain affordable tariffs to promote economic and social development.
(e) Operate EdL based on strong commercial principles.
(f) Replace dependence on imported fuels for energy generation.

The objectives of developing the power sector are specified in the Law on Electricity as developing domestic energy such as hydropower energy, solar energy, coal and biomass to reduce energy imports, developing rural electrification, and achieving an electrification rate of 90% by 2020. Under the Law on Electricity, the electricity business is to be implemented according to the following principles:

(a) Consistent with the “National Socio-economic Development Plan.”
(b) Efficient, economical, and sustainable.
(c) Protect environment, society, and nature (communities, forests, and water resources).
(d) Guarantee of safety.

MEM established the strategy for the power sector titled “The Strategy Plan For Developing the Energy and Mines from 2006 to 2020” (MESD) in 2006 and revised it in 2008. In the preamble of the MESD, the objectives are defined as contributing to stable and continuing growth and reduction of poverty. In MESD, the following directions are detailed as a strategy for the power sector.

(a) Promoting small and medium-scale electricity production with private participation
(b) Promoting development of alternative energies for generating electricity.
(c) Development of power stations
(d) Expansion of transmission lines for domestic demand

(3) Electricity import/export policies

According to Article 19 of the Electricity Law (December 20, 2011), when electricity is exported, priority on providing sufficient supplies for domestic demand has to be assured, taking into account industrial prosperity and the country's social and economic development.

The law also prescribes that importing electricity requires approval of the government, taking into account the needs of the country's social and economic development.

(4) Renewable Energy Development Strategy

The Government of Lao PDR (GoL) announced the “Renewable Energy Development Strategy (hereinafter, REDS)[5]” in June 2010.

The GoL aims to increase the share of renewable energies to 30% of total energy consumption by 2025 as shown in Table 2.3-1. To reduce imports of fossil fuels, the GoL outlines tentative development of biofuels to substitute 10% of transportation fuel demand by 2025.

Details are described in 3.3.

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[5] “Renewable Energy Development Strategy in Lao PDR:” Government of Lao PDR, 2011

Table 2.3-1 Capacity to Meet 30% Target for Renewable Energy Development by 2025

Item	Renewable energy types	Potential	Existing	2015		2020		2025	
		MW	MW	MW	ktoe	MW	ktoe	MW	ktoe
A	**Electricity**			**140**		**243**		**666**	**427**
1	Small Hydropower	2000	12	80	51	134	85	400	256
2	Solar	511	1	22	14	36	23	48	31
3	Wind	>40		6	4	12	8	73	47
4	Biomass	938		13	8	24	16	58	37
5	Biogas	313		10	6	19	12	51	33
6	Solid waste	216		9	6	17	11	36	23
7	Geothermal	59							
B	**Biofuel**	**ML**	**ML**	**ML**		**ML**		**ML**	
1	Ethanol	600		10	7	106	178	150	279
2	Biodiesel	1200	0.01	15	13	205	239	300	383
C	**Thermal energy**	**ktoe**	**ktoe**						
1	Biomass	227			23		29		113
2	Biogas	444			22		44		178
3	Solar	218			17		22		109
Total									
Energy demand (ktoe)					**2504**		**4064**		**4930**
Renewable energy contribution					**172**		**668**		**1479**
Proportion					**7 %**		**20%**		**30%**

Source: Prepared by JICA Team based on REDS

2.3.2 Issues Concerning Energy Policy and System

An Integrated energy policy has not been formulated.

It seems that present energy policy focuses mainly on electricity as a product to obtain foreign currency. There is also no basic supply/demand plan for oil and coal. It is unclear where management and responsibility of the government for export/import and production lie.

It might be time for Lao PDR to consider formulating a national energy plan (Energy Master Plan), which is consistent with the level of the macro-economy, such as a five-year plan (socioeconomic development plan).

The present energy policy, which is discussed in the (Reference) below, is well prepared, answering the needs of the present financial situation and growing electricity domestic/export demand.

It is generally said that an energy policy is required to satisfy the conditions of Energy Security, Economics, and Environment. These so-called 3E should be respected.

Considering energy policy in the (Reference) through 3E above,

(a) From Energy Security and Cost competitiveness point of views, it can be well prepared and satisfactory. Based on interdependence among GMS, electricity trade, and good balance of supply/demand, it is a very reasonable and practical approach.

(b) Promoting cost-competitive biofuels production for transportation use will also contribute to Energy Security, Economics, and Environment.

(c) From an Environmental point of view, large-scale development of small hydro will be very useful.

However, it may not be possible to supply all of the rapidly increasing demand for electricity in the coming ten years only with interdependence among GMS.

That is, when a rapid increase of domestic electricity demand is assumed in the future, the need should not be understated to enhance the independence and flexibility of emergency responses in Lao PDR alone, and it is considered important to take adequate note of the following points.

(a) Strengthening the power generation capacity by EdL-Gen (not relying 100% on IPP)
(b) Optimizing proportions of electricity exported and domestic supply
(c) Diversifying and decentralizing power sources

In conclusion, certain policies and directions for electricity are clear at a practical level. However, they appear not to have been coordinated overall as the positioning of electricity planning in general energy and consistency at a macro-economy level such as through a five-year plan (socioeconomic development plan) are unclear.

As economic growth increases, it will become difficult to obtain sufficient results unless there is consistent planning on a nationwide scale and effective investments.

In this context, it might be time for Lao PDR to consider formulating a national energy plan (Energy Master Plan), which is consistent with the level of the macro-economy, such as a five-year plan (socioeconomic development plan)

(Reference) Discussion on Energy Policy

A high-ranking official of MEM responded to our interview concerning the energy strategy at MEM on 29 May 2012. The official stressed the importance of the points below.

(a) Interdependence among GMS is most important and beneficial for the demand/supply balance of electricity. Optimal use of energy resources is possible.
(b) Cost effectiveness and competitiveness
(c) Expansion of distribution network and promotion of renewable energy including small hydro, which have less impact on the environment
(d) Promotion of biofuels for transportation use

The high-ranking official explained as follows.

Considering the present financial situation of Lao PDR, the energy policy should be practical for deploying the supply infrastructure.

Because Lao PDR is surrounded by Thailand, Vietnam, Cambodia, Myanmar, and China, it is important to balance electricity supply/demand with these countries. For example, Lao PDR exports electricity to Thailand throughout the year. However, in the dry season when generation volume from hydro is below domestic demand, Lao PDR imports electricity from Thailand at the same rate. Interdependence among GMS is the most beneficial way to balance the supply/demand of electricity. Optimal use of energy resources is possible among neighboring countries.

To make this possible, building trust among GSM nations is essential.

Conversely, it is not practical to develop a coal-fired power plant in the southern area to balance the supply/demand of electricity in the central area in the dry season.

Because Lao PDR has no petroleum resources, Lao PDR is struggling to promote biofuel production from palm tree or jatropha for transportation use. But, these must be economically competitive with oil products.

3 Present Situation of Energy Sub-sectors

3.1 Electric Power Sector

3.1.1 Outline of Electric Power Sector

(1) Legal Framework on Electricity

1) Laws and Regulations on Electricity

Laws and regulations related to electricity in Lao PDR are shown in Table 3.1-1.

Table 3.1-1 Laws and Regulations on Electricity

No.	Names of documents
1	The Law on Electricity, 2011
2	Lao Electric Power Technical Standards, 2004
3	Guideline on Operation and Managing Lao Electric Power Technical Standards, 2007
4	Safety Rules for Operation and Maintenance of Electrical Facilities, 2007
5	Environmental Management Standard Documents, 2001
6	Regulation on Implementing the Environmental Assessment for Electricity Projects in Lao PDR, 2001
7	Environmental Management Standard for Electricity Projects, 2003
8	National Policy on Environmental and Social Sustainability of the Hydropower Sector in Lao PDR, 2006

Source: MEM

2) The Law on Electricity

The Law on Electricity was promulgated in April 1997. It was amended in December 2008 and in December 2011. The amendment in 2011 extended the definition of small hydropower from 5 MW to 15 MW, which is consistent with the “Renewable Energy Strategy” of the Government of Lao, and articulated the effectiveness of concessions on IPP projects.

Before the amendment in 2011, some Memorandums of Understanding (MOU) or Project Development Agreements (PDA), which achieved no progress after being agreed may expire at the judgment of the Ministry of Planning and Investment (MPI). In the amendment to the Law on Electricity in 2011, extensions of MOU and PDA are clearly defined. A MOU or a PDA can be extended by submitting an application to the government and getting approval from the government; however, the duration of an extension is limited as follows:

(a) The maximum extension period of a MOU is nine months. The number of extensions of MOU is not limited by the Law.

(b) The maximum extension period of a PDA is six months. The number of applications for PDA extension is limited to three for an export project and two for a domestic project.

(c) A MOU or a PDA expires if the project developer cannot implement the conditions of the agreement.

(2) Electricity Tariff

1) General

Electricity tariffs in Lao PDR are defined by the Law on Electricity. Electricity tariffs for domestic supplies and exports are set in Articles 47 and 48, and tariffs for rural electrification are defined in Article 49. According to Article 47 of the Law on Electricity, electricity tariffs should be established by the Government of Lao; therefore, Electricité du Laos (EdL) submits a draft electricity tariff to the Ministry of Energy and Mines (MEM) and the Government of Lao PDR approves modification of the tariff in principle.

Article 47 Electricity Tariff

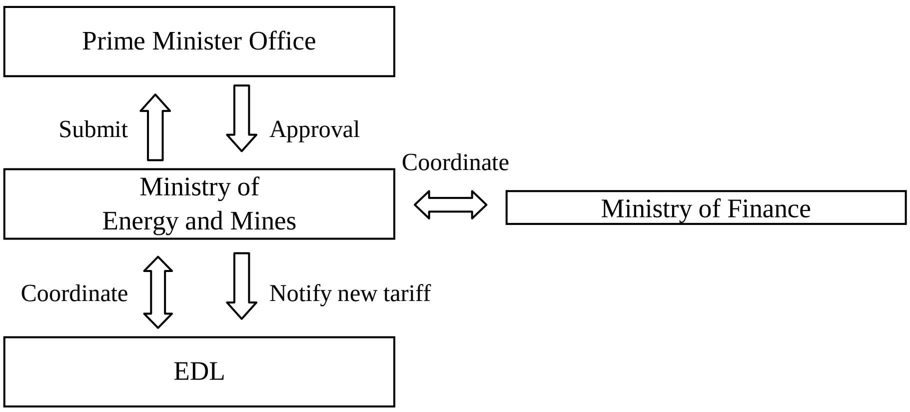
The determination of electricity shall ensure the socio-economic conditions of the country and shall be suitable to the targets of use and types of user.

Electricity prices shall be stable and ensure electricity investment return and development.

The Ministry of Energy and Mine shall cooperate with other sectors and parties concerned to study the electricity price structure of each type to be submitted to the Government for consideration within each period.

Electricity prices for use targets and user types shall be determined by the Government.

The procedure for determining a new electricity tariff is shown in Figure 3.1-1.



Source: MEM

Figure 3.1-1 Procedure for Determining Electricity Tariff

2) Electricity Tariff for Domestic Customers

Table 3.1-2 shows the historical record of EdL's electricity tariff for domestic customers over the last 10 years. The electricity tariff is set in nine categories for low voltage supply and four categories for medium voltage supply. The tariff for residential use and irrigation is set at a lower level than other for customers as shown in the Table.

The historical record of the average tariff of EdL is shown in Figure 3.1-2. The average tariff increased from 52.5 kip/kWh in 1997 to 559 kip/kWh in 2010. After 1998, the average tariff in dollar volume shows the same trend as the tariff in kip because the kip/dollar exchange rate has been stable since 1998.

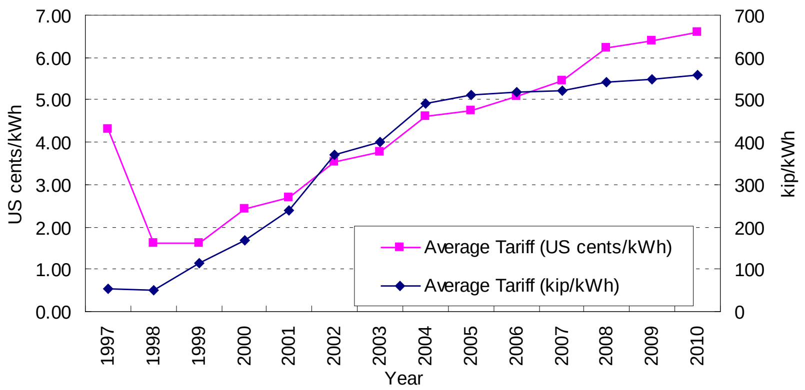
The electricity tariff increased 2.3% per month, equivalent to 30% per year from 2002 to 2004. According to the plan for the electricity tariff to 2011 approved by the Government of

Lao in 2005, the tariff was been raised by 1% per year.

Table 3.1-2 Electricity Retail Tariff for Domestic Customers (EdL)

(kip/kWh)

Source: EdL Annual Report 2001-2010



Source: EdL Annual Report 2001-2010

Figure 3.1-2 Historical Record of Average Tariff of EdL

The Government of Lao approved and announced a new electricity tariff system on 12 March 2012, as shown in Table 3.1-3. The tariff increases gradually from March 2012 to December 2017 at an annual rate of about 2%. The category of consumer was revised as follows:

(a) The category for Education and Sports is newly defined for low voltage and medium voltage. The tariff for Education and Sports is set to be the same as that for a Government Office.

(b) The category for Industry for medium voltage is divided into two categories up to power demand.

(c) Tariff for entertainment for medium voltage is newly defined.

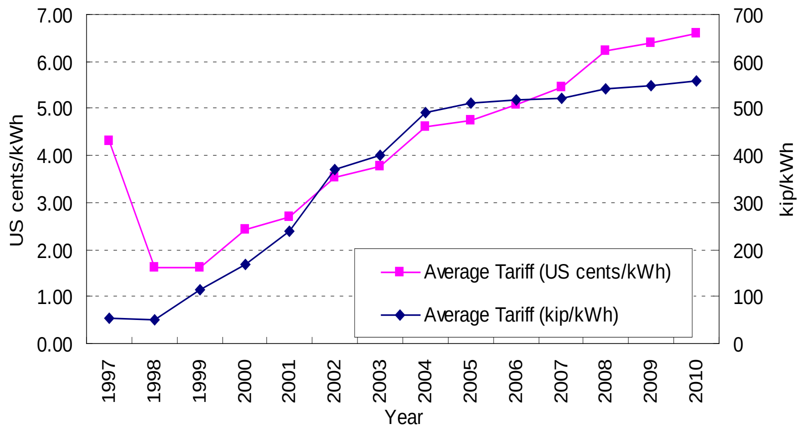
Table 3.1-3 New Electricity Tariff of EdL

unit : kip/kWh

Classification			2011	2012	2013	2014	2015	2016	2017
Low Voltage 0.4 kV	Residential	0-25 kWh	269	321	328	334	341	348	355
		26-150 kWh	320	382	390	398	405	414	422
		150 k Wh-	773	923	941	960	979	999	1,019
	Irrigation		399	476	486	496	506	516	526
	Government Office		656	783	799	815	831	848	865
	Industry		591	706	720	734	749	764	779
	General Business		835	997	1,017	1,037	1,058	1,079	1,101
	International		1,077	1,286	1,312	1,338	1,365	1,392	1,420
	Entertainment		1,106	1,321	1,347	1,374	1,401	1,429	1,458
	Education & Sports		-	783	799	815	831	848	865
Medium Voltage 22-35 kV	Irrigation		340	406	414	422	431	439	448
	Industry (less than 5 MW)		502	599	611	624	636	649	662
	Industry (over 5 MW)		-	647	660	673	687	700	714
	Government Office		557	665	678	692	706	720	734
	General Business		647	647	660	673	687	700	714
	Education & Sports		-	665	678	692	706	720	734
	Entertainment		-	1,255	1,280	1,305	1,331	1,358	1,385

Source: "Improve New Electricity Price" Ministry of Energy and Mines, Ref. No. 325, 9.3.2012

Figure 3.1-3 shows the historical and planning tariff from 2002 to 2017 for the major categories. The tariff for residential customer below 25 kWh per month increased six times in 15 years. Tariffs for Industry and General business increased more gradually.



Source: EdL Annual Report 2001-2010, Improve New Electricity Price (MEM)

Figure 3.1-3 Electricity Tariff for Each Category

3) Import and Export Tariff of EdL

EdL exports electricity to Thailand from Nam Ngum 1 and Xeset 1 power stations when surplus electricity can be supplied from the EdL system.

Table 3.1-4 shows the export tariff from EdL to the Electricity Generating Authority of Thailand (EGAT). Common rates are applied to the Nam Ngum 1 system and Xeset 1 system.

On the other hand, if the supply from domestic power stations is insufficient for domestic demand, EdL imports electricity from the EGAT system. Tariffs for importing electricity from

EGAT in Nam Ngum/Nam Leuk, Savannakhet and Thakhek systems are set in common.

In addition, in rural areas near the national border, electricity is supplied from neighboring countries such as Thailand, Vietnam, and China through transmission and distribution lines from these countries. Import tariffs from Provincial Electricity Authority of Thailand (PEA) and Vietnam are set as shown in Table 3.1-5. The trading tariff for PEA and Vietnam is set higher than the rate for EGAT.

EdL concluded the Power Purchase Agreement (PPA) with Thailand, Vietnam, and China on the power trade. Import and export tariffs with Thailand were contracted under the PPA entered into in February 2010. A new PPA for importing electricity from China through a 115 kV transmission line was concluded between Lao PDR and China.

Table 3.1-4 Trading Tariffs for Export Electricity

Country	Power System	Voltage	Classification	Export Tariff		*in USD (cents/kWh)*
Thailand	Nam Ngum 1, Xeset 1	115 kV	Peak	1.60	THB/kWh	*5.08*
			Off Peak	1.20	THB/kWh	*3.81*

Peak: Monday-Friday 9:00-22:00
Off Peak: Monday-Friday 22:00-9:00
Saturday, Sunday, Thai official holidays 0:00-24:00

Source: EdL Annual Report 2010

Table 3.1-5 Tariffs for Import Electricity

Country	Supply Area	Voltage	Classification *1		Import Tariff		*in USD Volume*	
Thailand (EGAT)*2	Vientiane, Bolilhamxai, Khammouane, Savannaket, Champasak	115 kV	Normal	Peak	1.79	THB/kWh	*5.68*	*cents/kWh*
				Off Peak	1.39	THB/kWh	*4.41*	*cents/kWh*
			Emergency	Peak	1.60	THB/kWh	*5.08*	*cents/kWh*
				Off Peak	1.20	THB/kWh	*3.81*	*cents/kWh*
Vietnam (EVN)	Houaphan, Xepone, Samury, Phoukua	35 kV 35/22 kV			0.06	USD/kWh	*6.00*	*cents/kWh*
Thailand (PEA)		22 kV	Peak		2.6950	THB/kWh	*8.55*	*cents/kWh*
			Off Peak		1.1914	THB/kWh	*3.78*	*cents/kWh*
			Demand Charge		132.93	THB/kW	*4.22*	*USD/kW*
			Service Charge		228.17	THB/month	*7.24*	*USD/month*
			Fuel Adjustment		0.9255	THB/kWh	*2.94*	*cents/kWh*
Thailand (EGAT)	Sepone gold mine, Cement factory in Thakhek	115 kV	Peak		2.7595	THB/kWh	*8.75*	*cents/kWh*
			Off Peak		1.3185	THB/kWh	*4.18*	*cents/kWh*
			Demand Charge		74.14	THB/kW	*2.35*	*USD/kW*
			Service Charge		228.17	THB/month	*7.24*	*USD/month*
			Fuel Adjustment		0.9255	THB/kWh	*2.94*	*cents/kWh*
China	Boten in Luangnamtha	10 kV			0.62	CNY/kWh	*9.72*	*cents/kWh*
China	Sing District in Luangnamtha	22 kV			0.0857	USD/kWh	*8.57*	*cents/kWh*
China	Namo Substation in Oudomxay	115 kV			0.41	CNY/kWh	*6.43*	*cents/kWh*

*1 Classification
Peak: : Monday-Friday 9:00-22:00
Off Peak Monday-Friday 22:00-9:00
Saturday, Sunday, Thai official holidays 0:00-24:00

*2 In case of import over export, EdL should pay 1.30 TBH/kWh more for the excess.

Source: EdL Annual Report 2010

3.1.2 Electricity Supply and Demand

(1) Hydropower Potential in Lao PDR

Lao PDR has a large untapped hydropower potential exceeding its domestic electricity demand. The Government of Lao is promoting the development of its hydropower potential in a strategy both for supplying electricity domestically to improve living standards and for earning foreign exchange by exporting electricity to neighboring countries. Lao PDR is strategically located in the Greater Mekong Sub-region (GMS), surrounded by countries with expanding electricity demand including Thailand, Vietnam, Cambodia, and China.

The theoretical hydropower potential in the Mekong River Basin is estimated at 53,000 MW. The Mekong River flows from Yunnan Province in China to the north-east region of Lao PDR, and flows down across Lao PDR about 1,900 km. Most of the hydropower potential in Lao PDR exists along the mainstream of the Mekong River and its tributaries. The theoretical hydropower potential in Lao PDR excluding the mainstream of the Mekong River amounts to about 26,000 MW. The exploitable hydropower potential including the share of the Lao PDR in the mainstream of the Mekong River is estimated at about 23,000 MW. About 15,000 MW of the potential is located within the country and remaining 8,000 MW represents the share of Lao PDR in the mainstream of the Mekong River. While 2,560 MW of hydropower in Lao PDR has been developed so far, another 1,330 MW of hydropower projects are under construction.

The development of the mainstream of the Mekong River is planned as a cascade. Twelve projects with a total capacity of about 14 GW are proposed for the mainstream, eight of the 12 projects are located within Lao PDR and two projects are located on the border river between Lao PDR and Thailand. The total installed capacity of the Lao projects is 6,896 MW, and that of the Lao-Thailand projects is 2,951 MW. The total installed capacity of Lao projects including the share of the boundary amount to 8,372 MW.

Table 3.1-6 Projects on Mekong Mainstream

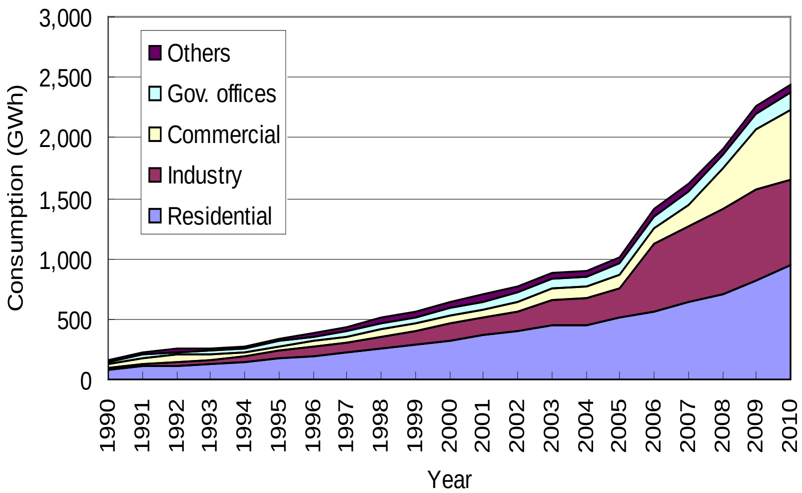
Project	Country	Installed Capacity (MW)
Pakbeng	Lao PDR	1,230
Luangprabang	Lao PDR	1,410
Xayabury	Lao PDR	1,260
Paklay	Lao PDR	1,320
Sanakham	Lao PDR	700
Pakchom	Lao PDR/Thailand	1,079
Ban Koum	Lao PDR/Thailand	1,872
Latsua	Lao PDR	686
Don Sahong	Lao PDR	240
Thakho Diversion	Lao PDR	50
Stung Treng	Cambodia	980
Sambor	Cambodia	2,600
Total		**13,427**

Source: Final Report, SEA of Hydropower on the Mekong Mainstream (2010)

(2) Demand and Supply of Electricity

1) Electricity Demand

Electricity consumption in Lao PDR has increased rapidly as a result of the rapid growth of demand from industry and commerce. The average growth rate of electricity consumption from 2000 to 2010 is relatively high at 11% per year. The historical record of electricity demand is shown in Figure 3.1-4. Electricity demand for residential users has been growing at over 10% since 1990. After 2005, total consumption increased rapidly as a result of the high growth rate of demand from industrial and commercial users. From 2005 to 2010, the average growth rate of industrial demand was 25%, and that of commercial demand was 40%.



Source: DOE/DEPP Electricity Statistics 2010, EdL Electricity Statistics 2010

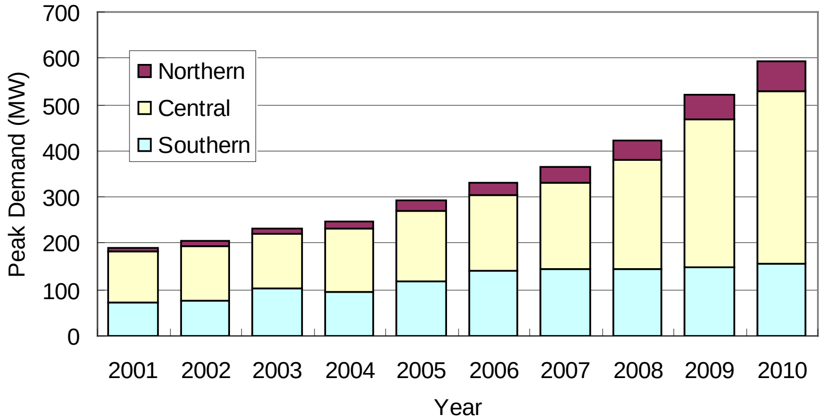
Figure 3.1-4 Record of Electricity Demand

Table 3.1-7 Annual Growth Rate of Electricity Demand

Year	1990-2010	2000-2010	2005-2010
Residential	13.3%	11.2%	13.0%
Industry	21.5%	18.0%	24.5%
Commercial	15.1%	24.0%	38.3%
Gov. offices	9.8%	9.3%	8.1%
Agriculture	10.4%	2.4%	3.8%
Embassies	0.9%	3.9%	5.0%
Entertainment	-	-4.3%	5.7%

Source: MEM/DEPP Electricity Statistics 2010, EdL Electricity Statistics 2010

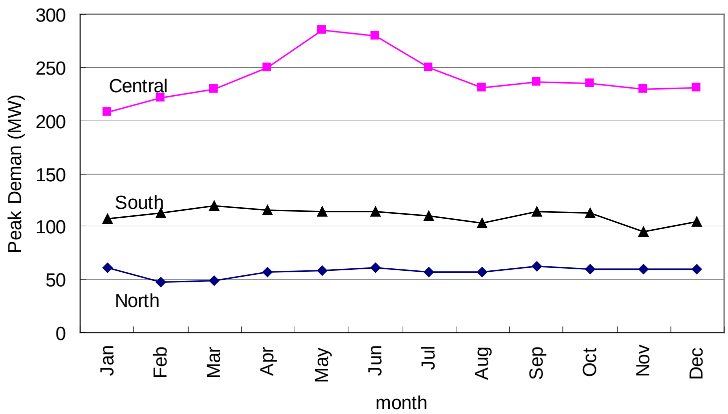
Domestic peak demand has increased threefold in the last 10 years from 191 MW in 2000 to 594 MW in 2010 with an average annual growth rate of 12%. In 2010, peak demand in the Central Region was 370 MW, which was more than 60% of total domestic demand.



Source: MEM/DEPP Electricity Statistical Yearbook 2010, EdL PDP 2010 Revision 1

Figure 3.1-5 Record of Peak Demand

Figure 3.1-6 shows monthly peak demand for each region. In the central region, peak demand varies by season, and demand in hot and humid months such as May and June is about 40% higher than that in the other seasons. In the north and south regions, a seasonal deviation of peak demand is still not noticeable.



Source: MEM/DEPP Electricity Statistics Yearbook 2010

Figure 3.1-6 Monthly Peak Demand in 2010

(3) Electricity Supply

Table 3.1-8 shows the existing power stations in Lao PDR as of end of year 2011. Micro-hydropower stations constructed for rural electrification are not included in this Table. The total capacity of 18 existing hydropower stations is around 2,600 MW, of which 390 MW is owned by EdL and EdL-Gen company and 104 MW is owned by investors of Domestic Independent Power Producer (IPP(d)), which supplies electricity to domestic consumers. Power stations of Independent Power Producer for export supply (IPP(e)) have the largest share of generating capacity at 80% of total installed capacity in Lao PDR. The two largest hydropower stations, Nam Theun 2 (1,075 MW) and Nam Ngum 2 (615 MW), started commercial operation in 2009 and 2010, respectively.

Table 3.1-8 Existing Power Plants

Name	Area	Ownership	Installed Capacity (MW)	COD	Owner	Country
Nam Dong	Northern	EdL	1.0	1970		
Xelabam	Southern	EdL-Gen	5.0	1970		
Nam Ngum 1	Central	EdL-Gen	155.0	1971		
Xeset 1	Southern	EdL-Gen	45.0	1990		
Nam Ko	Northern	EdL	1.5	1996		
Theun Hinboun	Southern	IPP(e)	220.0	1998	•EdL 60% •Nordic 20% •GMS 20%	Lao PDR Norway Thailand
Houay Ho	Southern	IPP(e)	152.1	1999	•EdL 20% •Glow 67.25% •Hamaraj Land & Development 12.75%	Lao PDR Belgium Thailand
Nam Leuk	Central	EdL-Gen	60.0	2000		
Nam Ngai	Northern	EdL	1.2	2003		
Nam Mang 3	Central	EdL-Gen	40.0	2004		
Xeset 2	Southern	EdL-Gen	76.0	2009		
Nam Theun 2	Southern	IPP(e)	1,075.0	2009	•LHSE 25% •EDF 40% •EGCO 35%	Lao PDR France Thailand
Nam Ngum 2	Northern	IPP(e)	615.0	2010	•EdL 25% •CH. Kanchang 28.5% •PT Construction & Irrigation 4% •Ratchaburi 25% •Bangkok Expressway PCL 12.5% •TEAM Consulting Engineering 1% •Shalapak Group 4%	Lao PDR Thailand Lao PDR Thailand Thailand Thailand USA
Nam Lik 1/2	Central	IPP(d)	100.0	2010	•EdL 10% •China International Water & Electric Corp (CWE) 90%	Lao PDR China
Nam Tha 3	Northern	IPP(d)	1.25	2011	•DPS Bridge and Road Construction Company	Lao PDR
Nam Nhon	Northern	IPP(d)	2.4	2011	•Nam Nhone Co 100%	Lao PDR
Nam Phao	Central	IPP(d)	1.6	2011	•Lao Company	Lao PDR
Total			**2,552.1**			
Ownership		EdL	3.7			
		EdL-Gen	381.0			
		IPP(d)	105.3			
		IPP(e)	2,062.1			

Note: IPP(e) Independent Power Producer for power export, IPP(d) Domestic Independent Power Producer

Source: MEM, EdL Annual Report 2010

Historical record of power supply from power stations in Lao PDR and power exports and imports is shown in Table 3.1-9 and Figure 3.1-7. In the table, “Generation (EdL)” represents total electricity generation by power stations operated by EdL, EdL-Gen, Provincial Government, and other operators including small power plants for rural electrification. “Generation (IPP)” represents generation by IPP power stations for both domestic supply and export.

Due to the increase of domestic electricity demand, electricity exports decreased to 2009. The ratio of electricity exports to total generation fell to 57% in 2009; however, as a result of the commencement of operation of Nam Theun 2 and Nam Lik 1-2 Hydropower Station, the ratio of export electricity jumped to 78%.

During the dry season, the amount of stable capacity of hydropower plants for domestic supply is much smaller than total demand in Lao PDR. As a result of the shortage of supply from the hydropower station for domestic supply, EdL imports electricity from neighboring countries. The amount of electricity imported increased to 1,210 GWh in 2010, which is equivalent to half of the domestic electricity supply. Total electricity imports from neighboring countries are equivalent to 20% of electricity exports to neighboring countries.

Table 3.1-9 Record of Electricity Supply and Trade

Generation — Unit: GWh

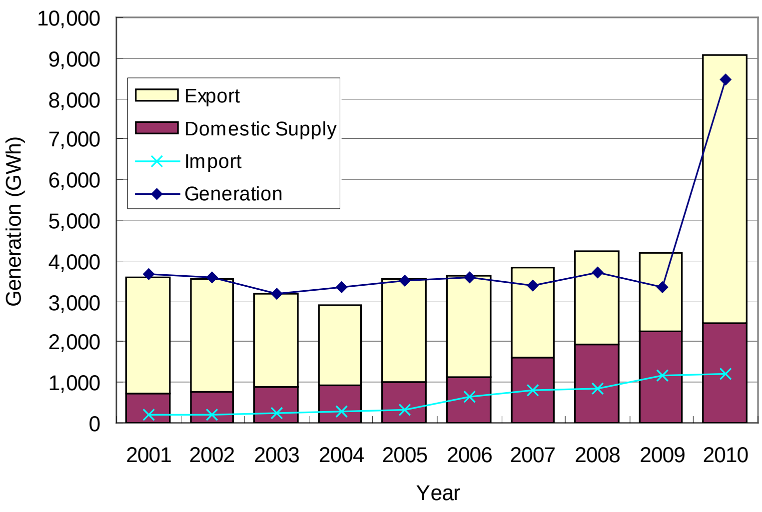
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Generation (EdL) [1]	*1,554*	*1,570*	*1,317*	*1,416*	*1,715*	*1,640*	*1,398*	*1,778*	*1,656*	*1,553*
Generation (IPP)	*2,100*	*2,034*	*1,861*	*1,931*	*1,794*	*1,956*	*1,975*	*1,939*	*1,710*	*6,896*
Subtotal	3,654	3,604	3,178	3,348	3,509	3,595	3,374	3,717	3,366	8,449
Import	184	201	229	278	330	631	793	845	1,175	1,210
Total	**3,838**	**3,805**	**3,408**	**3,625**	**3,839**	**4,226**	**4,167**	**4,562**	**4,541**	**9,659**

Supply — Unit: GWh

Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Domestic Supply	710	767	884	903	1,011	1,406	1,616	1,916	2,258	2,441
Export	2,871	2,798	2,285	2,425	2,506	2,487	2,230	2,315	1,921	6,646
Total	**3,582**	**3,565**	**3,168**	**3,327**	**3,517**	**3,893**	**3,846**	**4,231**	**4,179**	**9,087**

Note 1: Generation (EdL) includes generation by EdL, EdL-Gen, and other domestic suppliers such as provincial operators.

Source: MEM/DEPP Electricity Statistics Yearbook 2010



Source: MEM/DEPP Electricity Statistics Yearbook 2010

Figure 3.1-7 Electricity Supply and Trade

Generation records of the EdL and IPP power station are shown in Table 3.1-10. The generation record of EdL in 2010 includes the generation of six EdL-Gen power stations transferred from EdL.

Table 3.1-10 Electricity Supplied from Existing Power Plants

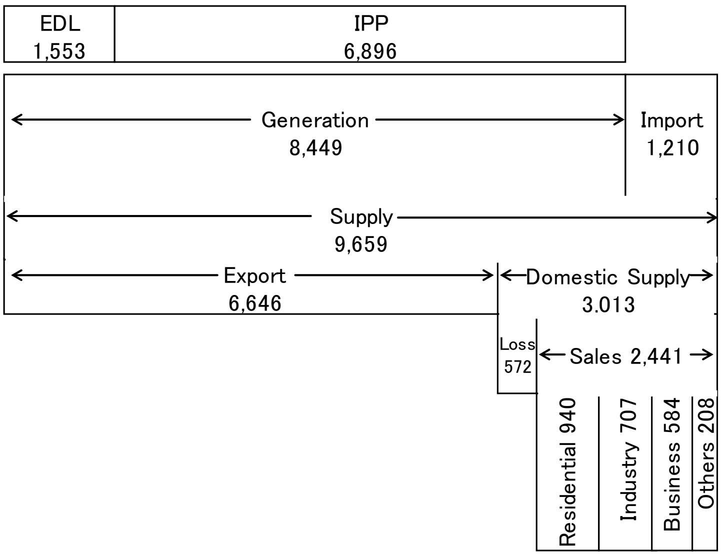
(GWh)

Year		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
EdL	Generation	1,554	1,570	1,317	1,416	1,715	1,640	1,398	1,778	1,656	1,553
	Domestic Supply	710	767	884	903	1,011	1,114	1,616	1,916	2,258	2,441
	Export	796	771	435	51	728	547	268	392	230	341
	Import	182	201	229	278	326	631	793	845	1,175	1,210
IPP Total	Generation	2,100	2,034	1,861	1,931	1,794	1,956	1,975	1,939	1,710	6,896
	Selling to EdL	3	5	10	14	16	15	13	16	19	579
	Export	2,075	2,027	1,850	1,918	1,778	1,940	1,962	1,924	1,691	6,305
Theun Hinboun	Generation	1,507	1,455	1,432	1,528	1,366	1,489	1,501	1,547	1,456	1,339
	Selling to EdL	1	1	4	6	8	10	11	12	15	29
	Export	1,485	1,454	1,427	1,521	1,358	1,479	1,489	1,535	1,440	1,298
Houay-Ho	Generation	593	579	429	403	429	466	475	393	254	370
	Selling to EdL	3	4	6	7	8	5	2	4	3	1
	Export	590	573	423	396	420	461	473	389	251	369
Nam Theun 2	Generation										4,910
	Selling to EdL										272
	Export										4,638
Nam Lik 1-2	Generation										277
	Selling to EdL										277
	Export										0

Source: MEM/DEPP Electricity Statistics Yearbook 2010

Figure 3.1-8 shows the electricity supply-demand balance in Lao PDR in 2010. In 2010, EdL, EdL-Gen, and IPP power stations in Lao PDR generated 8,449 GWh and EdL imported 1,210 GWh from neighboring countries. The gross electricity supply totaled 9,659 GWh in 2010. The electricity supply increased sharply as a result of the commencement of operation of Nam Theun 2, which generated 4,910 GWh in 2010. One third of the total electricity in Lao PDR was supplied to meet domestic demand, and the remainder was exported to Thailand.

(unit: GWh)



Source: MEM

Figure 3.1-8 Electricity Supply-Demand Balance in 2010

3.1.3 Power Development Plan

(1) Outline of Power Development Policy

Ministry of Energy and Mines (MEM) sets the strategy for power development based on the “National Socio Economic Development Plan.” The responsibility of MEM for power development is established by Article 10 of the Law on Electricity.

MEM is charged with working with all concerned organizations to draw up the “Power Development Plan” and submit it to the Government for approval.

Requisites of power development plan are also prescribed in Article 10 as follows:

1. *Ensure principles of using natural resources in appropriate, economical, and highly effective manner;*
2. *Set targets, directions, mechanisms, and methods for developing power projects technically and economically; ensure the safe and stable supply of electricity, and mitigate social and environmental impacts of power development;*
3. *Ensure domestic electricity demand, which is a fundamental for economic and social growth in each period and policy for national socio-economic development; and,*
4. *Set targets for electricity exports based on the exclusive right of domestic supply and demand in neighboring countries.*

MEM established the strategy for the energy and mine sector titled “Strategy Plan for 2006 to 2020.” Based on the power development strategy established by MEM, EdL formulated the “Power Development Plan” for domestic power development. The current PDP formulated by EdL (PDP 2010 revision-1) corresponds mainly to items 2. and 3. of Article 10 of the Law on Electricity.

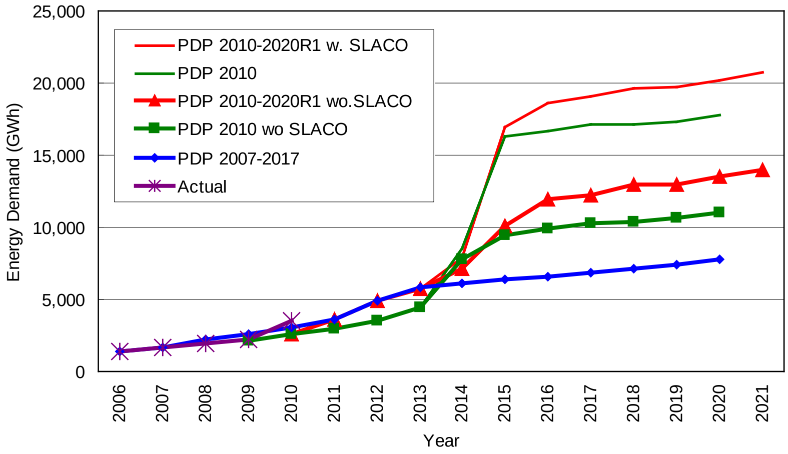
(2) “Power Development Plan 2010-2020”

The latest “Power Development Plan” formulated by EdL is “Power Development Plan 2010-2020 Revision-1” (PDP2010-2020 Revision-1). Article 9 of the Law on Electricity states that the electricity enterprise shall prepare the electricity development plan. EdL has been preparing the “Power Development Plan” every three to five years. EdL formulated the “Power Development Plan” 2010-2020” (PDP2010-2020) in August 2010, revising the former PDP2007-2017. In August 2011, EdL updated PDP2010-2020 by reflecting the latest electricity demand forecast and prospective project developments.

PDP2010-2020 was submitted to the government and obtained the approval of the Prime Minister’s Office according to Article 10 of the Law on Electricity. The content of the PDP2010-2020 Revision-1 updated data; therefore, there was no need to get approval for PDP2010-2020 Revision-1.

(3) Demand Forecast

Figure 3.1-9 shows the demand forecast calculated by EdL in PDP2007-2017, PDP2010-2020, and PDP2010-2020 Revision-1 (PDP2010-2020R1). In the Figure, electricity demand in PDP2010-2020 and PDP2010-2020R1 w.SLACO includes significant demand from Sino-Lao Aluminum Corporation (SLACO), an aluminum refining project in the southern region. Comparing the demand forecast between PDP2007-2017 and PDP2010-2020 Revision-1, demand after 2014 is estimated to be much larger in the latest forecast than previously.



Source: EdL "Power Development Plan 2007, 2010, 2010 Revision 1"

Figure 3.1-9 Power Demand Forecast in "Power Development Plan"

The methodology of the demand forecast carried out by EdL was originally introduced in the JICA Study, and has been improved by EdL. EdL gathers data for the calculation as follows:

1) Demand in Residential Sector

EdL gathers current data on population, households, and villages in rural and urban areas from the Department of Statistics, Ministry of Planning and Investment (MPI). EdL makes the forecast based on certain assumptions such as growth rate of population and number of persons per household. EdL estimates future electricity consumption per household by multiplying the growth rate for data on current electricity consumption. The future value for electrification rate is based on the Government's target. System losses are assumed to improve 0.2% annually from the present level. Based on these assumptions, electricity consumption for residential demand is forecasted.

2) Demand in Non-residential Sector

Demand in the non-residential sector is forecasted by aggregating demand from two classes of consumer. Large industrial demand such as from mines, cement factories, special economic zone (SEZ), and construction of power plants and railways are forecasted and calculated on a project-by-project basis, then total large industrial demand is calculated. Future demand data of large projects are supplied by the relevant organization. Electricity consumption by mines and cement mills is estimated by the Ministry of Energy and Mines (MEM). Demand for railway construction is provided by the Ministry of Public Works and Transport. EdL learns from developers of the SEZ about demand in SEZ. Table 3.1-11 shows the peak demand forecast in PDP2010-2020 Revision-1.

The demand for the residential sector grows gradually from 2010 to 2020 with an average rate of increase of about 7%. Non-residential demand is expected to increase substantially due to the rapid growth of demand from factories and mines. The average growth rate of non-residential demand, except SLACO, is 33% per year from 2010 to 2020.

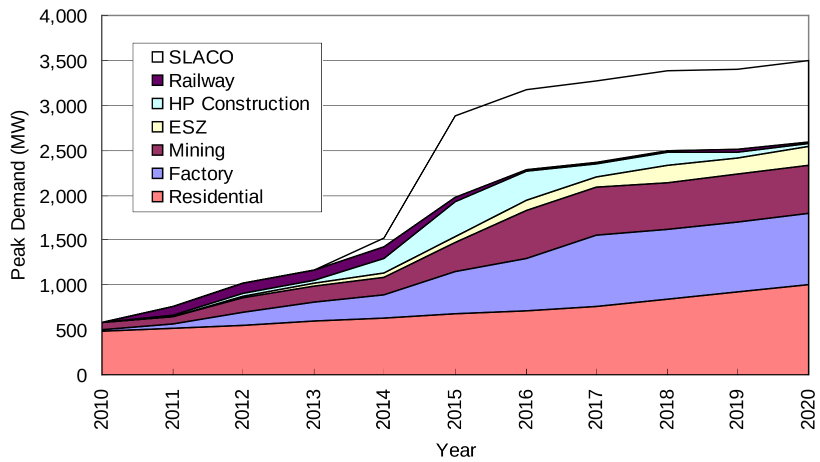
Table 3.1-11 Demand Forecast

(MW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Residential	492	522	557	592	631	673	718	769	838	916	1,004
Factory	17	45	133	214	260	475	578	778	785	793	794
Mining	75	77	168	176	192	320	536	539	521	524	527
SEZ *1	-	-	10	35	58	70	116	120	180	180	210
HPConst. 2	-	24	33	27	159	395	311	143	147	70	41
Railway	-	92	120	120	120	49	21	21	21	21	21
Subtotal	**584**	**758**	**1,021**	**1,165**	**1,420**	**1,982**	**2,281**	**2,371**	**2,492**	**2,504**	**2,597**
SLACO	-	-	-	-	100	900	900	900	900	900	900
Total	**584**	**758**	**1,021**	**1,165**	**1,520**	**2,882**	**3,181**	**3,271**	**3,392**	**3,404**	**3,497**

Notes 1: SEZ: Special Economic Zone, Notes 2: HP Const.: Hydropower Construction

Source: EdL PDP2010-2020 Revision-1



Source: EdL PDP2010-2020 Revision-1

Figure 3.1-10 Peak Demand Forecast in the “Power Development Plan”

3) Demand for SLACO aluminum refining project

Sino-Lao Aluminum Corporation (SLACO) is an aluminum-refining project planned for Attapeu and Champasak Province in the southern part of Lao PDR. SLACO signed a mining agreement for bauxite mines and processing plants with the Government of Lao in 2008.

An aluminum smelting and refining process consumes large volumes of electricity; therefore, a large electricity supply is required for the SLACO project. EdL and SLACO signed a MOU for power supplies in December 2008. According to the MOU, 900 MW of electric power is required for the first stage of the SLACO project. Furthermore, 1,800 MW will be required for the second stage of the SLACO project and 3,600MW for the final stage.

According to information from MEM, the price of electricity supplied to SLACO is crucial for the feasibility of the SLACO project, in order to achieve competitiveness in the international market.

(4) "Power Development Plan" for Domestic Supply

Projects developed for domestic supply are as listed in Table 3.1-12 of PDP2010-2020 Revision-1. When revising PDP2010-2020, the development plan of each project was examined, and in some projects, ownership, installed capacity, and Commercial Operation Date (COD) were updated on the basis of the latest information.

Table 3.1-12 "Power Development Plan" in PDP2010-2020 Revision-1

NORTHERN

Name	Ownership	Capacity (MW)	COD	Province	Status
Nam Dong	EdL	1.0	1970	Luangprabang	Existing
Nam Ko	EdL	1.5	1996	Oudomxay	Existing
Nam Ngai	EdL	1.2	2003	Phongsaly	Existing
Nam Nhon	IPP(d)	2.4	2011	Bokeo	Existing
Nam Tha 3	IPP(d)	1.3	2011	Luangnamtha	Existing
Nam Ngum 5	IPP(d)	120.0	2012	Xiengkhuang	
Nam Long	IPP(d)	5.0	2013	Luangnamtha	
Nam Ham 2	IPP(d)	5.0	2013	Xayabury	
Nam Boun 2	EdL-Gen	15.0	2014	Phongsaly	
Nam Ngiew	IPP(d)	20.0	2014	Xiengkhuang	
Nam Beng	IPP(d)	34.0	2015	Oudomxay	
Nam Khan 2	EdL-Gen	130.0	2015	Luangprabang	
Nam Sim	IPP(d)	8.6	2015	Huaphanh	
Nam Pot	IPP(d)	15.0	2015	Xiengkhuang	
Nam Chiene	EdL-Gen	80.0	2015	Xiengkhuang	
Nam Phak	EdL-Gen	30.0	2015	Oudomxay	
Hongsa (Lignite)	IPP(e)	100.0	2015	Xayabury	
Nam Ngiep 2	IPP(d)	180.0	2015	Xiengkhuang	
Nam Pha	IPP(d)	130.0	2015	Luangnamtha	
Nam Tha 1	IPP(d)	168.0	2016	Luangnamtha	
Nam Ou 2	IPP(d)	120.0	2016	Luangprabang	
Nam Ou 6	IPP(d)	180.0	2016	Phongsaly	
Nam Ou 5	IPP(d)	240.0	2016	Phongsaly	
Nam Khan 3	EdL-Gen	47.0	2016	Luangprabang	
Nam Xam 1	IPP(e)	47.0	2016	Huaphanh	
Nam Seung 1	IPP(d)	42.0	2017	Luangprabang	
Nam Seung 2	IPP(d)	134.0	2017	Luangprabang	
Nam Ou 1	IPP(d)	160.0	2018	Luangprabang	
Nam Ou 3	IPP(d)	150.0	2018	Luangprabang	
Nam Ou 4	IPP(d)	116.0	2018	Phongsaly	
Nam Ou 7	IPP(d)	190.0	2018	Phongsaly	
Nam Ma 1.2.3.4.5	IPP(e)	22.4	2019	Huaphanh	
Nam Ngum 4	IPP(e)	110.0	2019	Xiengkhuang	
Mekong (Xayabury)	IPP(e)	60.0	2019	Xayabury	
Mekong (Laungprabang)	IPP(e)	114.0	2020	Luangprabang	
Mekong (Pak Beng)	IPP(e)	150.0	2020	Luangprabang	
Total		**2,853.4**			

CENTRAL

Name	Ownership	Capacity (MW)	COD	Province	Status
Nam Ngum 1	EdL-Gen	155.0	1971	Vientiane	Existing
Nam Leuk	EdL-Gen	60.0	2000	Vientiane	Existing
Nam Mang 3	EdL-Gen	40.0	2004	Vientiane	Existing

Nam Lik 1/2	IPP(d)	100.0	2010	Vientiane	Existing
Nam Song (Extension)	EdL-Gen	6.0	2011	Vientiane	Existing
Nam Phao	IPP(d)	1.6	2012	Borikhamxay	
Nam Gnuang 8	IPP(d)	60.0	2012	Borikhamxay	
Nam Sana	EdL-Gen	14.0	2013	Vientiane	
Nam Ngum 1 (Extension)	EdL-Gen	40.0	2014	Vientiane	
Nam Lik 1	IPP(d)	60.0	2014	Vientiane	
Nam Kene	IPP(d)	5.0	2014	Vientiane	
Nam Mang 1	IPP(d)	64.0	2015	Borikhamxay	
Kengseuaten	EdL-Gen	54.0	2016	Borikhamxay	
Nam Bak	IPP(d)	160.0	2015	Vientiane	
Nam Phouan	IPP(e)	30.0	2015	Vientiane	
Nam Phai	IPP(d)	60.0	2015	Vientiane	
Nam San 3	IPP(d)	48.0	2015	Xiengkhuang	
Nam Theun 1	IPP(e)	50.0	2018	Borikhamxay	
Nam San 3 (Down)	IPP(d)	30.0	2018	Xiengkhuang	
Nam Ngum (Down)	IPP(d)	60.0	2018	Vientiane Capital	
Nam Ngiep 1	IPP(e)	22.0	2018	Borikhamxay	
Total		**1,119.6**			

SOUTHERN

Name	Ownership	Capacity (MW)	COD	Province	Status
Xelabam	EdL-Gen	5.0	1970	Champasack	Existing
Xeset 1	EdL-Gen	45.0	1990	Saravane	Existing
Theun Hinboun	IPP(e)	8.0	1998	Borikhamxay	Existing
Houay Ho	IPP(e)	2.1	1999	Attapeu	Existing
Xeset 2	EdL-Gen	76.0	2009	Saravane	Existing
Nam Theun 2	IPP(e)	75.0	2009	Khammuane	Existing
Xekaman 3	IPP(e)	25.0	2012	Sekong	
Tadsalen	IPP(d)	3.2	2013	Savannakhet	
Xeset 3	EdL-Gen	23.0	2013	Champasack	
Xelabam (Extension)	EdL-Gen	7.7	2013	Champasack	
Xenamnoy 1	IPP(d)	15.0	2013	Sekong	
XeKaman 1 + Xanxai	IPP(e)	64.0	2014	Attapeu	
Houay Lamphan Gnai	EdL-Gen	88.0	2014	Sekong	
Houay Kapeuk	IPP(d)	5.0	2014	Saravane	
Houay Champi	IPP(d)	5.0	2014	Champasack	
Kaleum (Thermal)	IPP(d)	300.0	2014	Sekong	
Nam Kong 2	IPP(d)	66.0	2015	Attapeu	
Nam Kong 3	IPP(d)	42.0	2015	Attapeu	
Nam Phak / Houaykatam	IPP(d)	45.0	2016	Champasack	
Xeset 4	EdL-Gen	10.0	2015	Champasack	
Thakho (Mekong)	IPP(d)	50.0	2016	Champasack	
Sepon 3 (Down)	IPP(d)	30.0	2016	Saravane	
Sepon 3 (Up)	IPP(d)	70.0	2016	Saravane	
Nam Hinboun	EdL-Gen	40.0	2016	Khammuane	
Xekong 4	IPP(e)	60.0	2016	Sekong	
Xekatam	IPP(d)	75.0	2017	Champasack	
Xepian-Xenamnoy	IPP(e)	40.0	2016	Champasack	
DonSahong (Mekong)	IPP(d)	240.0	2017	Champasack	
Xeneua	IPP(d)	53.0	2018	Khammuane	
Xe Lanong 1	IPP(d)	60.0	2018	Savannakhet	
Xe Lanong 2	IPP(d)	45.0	2018	Saravane	
Xe don 2	IPP(d)	30.0	2018	Saravane	
Xebang Hieng 1	IPP(e)	60.0	2019	Savannakhet	
Total		**1,753.0**			

Source: EdL PDP2010-2020 Revision-1, EdL-Gen Annual Report 2010

To formulate the development plan for power stations, EdL drafted the “Power Development Plan” based on information on EdL, EdL-Gen, and Independent Power Producer (IPP) projects. A PPA project is listed in the year of the commercial operation date (COD) contracted under the PPA. EdL obtains information on IPP for export (IPP(e)) and IPP for domestic supply (IPP(d)) projects from the Ministry of Energy and Mines (MEM).

(5) Development Plan for Exports

The "Power Development Plan" for electricity export projects is shown in Table 3.1-13 based on the latest information from the Department of Energy Policy Planning (DEPP) and the Department of Energy Business (DEB) of MEM. The progress of the project in Table 3.1-13 is categorized based on the status of implementation procedures shown in Figure 3.1-11, i.e. Memorandum of Understanding (MOU), Project Development Agreement (PDA), Concession Agreement (CA), Under Construction (UC) and Existing.

As of the end of 2011, four projects; Theun Hinboun, Houay Ho, Nam Theun 2, and Nam Ngum 2 were in operation. The total installed capacity of existing IPP(e) power stations was 2,052 MW. Four projects with a total installed capacity of 2,680 MW are under construction, including Hongsa Lignite Thermal Power Project, which is the first coal thermal power station in Lao PDR with a total installed capacity of 1,878 MW. Seven projects on the Mekong Mainstream—Pakbeng, Luangprabang Xayabury, Paklay, Sanakham, Phou Ngoy, and Ban Koum—are listed as IPP(e) projects. Total installed capacity of IPP(e) projects amounts to about 17,000 MW. More than half of IPP(e) projects are at the stage of MOU.

Table 3.1-13 Development Plan of Projects for Exports

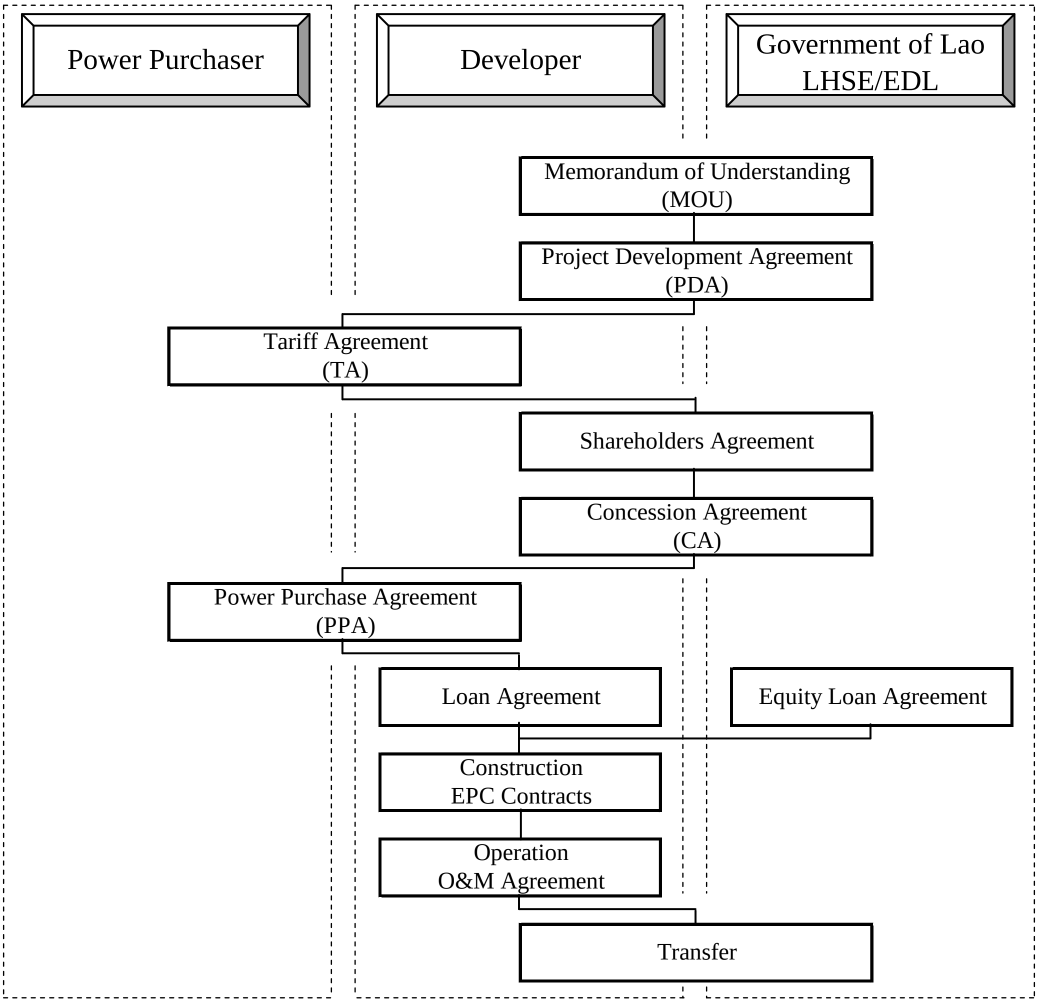
Name	Area	Province	Capacity (MW)			COD	Progress[2]	Planned Market
			Total	Export	Dom.[1]			
Theun Hinboun	Southern	Khammuan	220	212	8	1998	Existing	Laos/Thailand
Houay Ho	Southern	Attapeu	152	150	2	1999	Existing	Laos/Thailand
Nam Theun 2	Southern	Khammuan	1,075	1,000	75	2010	Existing	Laos/Thailand
Nam Ngum 2	Northern	Vientiane	615	615		2011	Existing	Thailand
Theun Hinboun (Extension)	Central	Borikhamxay	220	220		2012	UC	Thailand
Xekaman 3	Southern	Sekong	250	225	25	2012	UC	Laos/Vietnam
Xekong 3A	Southern	Champasack	105			2013	MOU	Laos/Vietnam
XeKaman 1+Xanxai	Southern	Attapeu	322	258	64	2014	UC	Laos/Vietnam
Hongsa (Thermal)	Northern	Xayabury	1,573	1,473	100	2015	UC	Laos/Thailand
Nam Mo	Northern	Xiengkhuang	120			2015	PDA	Vietnam
Nam Bak 1	Central	Vientiane	160			2015	MOU	Thailand
Nam Bak 2	Central	Vientiane	40			2015	MOU	Laos/Thailand
Nam Phouan	Central	Vientiane	60	30	30	2015	MOU	-
Xebang Hieng 2	Southern	Savannakhet	52			2015	MOU	Vietnam
Xekaman 4	Southern	Attapeu	80			2015	MOU	Vietnam
Xekong 3B	Southern	Champasack	100			2015	MOU	Laos/Vietnam
Nam Xam 1	Northern	Huaphanh	186	139	47	2016	PDA	Laos/Vietnam
Xekong 5	Southern	Sekong	330			2016	PDA	Laos/Thailand
Xepian-Xenamnoy	Southern	Champasack	390	350	40	2016	PDA	Laos/Thailand
Xekong 4	Southern	Sekong	300	240	60	2016	PDA	Thailand
Nam Ngum3	Central	Vientiane	460			2017	PDA	Thailand
Nam Mouan	Central	Borikhamxay	124			2017	MOU	Vietnam
Nam Kong 1	Southern	Attapeu	150			2017	PDA	Thailand
Sanakham (Mekong)	Northern	Xayabury	660			2018	PDA	-
Nam Theun 1	Central	Borikhamxay	523	473	50	2018	PDA	Laos/Thailand
Nam Ngiep 1	Central	Borikhamxay	263	241	22	2018	PDA	Laos/Thailand
Phou Ngoy (Mekong)	Southern	Champasack	651			2018	PDA	Thailand/Laos
Xayabury (Mekong)	Northern	Xayabury	1,285	1,225	60	2019	CA	Laos/Thailand
Nam Ma 1.2.3.4.5	Northern	Huaphanh	149	127	22	2019	MOU	Laos/Vietnam
Nam Ngum 4	Northern	Xiengkhuang	220	110	110	2019	MOU	Laos/Vietnam
Xebang Hieng 1	Southern	Savannakhet	60		60	2019	MOU	Vietnam
Pakbeng (Mekong)	Northern	Luangprabang	855	705	150	2020	PDA	-
Luangprabang	Northern	Luangprabang	1,410	1,296	114	2020	MOU	Laos/Vietnam

(Mekong)							
Nam Poui	Northern	Xayabury	60		TBD	MOU	-
Nam Phoun	Northern	Xayabury	74		TBD	MOU	Laos
Paklay (Mekong)	Northern	Xayabury	1,320		TBD	MOU	Laos/Thailand
Nam Mo 1	Northern	Xiengkhuang	80		TBD	MOU	Vietnam
Nam Neun	Northern	Huaphanh	65		TBD	MOU	Vietnam
Nam Xam 3	Northern	Huaphanh	186		TBD	MOU	Laos/Vietnam
Nam Feung	Central	Vientiane	28		TBD	MOU	Laos
Nam Ngiep Muang Mai	Central	Borikhamxay	38		TBD	MOU	-
Xebangnouan	Southern	Saravane	80		TBD	MOU	-
Xekong (down)	Southern	Attapeu	80		TBD	MOU	-
Dak E Meule	Southern	Champasack	130		TBD	MOU	Laos/Vietnam
Ban Koum (Mekong)	Southern	Champasack	1,872		TBD	MOU	Laos/Thailand
Nam Ang Thabeng	Southern	Attapeu	30		TBD	MOU	-
Xepian-Houay Soy	Southern	Attapeu	100		TBD	MOU	Thailand
Total			17,303				

Notes 1: Domestic,

Notes 2: MOU: Memorandum of Understanding, PDA: Project Development Agreement, UC: Under Construction

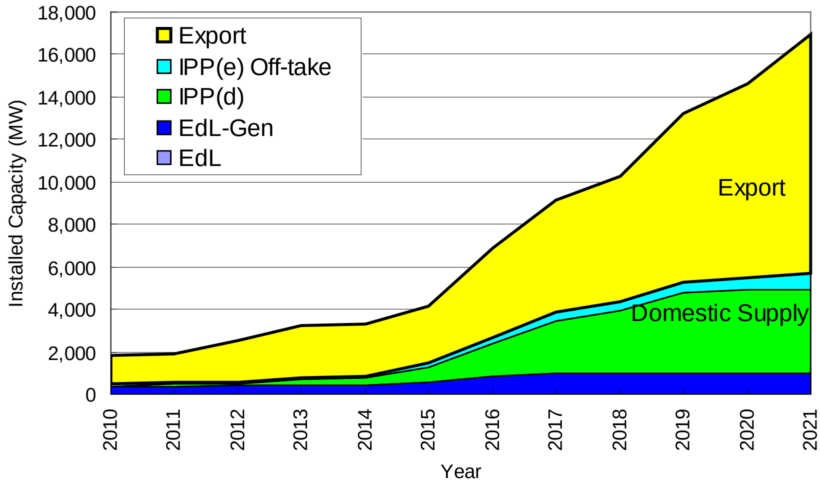
Source: MEM



Source: MEM

Figure 3.1-11 IPP Project Implementation Procedures

Based on the “Power Development Plan” of EdL and information from MEM, the total installed capacity of power stations by specified Commercial Operation Date (COD) is shown in Figure 3.1-12. In 2021, the total installed capacity of all categories of power station in Lao will be about 17,200 MW. Of these projects, 5,700 MW is for domestic supply from EdL, EdL-Gen and IPP(d), and off-take from IPP(e) power plants; 11,500 MW is for exports supplied from IPP(e) power plants.



Source: MEM

Figure 3.1-12 Total Installed Capacity in Lao PDR

(6) Development of IPP Projects

1) Coal Thermal Power Projects

(a) Coal thermal power projects in Lao PDR

As of 2009, energy production from coal accounted for only 2% of total energy production in Lao PDR. Lignite and anthracite coal are mined on a small scale at several locations. However, development of new coal mines with large-scale reserves is proceeding to use the coal both for export and power generation.

(b) Hongsa Lignite Power Project

Hongsa Mine-Mouth Power Project (Hongsa Power) combines a newly developed lignite mine and coal thermal power station. The installed capacity of the power station is 1,878 MW, comprising three units of 626 MW, and the first unit will start commercial operation in 2015.

Phu Fai Mining Company (PFMC) is the recipient of a lignite mining concession, which it subleases to Hongsa Power. Hongsa Power is the recipient of a power plant concession, and is the principal operator of both mining operations and power generation.

The shares of the two companies are owned by three companies—75% of the shares of PFMC and 80% of the shares of Hongsa Power are held by two Thai companies: Banpu Public Company Ltd. (BANPU) and Ratchaburi Electricity Generating Holding PCL (RATCH). The remaining shares, 25% of the PFMC and 20% of Hongsa Power, are held by

LHSE.

A summary of the mining and power project is shown in Table 3.1-14. The structure of the project is shown in Figure 3.1-13.

Table 3.1-14 Hongsa Lignite Mining and Power Project

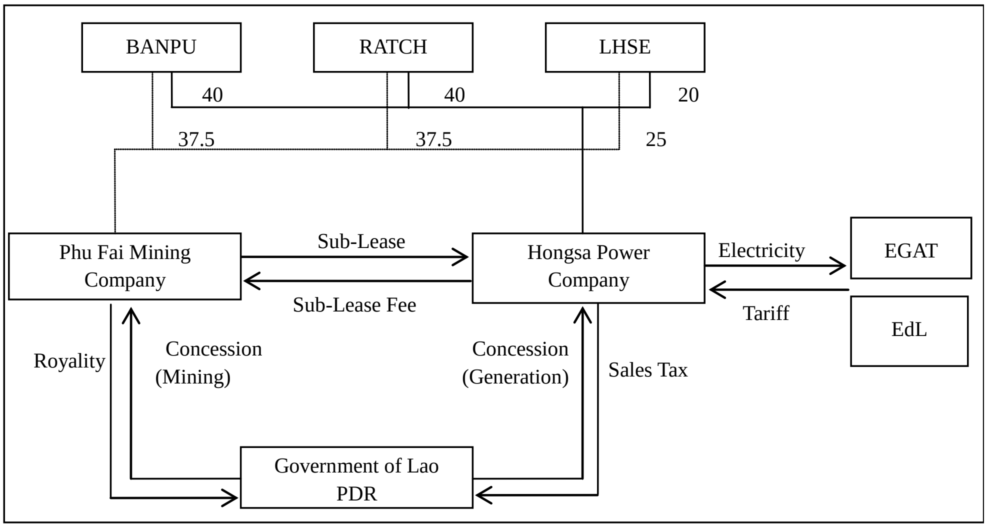
Mining Project

Item		Remarks
Concession recipient	Phu Fai Mining Company Ltd	Mining concession will be subleased to Hongsa Power.
Shareholder	BANPU(Thailand) 37.5% RATCH(Thailand) 37.5% LHSE(Lao) 25%	
Commercial operation date	2015	
Concession period of mining	25 years	Coal mine will be transferred to Lao Government in 2040.
Reserves of lignite	530 million tons	
Annual production	20 million tons/year	
Average heat rate	2,000 kcal/kg	
Key Features	Lignite mining Water reservoirs Resettlement	Opencast mining

Power Project

Item		Remarks
Concession recipient	Hongsa Power Company	
Shareholder	BANPU(Thailand) 40% RATCH(Thailand) 40% LHSE(Lao) 20%	
Commercial operation date	Unit 1 June 2015 Unit 2 November 2015 Unit 3 March 2016	
Concession period of generation	25 years	Plant will be transferred to Lao Government in 2040.
Capacity	1,878 MW	626 MW 3 units
Annual lignite consumption	20 million tons/year	

Source: MEM



Source: MEM

Figure 3.1-13 Structure of Hongsa Project

Two PPAs are contracted for the Hongsa Project. One is for power exports to Thailand signed between Hongsa Power and Electricity Generating Authority of Thailand (EGAT), and the other is for domestic electric power supply signed between Hongsa Power and EdL.

A total of 1,473 MW of 1,878 MW net output will be supplied to EGAT under EGAT PPA through a 500 kV transmission line connecting Hongsa and Mae Mo Coal Thermal Power Station in Thailand. 100 MW will be supplied to EdL through a 115 kV transmission line to EdL, and the remainder will support captive consumption by the coal mine and power station.

(c) Kaleum Thermal Power Project

In PDP2010-2020 Revision-1, another thermal power project, Kaleum lignite thermal power, is assigned as a new energy source in the southern region. In the PDP, Kaleum, which is designed with a total capacity of 600 MW, will be developed from 2010; its first unit generating 300 MW will start operation in 2014, and the second 300 MW unit will start operation in 2015.

The projects of Ban Padou and Kaleum mine and Kaleum thermal power station are being promoted by the Phonesack Group, which is wholly owned by Lao companies. The Phonesack Group had a concession for developing the Kaleum coal mine. The Phonesack Group established Xekong Power Plant Ltd., to engage in mining and power generation. However, neither MOU nor PDA has been concluded at the present time for the power project. The Phonesack Group is executing a feasibility study for the coal mine and power project.

2) Hydropower project in Mekong mainstream

The Lower Mekong countries, Lao PDR, Thailand, Cambodia, and Vietnam signed the “Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin” in April 1995. The agreement defines principles and processes to develop the waters of the Mekong River, which includes power development in the mainstream of the Mekong River.

The Lao National Mekong Committee (LNMC) submitted documents for prior consultation on the Xayabury Project to the Mekong River Commission (MRC) in September 2010, which was the first power project for the mainstream of the Lower Mekong Basin submitted to MRC.

In December 2011, it was decided at a meeting held by the MRC that construction of the dam would be postponed, and it was agreed that a further environmental impact assessment would be performed.

MEM mentioned to the JICA Team in June 2012 that the Xayabury hydropower project will be developed on schedule and start operation in 2019.

In the recent PDP (PDP2010-2020 Revision-1), five hydropower projects including Xayabury hydropower listed in Table 3.1-15 are planned to start operation within the planning period.

Table 3.1-15 Mekong Mainstream Projects in PDP

Area	Name	Ownership	COD	Installed Capacity (MW)	EdL Off-take (MW)
Northern	Xayabury	IPP(e)	2019	1,285	60
	Pak Beng	IPP(e)	2020	855	150
	Luangprabang	IPP(e)	2020	1,410	114
Southern	Thakho (Diversion)	IPP(d)	2016	50	50
	Don Sahong	IPP(d)	2017	240	240
Total				**3,840**	**614**

Source: EdL PDP2010-2020 Revision-1 and MEM

(7) Demand and Supply Balance in Domestic System

Based on electricity demand and supply described in the previous section, the demand and supply balance in Lao PDR is examined in PDP2010-2020 Revision-1 to confirm sufficient supply capacity for the future growth of electricity demand. Due to uncertainty in both demand and supply forecast, in particular large demand from the SLACO aluminum project after 2015, a base scenario and three alternative scenarios shown in Table 3.1-16 are examined in PDP2010-2020 Revision-1.

Table 3.1-16 Conditions for Demand-Supply Balance

Case	Demand	Supply		
	SLACO	Kaleum Thermal	Mekong Mainstream	Supply for SLACO
	900 MW (2015)	#1 300 MW (2014) #2 300 MW (2015)	Xayabury (60 MW) Pak Beng (150 MW) Luangprabang (114 MW) Thakho (50 MW)) Don Sahong (240 MW)	Nam Kong 1 (75 MW) Xekong 4 (300 MW) Xekong 5 (190 MW)
Case 1	-	○	○	-
Case 2	○	-	○	○
Case 3	○	○	○	○
Case 4	○	-	-	○

Source: EdL PDP2010-2020 Revision-1 and MEM

On the demand side, demand for SLACO is not considered in the base scenario (Case 1). In the alternative scenarios (Cases 2, 3, and 4), 900 MW of the demand for SLACO is included in large industrial demand starting from 2015.

On the supply side, the Kaleum coal thermal power project in Sekong province and five hydropower projects on Mekong mainstream are to be developed on schedule based on scenario (Case 1). In the alternative scenario (Cases 2, 3, and 4), three hydropower plants in the south, Nam Kong 1, Xekong 4, and Xekong 5 are to be electricity supply sources for the SLACO project. At present, PDAs for these three hydropower projects have been concluded with Region Oil Company, a Russian company as IPP(e) projects; however, it is planned to change the status of these projects from IPP(e) to direct electricity supply source (back-to-back supply) for the SLACO project in the alternative scenarios. The contract between SLACO and Region Oil Company is still under negotiation.

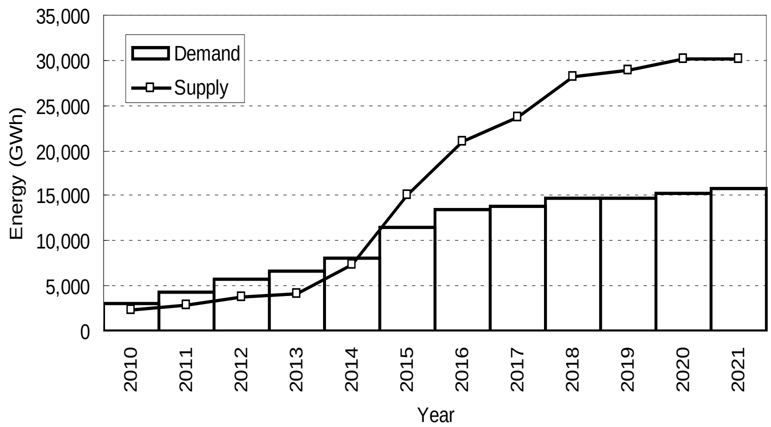
Although four scenarios are examined in PDP2010-2020 Revision-1, MEM mentioned in

June 2012 to the JICA Study Team that the following measures are practical and reasonable regarding the electricity supply to the SLACO project.

- Electricity demand for the SLACO project will be supplied by either Kaleum coal thermal power or imported from EGAT through a back-to-back contract, i.e., supplied directly from power plants to the SLACO project.
- Supplying electricity to the SLACO project from hydropower stations (Nam Kong 1, Xekong 4, and Xekong 5) is not feasible because of fluctuations of the outputs of hydropower plants.

Therefore, the base scenario (Case 1) of the "Power Development Plan" is examined in the following section of this study.

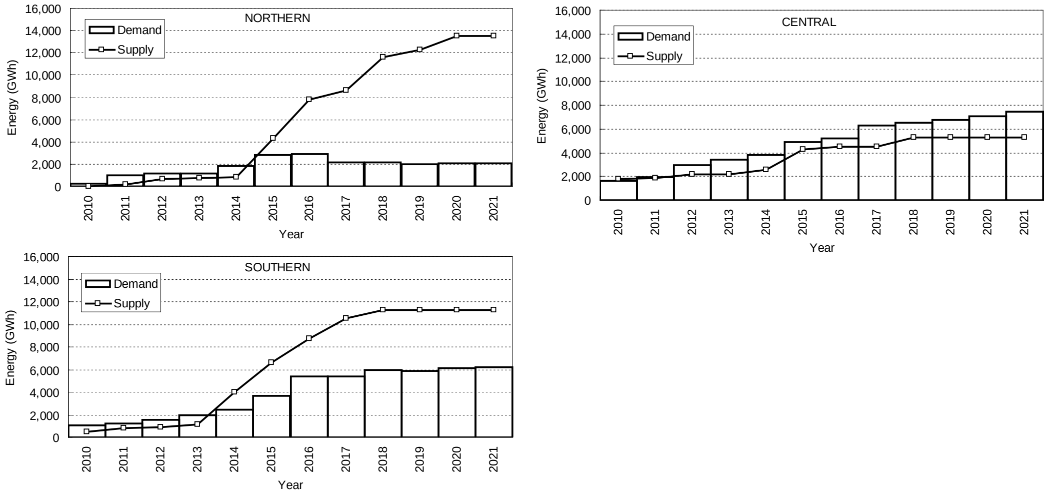
The power supply and demand balance in Lao PDR from 2010 to 2021 is shown in Figure 3.1-14. This figure shows the balance in terms of electrical energy, which is the balance of power generation (GWh) and electricity consumption (GWh) for the year. In this figure, demand for the SLACO Aluminum Project is excluded. The electricity energy balance for the whole country will be negative until 2014. After 2015, the electricity supply increases rapidly due to the development of the IPP for domestic supply projects. In 2021, the surplus electricity supply reaches about 14,000 GWh per year, which can be exported to neighboring countries.



Source: EdL PDP 2010-2020 Revision-1

Figure 3.1-14 Electricity Demand and Supply Balance Nationwide

Figure 3.1-15 shows the electricity demand-supply balance for each region: Northern, Central, and Southern systems. In the Northern and Southern systems, a substantial surplus of electricity will be supplied; meanwhile, the electricity demand-supply balance will be negative in the Central system throughout the planning period. This means electricity should be supplied to the Central system from the Northern or Southern system, and imported from Thailand.

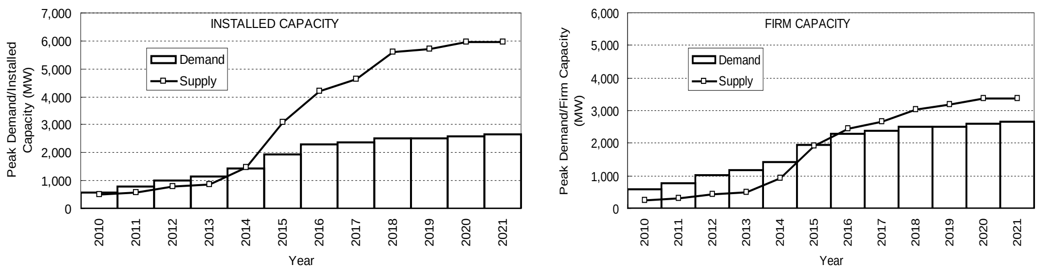


Source: EdL PDP 2010-2020 Revision-1

Figure 3.1-15 Electricity Demand and Supply Balance for Each Region

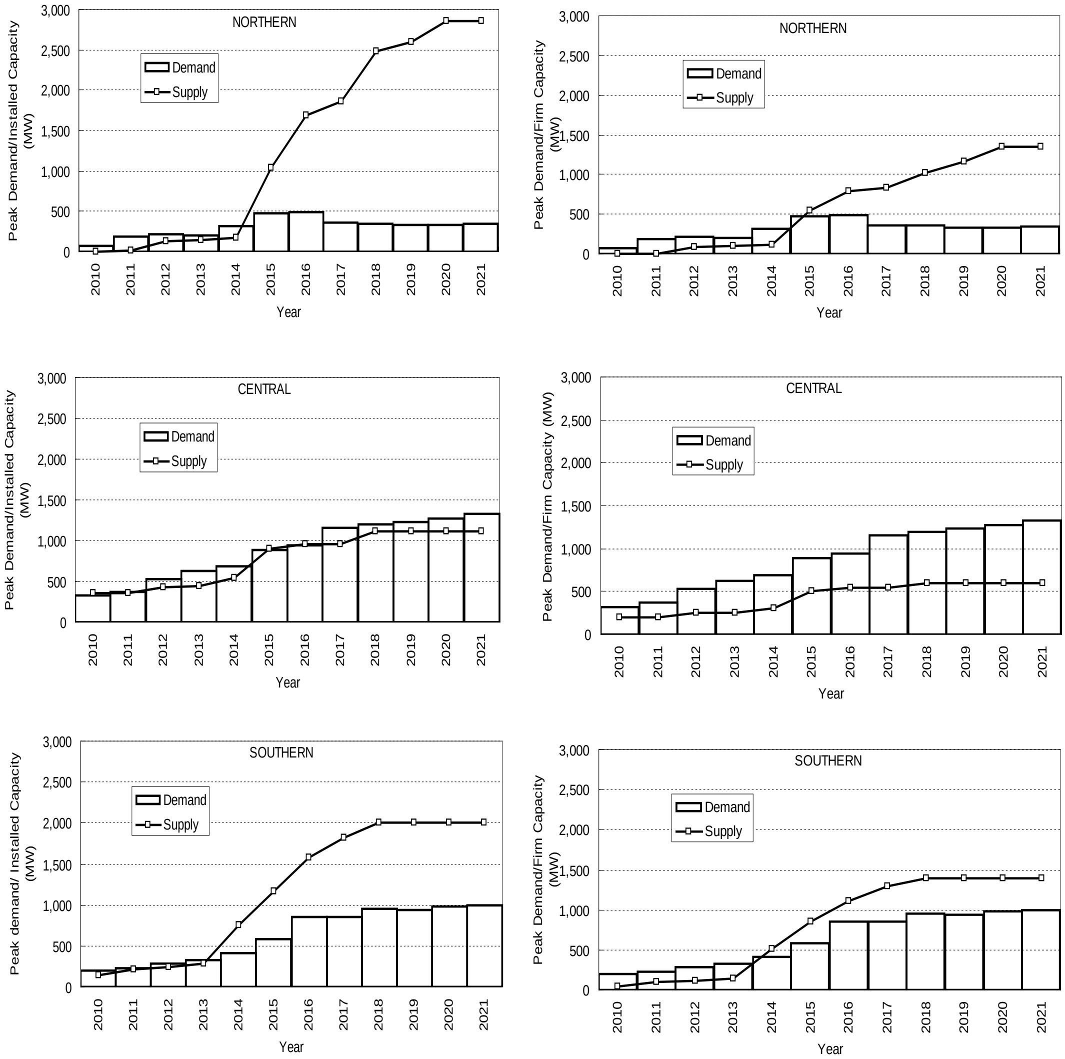
The power balance of the system, which is the supply capacity for peak demand, for the whole country is shown in Figure 3.1-16. In the Figure, supply capacity is calculated by totaling the installed capacities of power stations. Peak demand will exceed total supply capacity by 2014; therefore, the power balance will be negative. After 2015, supply capacity exceeds power peak demand. In 2021, installed capacity of power stations planned for domestic supply will be about 6,000 MW, achieving a substantial margin over peak demand of 2,600 MW.

Because all power stations in Lao PDR, except the proposed Hongsa Power, are hydropower stations, supply capacity is provided by the discharge of the river. In the dry season, when river flow decreases, the output of a hydropower station is much lower than its installed capacity. To ensure supplies from domestic power stations, firm outputs from hydropower stations should be considered as the supply capacity. The figures to the right in Figure 3.1-16 and Figure 3.1-17 show the demand and supply balance for the firm capacity of the power plants.



Source: EdL PDP 2010-2020 Revision-1

Figure 3.1-16 Power Demand and Supply Balance Nationwide



Source: EdL PDP 2010-2020 Revision-1

Figure 3.1-17 Power Demand and Supply Balance for Each Region

(8) Supply Capacity Nationwide

In the previous section, we reviewed the demand-supply balance within the EdL system, i.e., the domestic power system. The supply capacity for the domestic power system consists of supplies from EdL, EdL-Gen and IPP for the domestic supply (IPP(d)), and off-take from IPP for exports (IPP(e)). As mentioned in the previous section, a large proportion of the capacity of power stations has been developed or planned in Lao PDR. In this section, we review the demand-supply balance nationwide including generation for export by IPP(e) power stations. Naturally, most of these IPP(e) projects have a MOU, PDA, or CA, and some already have a long-term power purchase agreement (PPA) with the off-taker in neighboring countries. On the other hand, some of the IPP(e) projects have modified the electricity supply destination to domestic and changed status to IPP(d) project.

Demand-supply balance nationwide including power for export is shown in Table 3.1-17 and

Figure 3.1-18. In the table, Hydro(d) represents generation for domestic supply from EdL, EdL-Gen, IPP(d), and off-take from IPP(e) hydropower stations, Hongsa(d) represents the domestic supply from Hongsa thermal power project (100 MW), Hydro(e) represents generation for export from IPP(e) hydropower, and Hongsa(e) represents power exported to Thailand from the Hongsa thermal power station.

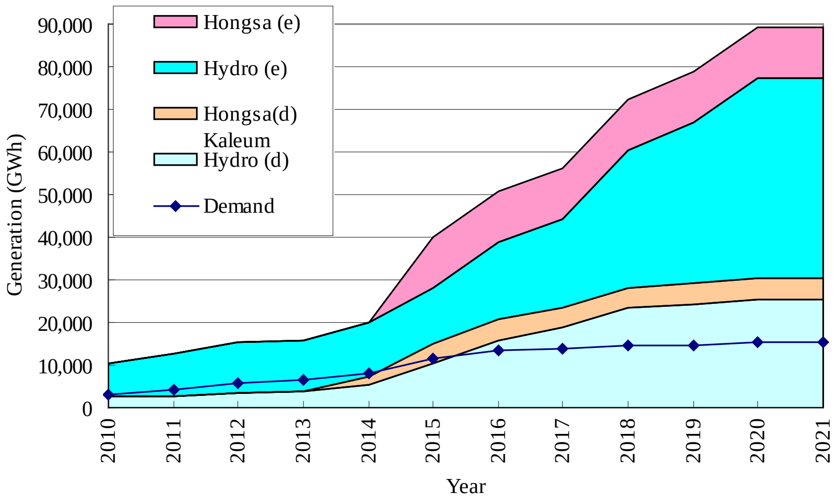
In 2021, the total power generation in Lao PDR will reach around 90 TWh. 20% of electricity will be generated by thermal power and 80% by hydropower in 2021. The amount of power exported from IPP(e) will be 58 TWh, which is about 65% of the total generated in Lao PDR. The total supply capacity nationwide is six times larger than domestic demand.

Table 3.1-17 Demand-Supply Nationwide

(Unit: GWh)

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Hydro (d)	2,681	2,724	3,651	3,994	5,284	10,199	15,832	18,751	23,295	24,313	25,572	25,572
Hongsa(d), Kaleum	0	0	0	0	2,100	4,901	4,901	4,901	4,901	4,901	4,901	4,901
Hydro (e)	7,677	9,895	11,727	11,727	12,585	13,101	18,063	20,706	32,150	37,720	46,744	46,744
Hongsa (e)	0	0	0	0	0	11,881	11,881	11,881	11,881	11,881	11,881	11,881
Total	**10,358**	**12,618**	**15,378**	**15,721**	**19,969**	**40,082**	**50,677**	**56,239**	**72,227**	**78,815**	**89,098**	**89,098**

Source: MEM, EdL PDP 2010-2020 Revision-1



Source: MEM, EdL PDP 2010-2020 Revision-1

Figure 3.1-18 Demand-Supply Balance Nationwide

3.1.4 Issues Related to "Power Development Plan"

(1) Demand and Supply in Great Mekong Sub-region

1) Demand Forecast in Lower Mekong Region

Lower Mekong countries, Lao PDR, Thailand, Vietnam, and Cambodia have recorded high GDP growth with the stimulation of economic activities after the recovery from the Asian Financial Crisis. The total GDP of the four countries reached 440 billion USD in 2010.

In the Lower Mekong region, economic infrastructure such as transportation and distribution networks is being developed and improved by means of ODA. Sufficient, stable electricity supplies are equally important for the further development of this region.

In the Lower Mekong countries, energy demand in Thailand and Vietnam is considerably larger than demand in Lao PDR and Cambodia. Electric power generation in Lower Mekong countries is shown in Table 3.1-18. Power generation in Thailand and Vietnam is overwhelmingly larger, at more than 20 to 50 times that in Lao PDR. In Thailand, 95% of the electricity is generated by thermal power plants, 71% by natural gas-fired plants, and 20% by coal-fired plants. In Vietnam, the share of natural gas thermal power generation is the largest at 43%; hydropower generation accounts for 36% of generation, and is the second largest source.

Table 3.1-18 Electric Power Generation in Lower Mekong countries

(TWh)

	Thermal			Hydro	Others	Total
	Coal	Oil	Natural Gas			
Lao PDR				3.4 (100%)		3.4
Thailand	29.6 (20%)	6.6 (4%)	105.0 (71%)	7.1 (5%)	0.1 (0.1%)	148.4
Vietnam	15.0 (18%)	2.1 (3%)	36.0 (43%)	30.0(36%)		83.2
Cambodia		1.2 (96%)			0.0	1.2

Source: IEA Energy Balance of non-OECD Countries 2011

Table 3.1-19 shows power production and trade in Lower Mekong countries. Vietnam is the largest power importing country in this region, importing mainly from China. Vietnam, Thailand, and Cambodia are net importing countries, whereas Lao PDR is the only country in this region that has a net export surplus of electricity.

Table 3.1-19 Power Trade in Lower Mekong Countries

(TWh)

	Production	Imports	Exports	Domestic Supply	Final Consumption
Lao PDR	3,366	1,175	1,921	2,620	2,258
Thailand	148,389	2,439	1,560	149,268	135,209
Vietnam	83,191	4,103	373	86,921	76,927
Cambodia	1,206	842		2,048	1,766

Source: IEA Energy Balance of non-OECD Countries 2011

2) “Power Development Plan” in Lower Mekong Countries

A brief summary of the “Power Development Plan” for Thailand, Vietnam, and Cambodia is given in Appendix 2.3. Among the Lower Mekong countries, Thailand and Vietnam are and will be the major electricity importing countries in this region.

The electricity supply in Thailand increased rapidly at an average growth rate of 6.6% from 1990 to 2009. Thailand is a net importer of electricity from Lao PDR and Malaysia, and an exporter to Cambodia. In the “Thailand Power Development Plan 2010-2030” (PDP2010), power imports from neighboring countries are planned to increase to 13.4% in 2020, and 17.8% in 2030 in terms of supply capacity.

Electric power demand in Vietnam increased at an average growth rate of 12.6% per year from 1990. The development of power sources, specifically power exchanges with neighboring countries, is described in the "National Power Development Plan for the Period 2011-2020 with Perspective to 2030" (PDP VII). It is planned in PDP VII that efficient power exchanges will be implemented with countries in the region, especially Lao PDR, Cambodia, and China. Imported electricity capacity is planned to be about 2,200 MW in 2020 and 7,000 MW in 2030, which is about 6% of the power supply of Vietnam.

Table 3.1-20 shows the power imports from Lao PDR planned in the "Power Development Plans" of Thailand and Vietnam. In the PDP of Thailand, projects after 2018 are not specified either by exporting country or project name. On the other hand, in the PDP VII of Vietnam, the capacities of the import projects from Lao PDR listed in PDP are not sufficient to achieve the target for electricity imports.

Table 3.1-20 Power Purchases from Projects in Lao PDR

Year	Thailand Power Development Plan		Vietnam Power Development Plan	
	Project	Capacity	Project	Capacity
2010	Nam Theun 2	920 MW		
2011	Nam Ngum 2	597 MW	Xekaman 3	250 MW
2012	Theun Hinboun Extension	220 MW		
2013				
2014			Nam Mo	95 MW
2015	Hongsa Thermal #1, #2	2x491 MW	Xekaman 1	290 MW
2016	Hongsa Thermal #3	491 MW	Xekaman 4	64 MW
2017	Nam Ngum 3	440 MW	Xekong 3A Xekong 3B	100 MW 105 MW
2018	(Not specified) *1	450 MW	Nam Sum 1 Xekong	90 MW 192 MW
2019	(Not specified) *1	600 MW	Nam Sum 3	196 MW
2020	(Not specified) *1	600 MW	Nam Mo 1	72 MW
2021	(Not specified) *1	600 MW	Xekong	150 MW
2022	(Not specified) *1	600 MW	Nam Theun 1	400 MW
2023	End of Theun Hinboun PPA (Not specified) *1	-214 MW 600 MW		
2024	(Not specified) *1	600 MW		
2025	(Not specified) *1	600 MW		
2026	(Not specified) *1	600 MW		
2027	(Not specified) *1	600 MW		
2028	(Not specified) *1	600 MW		
2029	(Not specified) *1	600 MW		
2030	(Not specified) *1	600 MW		

Note *1: Described as "Power Purchase from Neighboring Countries," and importing country not specified

Source: "Thailand Power Development Plan 2010-2030," "Vietnam National Power Development Plan for Period 2011-2020 with Perspective to 2030"

(2) Countermeasures against uncertainties in PDP

1) Uncertainty in demand forecast and project development in PDP

In the current "Power Development Plan" (PDP2010-2020 Revision-1), the rapid increase of large-scale industrial demand is forecasted especially after 2014. Total demand increases threefold in the next ten years. Furthermore, the demand for the SLACO aluminum project in 2015 has a significant impact on the electricity demand-supply in Lao PDR. Because current electricity demand is small compared to future demand, the deviation in the demand forecast has a significant impact on the electricity demand-supply balance.

Therefore, it is important to improve the precision of demand forecasts. Details are examined in Chapter 5 of this report. However, even though the credibility of the demand forecast has improved, there is still uncertainty over electricity demand because industrial demand in Lao PDR is strongly affected by the global economy and international prices of natural resources. In response to uncertainty over electricity demand, the flexibility of the electricity supply is also variable to respond to deviations from the demand forecast.

In addition to the uncertainty of the demand forecast, there is uncertainty over the development of electricity supplies. The total installed capacity of power stations in Lao PDR was 2,568 MW as of the end of 2011. It is planned that more that power stations generating more than 14,000 MW will be developed by 2021. More than half of the projects listed in PDP2010-2020 Revision-1 are still at the feasibility study (FS) stage, especially projects after 2015. To ensure electricity supplies to meet future demand, possible measures to improve power planning and increase the flexibility of power supply sources should be included in the power development plan.

2) Case study on uncertainty in power supply

In this section, as a case study on uncertainty, we review the impact of a delay in power development. We assume two cases as examples to calculate the impact on electricity demand-supply, examining a decrease in the domestic power supply and in power exports quantitatively.

Figure 3.1-19

Figure 3.1-19 shows the electricity demand-supply balance based on the following assumptions.

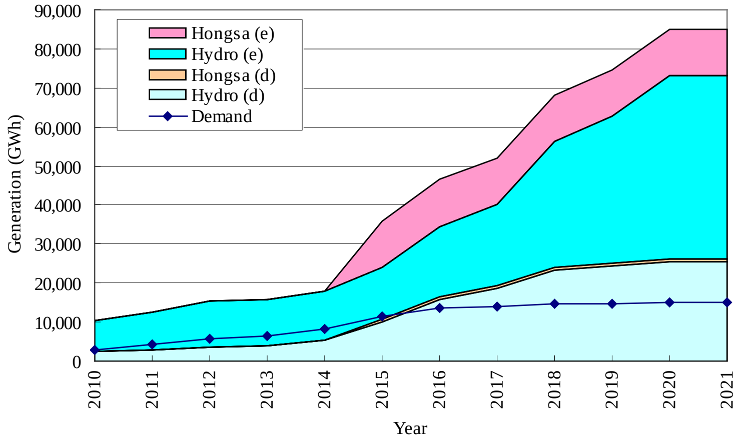
Case-A: Kaleum Thermal power station will be developed after 2021.

Case-B: In addition to Kaleum Thermal, hydropower projects on the Mekong mainstream will be developed after 2021.

As mentioned in 3.1.3(6), it is planned in PDP Revision-1 that Kaleum Thermal will supply 300 MW of electricity from 2014 and an additional 300 MW from 2015, and supply 4,200 GWh annually to the domestic system. Electricity demand in the southern region is forecasted at about 6,200 GWh in 2021; therefore, about two thirds of electricity in the southern region will be supplied from Kaleum Thermal. However, no MOU has been concluded so far on developing the project. In Case A, we review the supply capacity of the power plants to identify the impacts of the delay on the demand-supply balance nationwide.

In Case- B, we review another uncertainty affecting power supplies in Lao PDR. Although MEM mentioned to the JICA Team that hydropower projects in the Mekong mainstream will start operation on schedule, development of these projects will be affected by negotiations with neighboring countries. The capacity of the Mekong mainstream project is quite large; therefore, any delay with these projects affects both domestic electricity demand-supply and power exports.

(Case A)



(Case B)

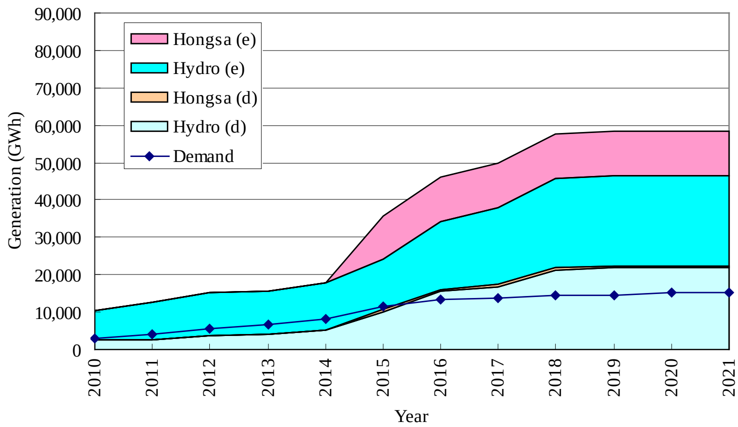


Figure 3.1-19 Demand-Supply Balance Nationwide

In Case A, total electricity supply in 2021 will decrease 5% from the base scenario. Total electricity supply including power exports is 5.5 times larger than domestic demand.

In Case B, it is assumed that hydropower projects in Mekong mainstream start operation after 2021. Pakbeng (855 MW), Luangprabang (1,410 MW), Xayabury (1,285 MW), Sanakham (660 MW), Phou Ngoy (651 MW), Thakho (50 MW), and Don Sahong (240 MW) are not considered in the supply capacity in 2021. Total power generation in Lao PDR decreases to 58 TWh, 35% less than the base scenario.

Total generation of power plants in Lao PDR including power exports to neighboring countries exceeds domestic demand substantially. However, considering the amount of electricity exports fixed by existing PPA and CA, additional power sources will be prepared to secure domestic supplies especially in Case B. In the next “Power Development Plan” (PDP), flexible power development measures should be considered to meet uncertainty in electricity demand and supply. Modification or liquidation of the project development scheme is one measure to respond to uncertainties.

3.2 Fossil Fuel Sector

3.2.1 Coal Sector

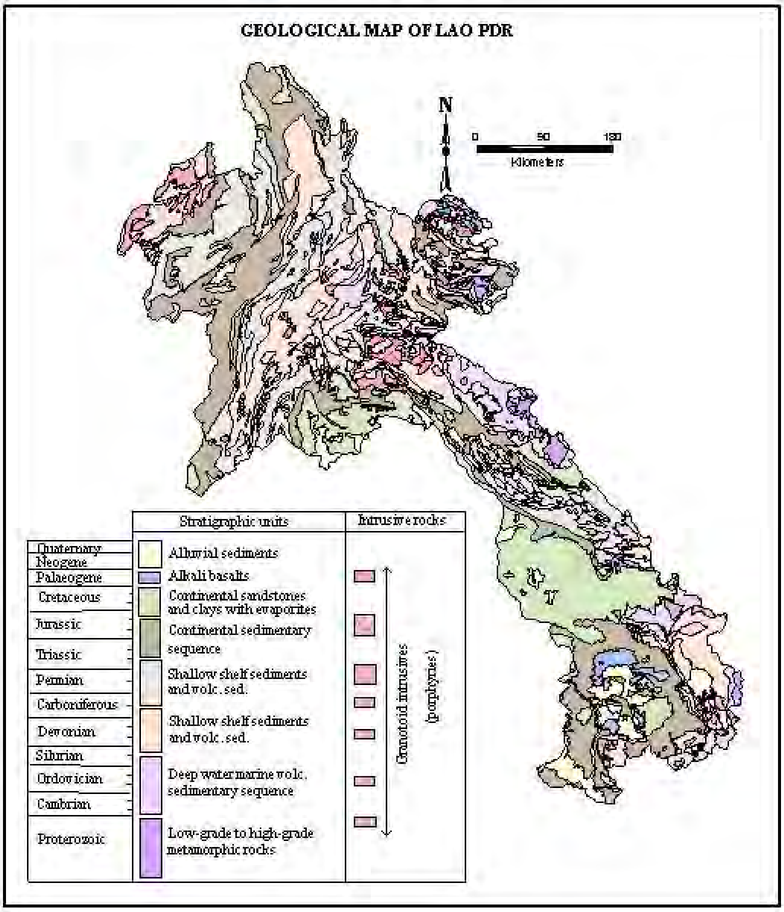
(1) Current situation concerning the Coal Sector

1) Coal resources

(a) Outline of geology

Lao PDR is located at the connection between land blocks formed during the Precambrian Era and has a complicated geological structure. Lao PDR is on the east side of the craton near the Khorat Plateau in central Thailand. Rugged mountain ranges including the Hercynian orogen (late Paleozoic) and the Indochina orogen (Mesozoic Era) are found around the outer edge of the Khorat Plateau.

Lao PDR mainly has formations from the Paleozoic and Mesozoic Eras in its land stretching north and south. There are formations from the Precambrian and Cenozoic Eras in the east and southeast parts of the country. In most parts of Lao PDR, the geological structure has a northwest - southeast alignment. However, there are some districts with a structure in the northeast - southwest direction in the northwest part of Lao PDR.



Source: Department of Geology & Department of Mines, MEM, “Mineral Development of Opportunities in LAO PDR”

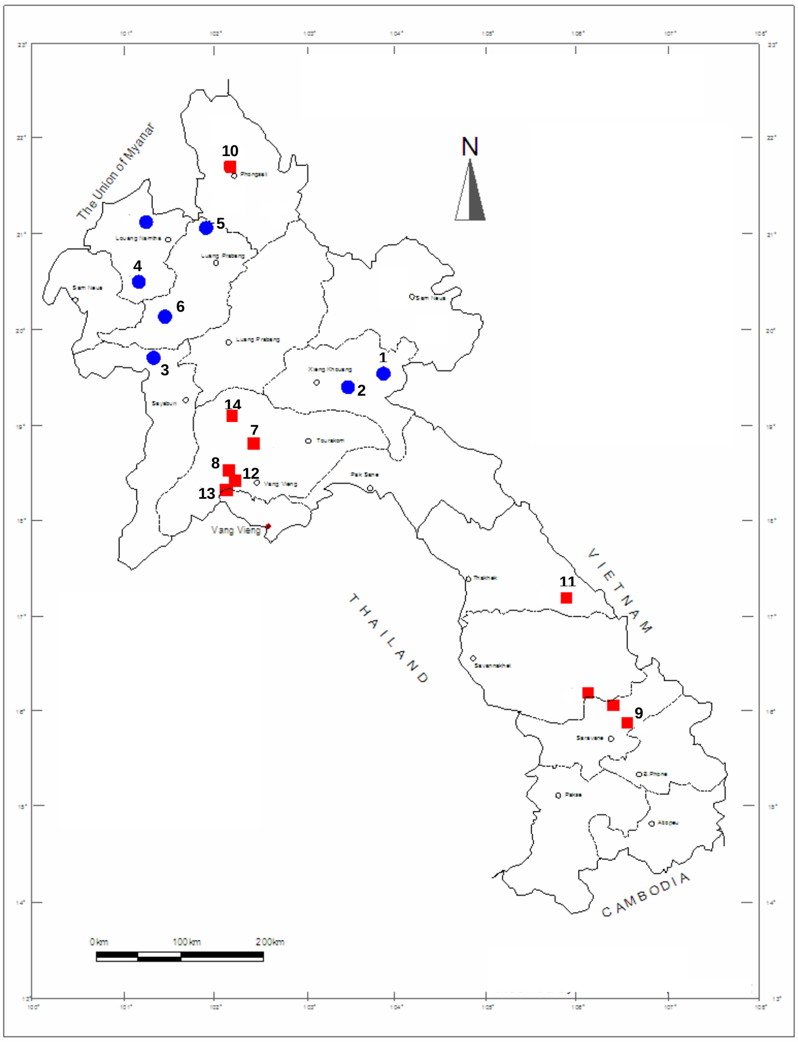
Figure 3.2-1 Geological Map

(b) Coal Basins

Lao PDR has anthracite reserves in a formation with a relatively complicated Paleozoic geological structure and lignite reserves in a formation with a relatively stable geological structure of the Tertiary Era of the Cenozoic.

There are anthracite reserves in the Vientiane, Saravane, and Phongsaly basins. Coal seams are discontinuous due to crustal movements and are cut by faults, which makes exploration and exploitation difficult. According to Vietnamese data, anthracite in Bochan and Saravane areas originated in the Carboniferous.

Lignite is found in Hongsa, Viengphoukha, Khangphaniang, and Muong Phane basins in northern Lao PDR and these coal basins have medium-scale to large reserves. Other lignite basins in Ban Nateui, Ban Ai, and Muong Ngeun have small reserves. Coal seams with lignite reserves are relatively stable and continuous compared to the geological structure with anthracite reserves.



Source:Prepared based on Table 3. 2-1 referring to "NEDO, 'Study on the potential and possibility of future development of coal resources in Lao PDR,' March 2008"

Figure 3.2-2 Distribution Map of Coal Basins

(c) Coal reserves

Coal exploration was carried out by the Department of Geology and Mines, Lao PDR, and the Department of Geology, Vietnam until the 1980s, and the results have been reported. As for reserves of some coal concession areas including Hongsa, the exploration results of companies are reported to the government organization and summarized. However, although exploration is carried out by companies provided with coal concession areas, exploration results for the reserves of many coal concession areas have not been reported and government-affiliated organizations (the Department of Geology and the Department of Mines) have no grasp of the data as a whole. Exploration results by coal basin (materials from October 2001) that have been acquired so far are shown in Table 3.2-1.

The report shows that total reserves are 599.13 million tons, of which 514.43 million tons are indicated reserves. However, of the total reserves, those of the Hongsa lignite deposit where a mine-mouth power plant (lignite thermal power generation plant) is being constructed are 511 million tons, accounting for 85% of total reserves and 99% of indicated reserves. Although two coal deposits have inferred reserves of over 20 million tons, reserves of coal deposits other than Hongsa are extremely small.

Table 3.2-1 Coal Reserves and Quality (October 2001)

No.	Deposit Name	Location	Coal Type	Reserves (1,000 tons)				Coal Quality				Note
				C1 Indicated	C2 Inferred	P Hypothetic	Total	C.V. (kcal/kg)	Ash (%)	T.M. (%)	T.S. (%)	
1	Khangphaniang Lignite Deposit	B. Khanghaniang M. Nonghed, P. Xiengkhouang	Lignite	-	2,939	-	2,939	6,133 - 6,537 -	1.68 - 22.58 ave. 10.88	10.45 - 21.47 ave. 16.50	0.5 - 2.35 ave. 1.45	Dept. of Geology, Vietnam. 1982
2	Muong Phane Lignite Deposit	M. Phane, P. Xiengkhouang	Lignite	591	1,112	8,626	10,329	3,461 - 6,661 ave. 5,190	21.26 - 33.60 ave. 27.40	11.48 - 16.96 ave. 16.50	1.2 - 5.09 ave. 2.45	Intergeo, Vietnam. 1982
3	Hongsa Lignite Deposit	M. Hongsae, P. Sayaburi	Lignite	511,025	-	-	511,025	1,032 - 3,792 ave. 2,493	7.4 - 43.8 ave. 23.3	15 - 40 ave. 30.5	0.3 - 2.6 ave. 0.75	Hongsa Lignite Co., 1990s
4	Viengphoukha Lignite Deposit	B. Viengphoukha, M. Ngeun,	Lignite	-	-	10,974	10,974	4,900 - 5,200 ave. 5,000	10 - 15 ave. 12.5	- -	1.2 - 2.2 ave. 1.7	Viengphoukha Lignite Co., 1990s
5	Ban Ai Coal Deposit	B. Ai, M. Namo, P. Oudomxay	-	-	-	2,000	2,000	5,000	-	-	-	DGM & Vietnamese Geologists, 1989
6	Ban Khouang Lignite Deposit	Ban Khouang, Muong. Namo, P. Oudomxay	Lignite	-	-	115	115	-	-	-	-	DGM & Vietnamese Geologists, 1989
7	Ban Vangkhi Anthracite Deposit	Ban Vangkhi, P. Vientiane	Anthracite	-	-	400	400	5,584 - 5,638 -	-	-	-	DGM, 1989
8	Bo Chan Anthracite Deposit	Bo Chan, Nam Lik, P. Vientiane	Anthracite	2,010	2,144	4,000	8,154	8,044 - 8,367 ave. 8,150	.9 - 28.30.50 ave. 21	3.6 -40.8 ave. 21.5	0.94 - 1.34 ave. 1.05	V/O Technoexport, 1980s
9	Chakeui Anthracite Deposit	Chakeui P. Saravan	Anthracite	-	92	27,895	27,987	6,610 - 8,305 ave. 7,450	24.81 - 39.80 ave. 31.5	2.8 - 8.5 ave. 4.8	0.24 - 0.59 ave. 0.41	Dept. of Geology, Vietnam. 1985
10	Phongsaly Coal Deposit	Phongsaly area, P. Phongsaly	-	-	-	24,500	24,500	5,809 - 8,220 -	13.83 - 36.7 -	-	-	DGM, 1985
11	Pougbone Coal Deposit	B. Poungbone, M. Boulapha, P. Khammouan	-	-	-	-	0	8,400	-	-	-	Bulgarian Geologist Group, 1984
12	Nam Thom Coal Deposit	Nam Thom, P. Vientiane	-	-	-	400	400	5,584 - 5,638 -	32.58 - 34.80 -	-	-	Intergeo VN, 1988
13	Nam Sang Coal Deposit	NamSang, P. Vientiane	-	-	-	-	0	7,430	-	-	-	Intergeo VN, 1988
14	Vangmieng Coal Deposit	Ban Vang Mieng, M. Vangvieng,	-	A=805	-	-	805	2,400 - 2,900 -	42 - 59 -	10 - 13 -	0.17 - 0.25 -	Vangvieng Cement Factory, 1999

Source: GIC, DGM Lao, October 2001

Although not included in Table 3.2-1, coal exploration had been conducted between 1982 and 1985 by Vietnam in the Sekong - Salavan area, according to Phonesack Group. As a result, coal reserves in the area were reported to be 27 million tons (Inferred reserve, C2) and 92 million tons (Hypothetic reserve, P1). Moreover, the area has a potential reserve of 3 to 4 times as much as those of P1. Phonesack Group is implementing coal exploration in the area (Kakeum coal project).

(2) Coal development status

1) Coal concession areas

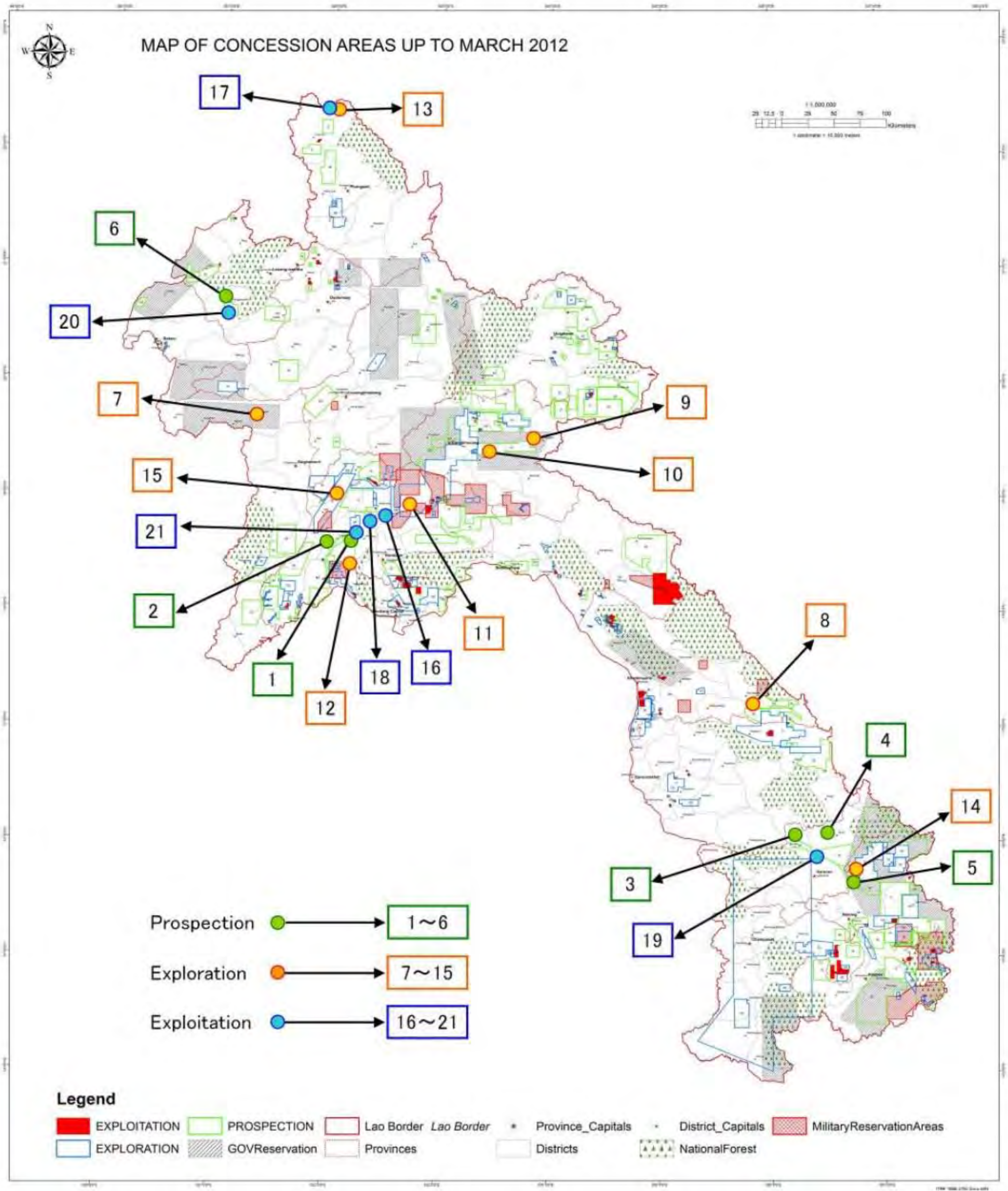
According to the acquired "Map of Concession Areas up to March 2012," 21 coal concession areas have been given to 17 companies as of March 2012. Coal concession areas are divided into three stages (prospect stage, exploration stage and exploitation stage) and organized, and coal concession areas under production are included in the exploitation stage. The map shows that there are six concession areas in the planning stage, nine concession areas in the exploration stage, and six concession areas in the exploitation stage. Table 3.2-2 shows a list of concession areas and Figure 3.2-3 shows a location map of coal concession areas developed based on "Map of Concession Areas up to March 2012."

Table 3.2-2 List of Coal Concession Areas (March 2012)

as of March 2012

No.*1)	Concession No.*2)	Company	Local/Foreign	Province	District	Area(ha)	Coal type	Activity
1	193	Agriculture Development (DAI)	Laos	Vientiane	Vangvieng	20	Anthracite	Prospection
		Agriculture Development (DAI)	Laos	Vientiane	Hinheup	20	Anthracite	Prospection
		Agriculture Development (DAI)	Laos	Vientiane	Vangvieng	10	Anthracite	Prospection
2	194	Dotserve	Thailand	Vientiane	Fuang	7,122	-	Prospection
3	76	Lao Cement Industry Ltd	Laos	Salavan	Toumian	11,191	-	Prospection
4	80	Phonesak Construction Ltd	Laos	Salavan	Ta-Oy	49,822	-	Prospection
5	80	Phonesak Construction Ltd	Laos	Xekong	Kaleum	49,804	-	Prospection
6	17	Vinacomin Lao Co., Ltd	Vietnam	Louang-namtha	Viangphoukha	14,264	-	Prospection
7	1	Hongsa lignite Co., Ltd	Thailand	Xayabouly	Hongsa	6,000	Lignite	Exploration
8	101	Jioun Internation Mineral Exploitation, Co., Ltd	Vietnam	Khammouan	Boualapha	4,028	-	Exploration
9	105	Agriculture Development (DAI)	Laos	Xiangkhouang	Nonghet	1,050	Lignite	Exploration
10	105	Agriculture Development (DAI)	Laos	Xiangkhouang	Khoun	2,000	Lignite	Exploration
11	119	Coorperation Mining	Laos	Vientiane	Xaisomboun	2,229	-	Exploration
12	149	Lao Intergrate	Laos	Vientiane Capital	Sangthoug	3,363	-	Exploration
13	3	Luthing Co., Ltd	China	Phongsaly	Gnot-Ou	996	-	Exploration
14	31	Industry Cement Lao, Co., Ltd	Laos	Xekong	Kaleum	2,000	-	Exploration
15	56	First Pacific Mining (Lao) Co., Ltd	China-Laos	Vientiane	Vangviang, Kasi	29,400	-	Exploration
16	75	Agriculture Industry	Laos	Vientiane	Vangvieng	187	-	Exploitation
		Agriculture Industry	Laos	Vientiane	Vangvieng	18	-	Exploitation
		Agriculture Industry	Laos	Vientiane	Vangvieng	10	-	Exploitation
		Agriculture Industry	Laos	Vientiane	Vangvieng	10	-	Exploitation
17	3	Luthing Co., Ltd	China	Phongsaly	Gnot-Ou	1,496	-	Exploitation
18	56	First Pacific Mining (Lao) Co., Ltd	Laos	Vientiane	Hinheup	2,000	Anthracite	Exploitation
19	34	Chong Yang Yuxi Yunnan China Co., Ltd	China	Saravan	Ta-Oy	500	Anthracite	Exploitation
20	2	Viengphoukha Coal Mine Co., Ltd	Thailand	Louang-Namtha	Viangphoukha	800	Lignite	Exploitation
21	166	State Enterprise for Agiculture - Industry Development imp - Exp	Laos	Vientiane	Hinheup	20	-	Exploitation

Note 1: Numbers correspond to those in Figure 3.2-3. Note 2: Concession area number
Source: Prepared based on "Map of Concession Areas up to March 2012" of the Department of Geology and Mineral, Ministry of Natural Resources and Environment



Note: Numbers correspond to those in Table 3.2-2.
Source: prepared based on "Map of Concession Areas up to March 2012" of Department of Geology and Mineral, Ministry of Natural Resources and Environment

Figure 3.2-3 Locations of Coal Concession Areas (March 2012)

Although the contents differ, the interview conducted with the Department of Geology and Mines in late April 2012 provided the following information. As of 2012, there are five sites in the planning stage, three coal concession areas in the exploration stage, and 12 coal concession areas in the exploitation stage. Of those in the exploitation stage, coal is produced in eight coal concession areas and four coal concession areas are under construction. The forms of coal company are: independent Lao company, independent overseas company (Thai and Chinese companies), incorporation of Lao and overseas companies (Lao PDR and China, Lao PDR, and Vietnam, Lao PDR and Thailand).

The coal concession areas in the exploitation stage are managed by the Department of Mines, MEM. Table 3.2-3 shows a list of coal concession areas managed by the Department of Mines. At present, seven companies have coal concession areas under development and producing coal.

Table 3.2-3 List of Coal Concession Areas Managed by the Department of Mines, MEM

Company	Equity	Province	District	Coal type	Area(ha)	Concession Agreement	Reserve (tons)	Reserves for Exploitation (tons)	Annual Design Production (tons/year)
Agriculture Development (DAI)	Laos	Vientiane	Vangvieng	Anthracite	20	Exploitation	1,160,000	847,340	45 - 50,000
		Vientiane	Vangmiang	Anthracite	10	Exploitation	103,326		
		Vientiane	Hinheup	Anthracite	20	Exploitation	4,000,000	suspended	suspended
		Xiangkhouang	Nonghet	Lignite	1,050	Exploitation	1,044,400	-	200,000
		Xiangkhouang	Khoun	Lignite	2,000	Exploitation	12,000,000	-	300,000
Phonesak Construction Ltd	Laos	Salavan	Ta-Oy	Anthracite	100,000	Prospection, Exploration, Exploitation	374,500,000	not dicided	not dicided
	Laos	Xekong	Kaleum	Anthracite					
Hongsa lignite Co., Ltd	Thailand	Xayabouly	Hongsa	Lignite	1,461	Exploitation	577,408,000	370,762,000	13.5 - 14.0 mt
Luthing Co., Ltd	China	Phongsaly	Gnot-Ou	Anthracite	1,465	Exploitation	1,340,802	1,141,426	50,000
First Pacific Mining (Lao) Co., Ltd	Laos	Vientiane	Vangvieng	Anthracite	2,000	Exploitation	23,119,101	2,080,711	138,713
Chong Yang Yuxi Yunnan China Co., Ltd	China	Saravan	Ta-Oy	Anthracite	500	Exploitation	2,732,000	225,450	45,000
Viengphoukha Coal Mine Co., Ltd	Thailand	Louang-Namtha	Viangphoukha	Lignite	800	Exploitation	-	9,500,000	1,000,000
Sichuan Golden Elephant	China	Oudomxay	Namo	Lignite	150	Exploitation	402,130	321,704	35,000

Note: As Phonesak Construction Ltd. is under exploration, reserves for development area and annual design production.

Source: Department of Mines, MEM.

2) Coal production status

According to the “Lao Statistical Yearbook,” coal production in 2010 was 713,300 tons (lignite: 501,600 tons, anthracite: 211,700 tons).

Table 3.2-4 Production Volume of Coal

(1,000 tons)

	Lignite	Anthracite	Total
1985	1	-	1
1990	3	-	3
1995	23	-	23
2000	300	-	300
2001	210	-	210
2002	270	31	301
2003	250	41	291
2004	300.0	46.0	346.0
2005	320.0	50.5	370.5
2006	319.2	62.0	381.2
2007	681.7	80.0	761.7
2008	379.2	104.7	483.9
2009	466.1	101.4	567.5
2010	501.6	211.7	713.3

Source: Lao Department of Statistics, “Statistical Yearbook 2010”

At present, coal is currently produced in eight coal concession areas in Lao PDR. For example, Veing Phoukha Coal Mine Co., Ltd. produces lignite in Louang Namtha Province, most of which is exported to Thailand. In Phongsaly Province, Luithing Co., Ltd. produces lignite and exports all of it to China. In Vientiane Province, Agriculture Industry Development Enterprises Imp-Exp & General Services, First Pacific Mining Lao Co., Ltd., etc., produce anthracite, and they are mainly used for kiln fuel in cement factories. Salavan Province and Sekong Province have also started anthracite production.

3) Coal consumption status

As mentioned above, most of the lignite produced in the northern Lao PDR is exported, and anthracite produced in Vientiane and the southern part is consumed in the industrial sector mainly as cement, and as bricks and fertilizer.

Lao PDR has eight cement factories, which use approximately 300,000 tons of coal per year. The cement factory in Khammuane province consumes approximately 120,000 tons of coal per year. However, it imports the total amount from Vietnam because there are no coal mines nearby. Other cement factories use anthracite produced at coal mines near the site. Although more than 5,000 kcal/kg of anthracite caloric value is required to maintain the production efficiency of cement kilns, the quality of domestic anthracite varies and calorific values are low. Therefore, the calorific value of anthracite used at cement factories sometimes falls below 5,000 kcal/kg, although anthracite blended high calorific value one and low calorific value one are used.

Table 3.2-5 List of Cement Factories

Name of Plant and Company	Production Capacity (Ton/year)	comennced year	Note
1. Lao Vangvieng Cement Plant # 1 (Wild Bull Brand) under State Enterprise for Agriculture Development Imp-Exp & General Server (DAI)	80,000	1995	expanding to 900,000 ton/year.
2. Lao Vangvieng Cement Plant # 2 (Gold Wild Bull Brand) under Lao Cement Company (LCC)	240,000	2002	
3. Luangprabang Cement Plant (Deer Brand)	50,000	2006	expanding to 150,000 ton/year.
4. Thakhek Cement Plant (Lion Brand) under Lao Cement Industry Plant (LCI).	1,000,000	2007	
5. Vientiane Cement Company (Dragon Brand) under Vientiane Cement Company (VCC),	100,000	2005	
6. Lao Savannakhet Cement Plant (Bison Brand) under Lao Savannakhet Cement Plan partnership,	130,000	2004	
7. Lao Savannakhet Cement Plant (Elephant Head Brand) under Chougya E.C Lao Cement Co., Ltd.	500,000	end of 2011	
8. BMC Cement Production Limited (Gold Elephant Brand)	300,000	February 2012	
Total	2,400,000		

Note: Factories 5, 6, and 8 have production lines that have not been completed which used clinker as the raw material to produce cement. Clinker is supplied from domestic cement plants and imported from neighboring countries such as Thailand and Vietnam.

Source: Prepared based on data provided by Cement Association

4) Coal prices

According to an interview, the price of coal imported from Vietnam is currently about 130 dollars/ton (on a factory-arrival basis, net 6,000 kcal/kg). This factory is located near the Vietnam border, but coal prices increase as the distance from the Vietnam border increases (e.g. Vientiane province) and trucking costs add up. Coal prices of coal mines in Vientiane Province are approximately 90 dollars/tons (minehead price, net 4,000 – 5,000 kcal/kg), which is relatively expensive because the scale of mining is small due to small reserves and poor geological conditions.

5) Coal demand

In the cement industry, coal demand increases as production capacity expands. However, there is an issue as to whether anthracite coal to meet increasing demand can be produced because of small anthracite coal reserves, delays in exploration, quality problems, etc. Cement production in 2011 was approximately 1.5 million tons and the shortfall was covered by imports from Thailand. As cement demand is expected to rise due to the future construction of many dams and the growth of cement production in the last few years has been approximately 6%, demand in the cement sector is likely to increase to 6 million tons by 2020.

In the power industry, in the Hongsa project, a 1,878 MW (gross) lignite-fired power plant is under construction for operation in 2015, together with the development of mines. Approximately 12 million tons of coal per year is to be used according to the plan. According to a report on the Hongsa project, Hongsa has deposits of approximately 700 million tons of lignite. The coal-mining area of this project is 12 km^2 (maximum 12 km x 5 km), coal mining of up to 300 meters is planned, and the total output of coal will be 341.26 million tons. This output corresponds to consumption over 25 years.

There is a construction plan for a coal-fired power plant in Kaleum, Sekong Province in southern Lao PDR. A feasibility Study has been conducted, and at the same time coal exploration has been carried out by Phonesack Group. As a result of exploration by Vietnam, a progress report on this survey states that there are 92 million tons (P1) of anthracite coal. It also suggests there are expectations of reserves of three to four times as much. Although we should wait for the results of exploration, if more than 300 million tons of reserves are found, the amount of coal to cover a power plant of the planned generation scale (phase 1: 2 x 300 MW, phase 2: 2 x 600 MW) will be secured.

(3) Issues concerning the coal sector

As mentioned above, coal is used mainly in the cement industry, and use of coal for electricity has been planned in Lao PDR. Coal demand in the industrial sector is expected to increase with the growth of cement production in the future, and coal will become a significant energy resource for industrial development. Lao government positions coal as an important energy resource that is a substitute for hydro energy as a stable power source that is available throughout the year. This section explains issues and measures concerning the expansion of coal use.

1) Issues

Coal is used as a material and source of heat in the process of cement production in the cement industry. Securing sufficient coal to meet the future expansion of cement production is a major issue. There are two ways to secure coal supplies: a cement company acquires coal concession areas and develops them or a cement company purchases coal from coal production companies. However, it is difficult to estimate coal production capacity and quality of produced coal with accuracy because coal reserves and properties of coal in concession areas are unclear (many sites are currently under exploration). If domestic production cannot cover demand, it would be necessary to import coal from Vietnam, etc.

Lao cement companies are small scale with low competitiveness. When free trade starts in the ASEAN region in 2015, these companies will have to compete with large-scale cement companies in Thailand and other countries. However, if they rely on imported coal, they will have disadvantages in terms of cost competition due to higher prices and in securing quantity.

Calorific values of anthracite produced in the country are low and vary significantly, which is a problem in the cement industry because it can reduce the efficiency of cement production.

Coal-fired power generation has been considered to be one way of securing stable power sources in Lao PDR, which has coal resources. At present, a lignite-fired power plant and a lignite coal mine are under construction in Hongsa. A coal-fired power plant is also planned in Kaleum, southern Lao PDR. Anthracite coal is found in the region and Phonesack Group is engaged in exploration. If sufficient coal reserves for power generation are confirmed, a construction plan for a coal-fired power plant is more likely to become feasible.

However, there is no information so far on large reserves in regions other than those stated above.

2) Measures

The following measures are necessary to use domestic coal efficiently.

(a) Coal exploration by the government

Lao PDR has coal as a domestic resource. Outcrops have been discovered by exploration and coal has been found throughout the country. However, coal exploration with a drilling survey has been delayed. Although coal exploration had been conducted by the 1980s with the cooperation of countries such as Vietnam, it has not been conducted by the government since the 1980s for financial reasons, and has been conducted by companies that own coal concession areas since the 1990s. Coal exploration is conducted only near the surface and not deep underground. Therefore, the following coal exploration needs to be implemented by the Lao government with cooperation from other countries.

- Coal exploration in areas where exploration has not been conducted, if any.
- Exploration in deeper parts of existing exploration sites.

(b) Managing coal concession areas and organizing information

Coal concession areas are managed by the Department of Mines, MEM, and the Department of Geology and Mineral, Ministry of Natural Resources and Environment. Each company conducts exploration for coal development and reports the results to the government; the government then organizes information on coal reserves and properties in each concession area. However, some companies do not report regularly and some reported information has not been organized. It is, therefore, necessary to obligate companies acquiring coal concession areas to report development status, exploration results (reserves, properties, etc.), and production status every year, and to establish a system to organize reported information.

- Strengthening management of coal mining areas (making annual report mandatory)

  Details of annual reports from companies with coal concession areas (examples)

  Concession areas under exploration: exploration plan, progress status, exploration results (confirmed reserves, properties, etc.)

  Concession areas under development: development plan, progress status, etc.

  Concession areas under production: production status, coal mining plan, etc.

- Identifying status of coal reserves (recoverable reserves), properties, and distribution by the government

(c) Cooperation between the Department of Geology and Mineral and the Department of Mines

Before the organizational reform, the Department of Geology and the Department of Mines came under the Ministry of Energy and Mines (MEM). The Department of Geology was under the Ministry of Natural Resource and Environment. Cooperation beyond organizations is, therefore, necessary such as on sharing information and division of roles.

(d) Human resources development

Coal exploration is not conducted by Lao PDR alone, and it is considered that there are few engineers who have skills for coal exploration and coal development. It is necessary to introduce overseas technologies for exploration and development, as well as to train engineers.

3.2.2 Petroleum Products Sector

(1) Petroleum and Natural Gas Resources

There are no official figures for the proven resources of oil and natural gas in Lao PDR. In the 1930s, oil seeps were reported and investigated by French colonial geologists, but it was not until 1986 that hydrocarbon exploration commenced when the Lao Government opened the country's economy to foreign investment and private investment. Three Production Sharing Contracts (PSCs) were signed between 1989 and 1991.

(a) UK-based Enterprise Oil held the Savannakhet PSC between September 1989 and January 1996. Two 2D seismic surveys were undertaken, but no wells were drilled under this PSC.

(b) The Pakse PSC was held by US-based Hunt Oil Company between February 1990 and November 1997. Following acquisition of 967 km of 2D seismic data, the wildcat well Pakse 1 was spudded in December 1996. The well was drilled to Total Depth (TD) at 2,540 m, but was dry. The well was plugged and abandoned in March 1997.

(c) Shlapak Development Company operated by UK-based Monument Oil was awarded a SDC PSC from January 1991 until October 1998. Monument acquired 494 km of 2D seismic data and spudded the wildcat well Naxay 1st in April 1996. But, it was found to be dry at a depth of 2,091 m and the well was plugged and abandoned in July 1998.

Following 1998, no further exploration was undertaken until 2008 when UK-based Salamander Energy Co Ltd acquired 350 km of 2D seismic survey in its Savannakhet PSC. Stakeholders in the project are a Lao private company NCD/LIBC (5%), state-run PetroVietnam (25%), International Finance Corporation (IFC), a member of the World Bank Group (10%), Australian Origin Energy (30%), and Salamander (30%).

In February 2010, Salamander Energy spudded its first well Bang Nouan 1 adjacent to the gas discovery Mukdahan-1 well in Thailand. The MB Century 26 rig was contracted for drilling. The Bang Nouan prospect was thought to be an extension of the proven Khorat Plateau play beyond the Mekong River, and was estimated to contain between 700 bcf and 1.2 tcf of potential gas reserves. The well was drilled to a total depth of 3,400 m and logging has been completed. Gas shows have reportedly been observed in Triassic-age Kuchinarai sandstones between 2,020 and 2,120 m and preliminary analysis indicates 25 m of potential gas pay. But, in August 2010, the company announced that the well had been plugged and abandoned because no significant flow of hydrocarbons to achieve a commercial flow rate was observed. In December 2010, Salamander and its partners elected to relinquish the Savannakhet PSC.

However, the well confirmed several elements of the hydrocarbon play. Gas shows in the Kuchinarai formation demonstrated long-distance gas migration from the source kitchen. The well also found a high permeability reservoir within the Pha Nok Khao formation, which constitutes a target for future wells in the area.

The company also holds a 20% stake in the Champasak & Saravan PSC. The Champasak & Saravan PSC covers 41,140 km^2 and is located south of and adjacent to Salamander's Savannakhet PSC. Salamander's interest was acquired in March 2008 through a cross-assignment agreement with PetroVietnam Exploration Production Corporation (PVEP). Salamander is now conducting a 2D seismic survey in the block to define the prospects for drilling in 2012.

(2) Petroleum Demand and Supply

Because Lao PDR lacks petroleum and natural gas resources, indigenous demand for petroleum products liquefied gas phase products (LPG) is met by importing from neighboring countries, especially Thailand and Vietnam. About 70% of petroleum imports are from Thailand and 30% from Vietnam. In 2010, the country imported 744,260 KL of products including gasoline, diesel fuel, boiler fuel, jet fuel, and lubricants. In addition, 1,510 metric tons of LPG were imported. About 45 to 50% of petroleum products imported are consumed in the capital Vientiane and in Vientiane province.

The Lao Fuel & Gas Association (LFGA), founded in 1991 by 18 petroleum companies and five LPG trade and sales companies, collects and reports to the Ministry of Ministry of Industry and Commerce each company's monthly sales volume and proceeds for each product. Because data collection is not compulsory and there are no penalties, the inaccuracy of reported data is a concern. Because these companies compete in the market with each other, they try to keep individual data confidential.

Although LFGA uses customs data collected by the Department of Import and Export, Ministry of Industry and Commerce for cross checking, these data are difficult to compare because they are mainly on a monetary basis and are recorded in the official fiscal year defined as from October to September of each year. Besides, it is sometimes pointed out that when comparing Lao PDR's major imports from Thailand against Thailand's major exports to Lao PDR, Lao PDR's import values are significantly smaller, especially in the fuel and gas category. Such a discrepancy is the result of false declarations by traders through such measures as declaring only a few invoices out of multiple invoices for a fuel cargo.

Of all imported products, diesel fuel had the largest share at 73.4% in 2010, followed by gasoline at 23.6%. The annual growth rates of these products were very high at 9.8% and 5.6%, respectively, since 2000 to 2010, reflecting rapid expansion of the car population in the country.

Before liberalization of the indigenous petroleum industry, only three companies, namely Lao State Fuel Company (LSFC), Shell, and Thailand national company PTT, were engaged in the petroleum supply business. LSFC was established in 1976 as a company wholly owned by the Ministry of Industry and Commerce (MOIC).

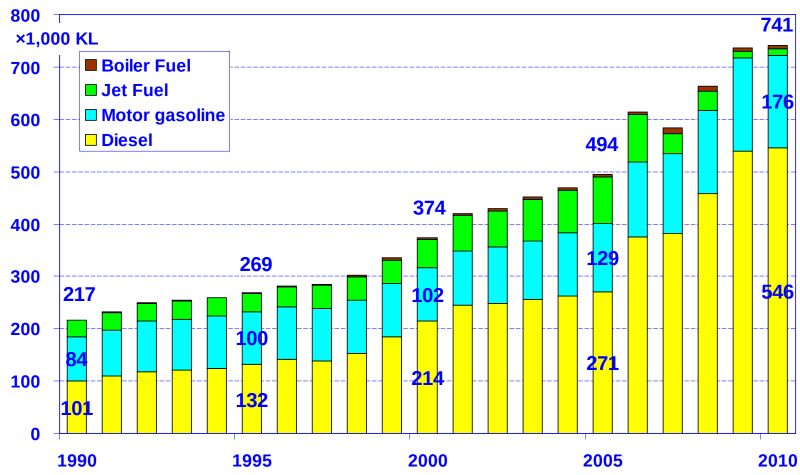


Figure 3.2-4 Imports of Petroleum Products

After introduction of the New Economic Mechanism in 1986, many foreign and domestic companies entered this market. PV Oil acquired Shell's assets in Lao PDR, including 73 filling stations and five storages in 11 cities and provinces, in December 2009, and started a gasoline distribution business. PV Oil is the trading arm of the Vietnamese state-run Vietnam National

Oil and Gas Group (PetroVietnam). In September 2011, Petrolimex (Petroleum Import and Export Company), the fuel-distribution arm of PetroVietnam, also began to do business through the acquisition of Chevron's fuel retail company. As of February 2012, there were 18 wholesale petroleum companies operating in Lao PDR.

Because the market for petroleum products in Lao PDR today is relatively small and private oil companies import their products separately and sell their goods at prices designed by the Government, the market is very competitive. LSFC’s share of the market was above 50% before 1986, but this has decreased to 30% today. However, if private companies are unable to generate profits because of the Government’s delay in raising prices in accordance with increases in imported CIF prices, they sometimes interrupt sales of products. In such cases, LSFC is obliged to sell a greater volume of products to meet demand at a loss.

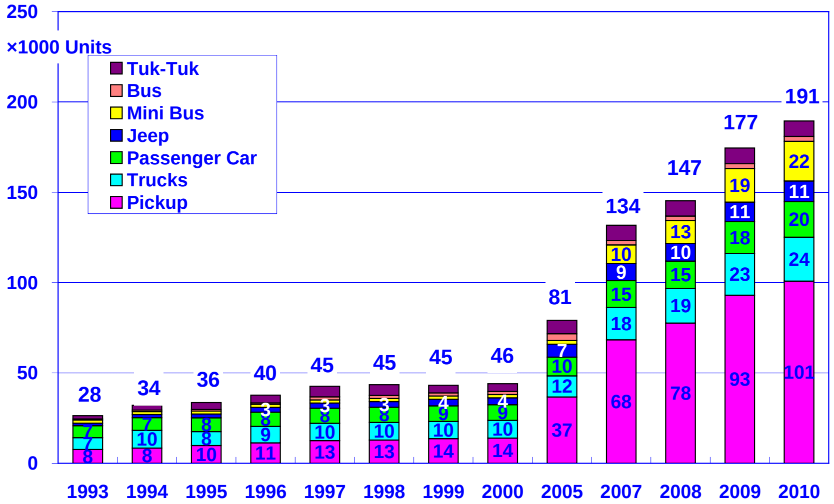


Figure 3.2-5 Trends in Number of Registered Car Population

These companies own and operate product storage terminals nationwide. There are 72 terminals in the country and the combined storage capacity is 60,000 KL. LSFC owns 16 terminals with a storage capacity at 27,000 KL. Of the total of 72 terminals, 26 are located in Vientiane Capital and three are owned by LSFC.

Imported products are stored at the terminal and delivered to consumers including gasoline stations using the loading capacity of 8 KL tank trucks. As of February 2012, there were 827 gas stations nationwide and 155 were located in Vientiane. LSFC owns 307 gas stations, and 40 are located in the Capital.

Petroleum companies are keen to reduce operating costs to gain more profit between import price and instructed sales price. Reducing transportation costs of petroleum products by introducing larger tank trucks is their primary concern. However, the road transportation infrastructure in Lao PDR is inadequate and is considered to be a major impediment. Transportation of fuel on the Mekong River is insignificant. LSFC imports 80% of products from Thailand and 20% from Vietnam. Because road conditions in the two countries differ, LSFC can use the maximum loading capacity of 45 KL tank trucks to import from Thailand and 35 KL tank trucks from Vietnam.

As for Jet Fuel, LSFC has exclusively supplied the product to international and domestic airlines after PV Oil's acquisition of Shell's assets in 2009. Its jet fuel depots are located at four airports; namely, Wattay International Airport, Savannakhet Airport, Pakse Airport, and Luangprabang Airport.

LSFC has two 25-ton LPG storage tanks at its terminal and imports LPG by tank truck, each with a loading capacity of 8 tons. LSFC then fills LPG in 1 Kg, 4 Kg, 15 Kg, and 48 Kg cylinders at the terminal for delivery to consumers.

According to the Department of Energy, 940,221 KL of petroleum products are planned to be imported in 2012. These are allocated by the Department of Domestic Trade (DODT) under the Ministry of Industry and Commerce (MIC) as the import quota to 18 registered petroleum companies. The quota is issued every half year, reflecting import and sales quantities of each company during the previous year.

Table 3.2-5 Import and Supply Plan for 2012

(Unit: KL)

		Import	Sales
Gasoline		216,862	213,574
	Regular	212,354	209,123
	Premium	4,508	4,450
Diesel Fuel		691,522	685,766
Kerosene		7,644	7,644
Jet Fuel		19,000	19,000
Lubricants		5,193	7,462
Total		940,221	933,445

(3) Fuel Oil Prices

The Department of Foreign Trade of the Ministry of Industry and Commerce is responsible for researching, planning, and implementing rules and regulations relating to foreign trade.

The Ministry also controls consumer prices in the form of instructions based on fluctuations of world oil prices and the import price of each product. Weekly import prices are collected by LFGA from its member companies, and reported to the Government.

Prices vary among the provinces of Khammuan, Savannakhet, Champassak, Bokeo, and Xieng Khuang, depending on transport costs. The Government adjusted fuel prices 15 times in 2009, 14 times in 2010, and 17 times in 2011. As of May 24, 2012, the pump price of regular gasoline in the capital was 10,750 kip/L and diesel fuel was 9,630 kip/L.

Imported products are subject to taxation. Indirect taxes, which consist of Business Turnover tax and Excise tax, are collected from the importation of petroleum products on a customs-cleared basis. Individuals, legal entities, and organizations that carry out activities are subject to Business turnover tax. Excise tax is collected from certain types of goods and services that are sold or provided within the territory of the Lao PDR.

As of June 2012, the following tax rates were applied to petroleum products.

Table 3.2-6 Tax Rates Applied to Petroleum Products

	Business Turnover Tax Rates %	
	Domestic Production	Importation and Sale of Goods
All types of inflammable fuel, lubricants, brake oil, hydraulic oil, grease and asphalt for roads	5%	5%
Inflammable gas and other similar gas	5%	5%
	Excise Tax Rates %	
Inflammable fuel		
Super gasoline	25%	
Regular gasoline	24%	
Diesel	12%	
Aviation gasoline	10%	
Lubricant oil, hydraulic oil, grease and brake oil	5%	

Imports of LPG are also subject to Business Turnover tax. Because the consumer price of LPG in Thailand is subsidized, Lao citizens who travel to Thailand bring home LPG cylinders mainly for their own use. Because they usually do not declare them at Lao customs, LPG import data in recent years showed a decrease contrary to expectations of an increase following past trends. In 2011, the country imported 773 tons of LPG; however, LSFC suggests that in reality this should be over 2,000 tons. According to the Government import plan, the country will import 821 tons in 2012.

(Unit: tons)

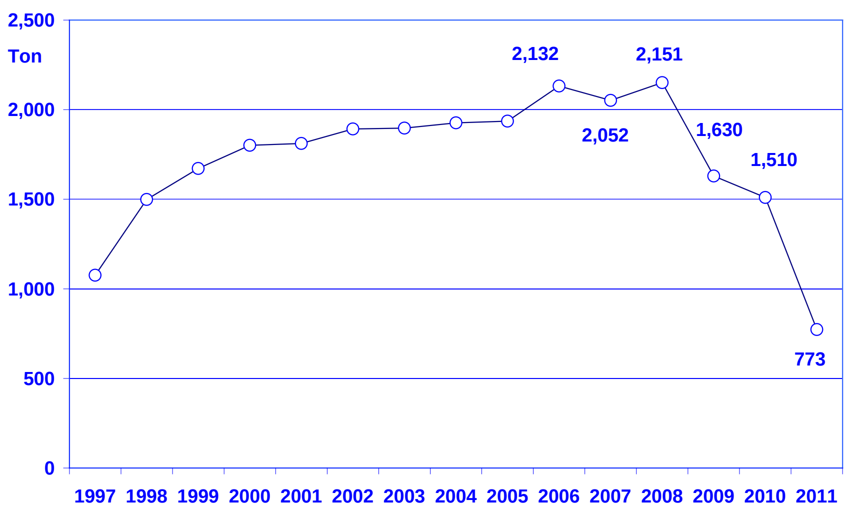


Figure 3.2-6 Trends of LPG Imports to Lao PDR

(4) Recommendations

Understanding the petroleum supply and demand balance is essential for the energy security strategy of the Government. Accurate, consistent, thorough, and timely data should be collected through a sound national statistical system. By acquiring these data and understanding the demand and supply balance of petroleum products, the Government can prepare plans for securing supplies if imports from neighboring countries are disrupted.

Therefore, it is suggested that the Government establishes a compulsory data-reporting system with petroleum companies. These data include monthly imports, sales and stockpile volume, and price of each product. Those defined to report data owe a duty to report under the law, and those who refuse to report may be fined or imprisoned. LFGA or preferably the Government itself collects the data, and an individual responder's data are kept confidential, while processed statistics must be published.

To avoid tax evasion and reduce tariff revenue losses, importers of petroleum products should be limited to a few companies with other companies purchasing imported products at CIF prices at the terminal. This will also enhance purchasing power, improve the accuracy of petroleum import statistics, and guarantee the quality of imported products. If LSFC were selected as the sole importer of LAO PDR, LSFC would be able to reflect diplomatic factors of the Government to secure supplies. At the same time, the Government would be able to set consumer prices in a more transparent way based on CIF prices reported by LSFC, although it would be more desirable for the Government to abolish instructed consumer prices and leave pricing to market mechanisms.

As a future plan, it is suggested that the Government consider a strategic stockpile of products to prepare for supply disruptions or to mitigate against sudden rises of import prices. If Lao PDR plans to introduce biomass-blended fuel, blending component, unfinished products of gasoline or diesel fuel should be imported from refineries, because in Vietnam and Thailand, finished products sold in the market are already blended with biomass. Imported blending components should be blended with domestic biomass at a facility adjacent to the strategic stockpiling terminal to ensure quality standards.

3.3 Renewable Energy Sector

3.3.1 Present situation of renewable energy use

(1) Electricity

The GoL has the target of increasing the national electrification rate to 90% on a household (HH) basis by 2020. The national target of 90% by 2020 will be achieved according to the World Bank (WB) Study[6] with 85% on-grid coverage and 5% off-grid coverage. Renewable energy (RE) such as micro/mini hydropower (MHP) and solar home systems (SHS) have been used for rural electrification in Lao PDR.

1) Small hydropower

The "Renewable Energy Development Strategy" in Lao PDR (REDS)[7] categorizes hydropower of less than 15 MW as small hydropower.

The total capacity of small hydropower less than 15 MW is about 14 MW (14,278 kW) as

[6] "Rural Electrification Master Plan" and "Hydro Assessment Studies in Lao PDR:" WB, May 2012

[7] "Renewable Energy Development Strategy in Lao PDR:" Government of Lao PDR, 2011

shown in Table 3.3-1(1).

Table 3.3-1(1) Small Hydropower Plants of Less than 15 MW

Name of Project	Location	Installed Capacity (kW)	Ownership
Nam Dong (H)	Luangprabang	1,000	EdL
Selabam (H)	Champasak	5,000	EdL
Nam Ko (H)	Oudomxay	1,500	EdL
Nam Ngay (H)	Phongsaly	1,200	EdL
Nam Tha 3	Luangnamtha	1,250	IPP(d)
Nam Nhon	Borkeo	3,000	IPP(d)
Micro-hydro	-----	1,178	EdL+PDEM
Total		**14,128**	

Note: EdL: Electricité du Laos, IPP(d): Domestic IPP, Prov.: Provincial Government

A list of small hydropower plants of less than 1,000 kW operated by the provincial government (PDEM) as an off-grid system is attached as Table 3.3-1(2).

According to the WB Study mentioned above, the Lao PDR has extensive off-grid potential areas for MHP; however, MHP is more costly than grid extension and off-grid by SHS, because of limited HHs and demand in target villages. In addition, most existing MHP sites have been facing difficulties with operation and maintenance (O&M), both technically and financially.

Table 3.3-1(2) Hydropower Plants of Less than 1,000 kW Operated by Provincial Governments (PDEM)

No.	Plant Names	Province Location	Installed Capacity, kW
1	Nam Boun 1	Phongsaly	110.0
2	Nam San	Huaphanh	110.0
3	Nam Sat	Huaphanh	250.0
4	Houay Samong	Attapeu	226.0
5	Nam Mong	Luangprabang	70.0
6	Nam Phoune	Houaphanh	40.0
7	Nam Et	Huaphanh	80.0
8	Nam Long	Huaphanh	20.0
9	Ban Paksobma	Xiengkhuang	55.0
10	Nam Ka 1	Xiengkhuang	12.0
11	Nam Ka 2	Xiengkhuang	55.0
12	Houay Se	Oudomxay	80.0
		Total :	**1,108.0**

2) Solar power: photovoltaic (PV)

Photovoltaic (PV) solar power plays a major role in rural electrification. 25,000 HHs were supplied by solar home systems (SHS) as of 2009, whose total capacity was 474 kW.

Installations of SHS have been carried out by the public sector and private sector, with funding from the WB, international organizations, or own investment by local private companies. Larger PV systems (capacity up to 40-100 kWp) have also been piloted in a joint project between MEM and NEDO, as a component of a hybrid power system with micro-hydropower in a remote rural area.

3) Biogas

A number of demonstration projects have been initiated and funded by several donor organizations to develop household and community-scale biogas systems using animal and livestock wastes.

4) Other biomass

Lao PDR generates substantial amounts of waste from agriculture and forest production and processing sugarcane bagasse, rice husks, corncobs, wood wastes, etc. Besides, with growing urbanization, major cities generate significant amounts of solid waste. At present, there is a sugar company with an installed capacity of 9.7 MW using bagasse for electricity generation.

(2) Biofuel

The country imported 560 million liters of fossil fuels in 2010, which has been increasing at 5% a year. To reduce imports of fossil fuels and optimize the use of marginal land, GoL encourages and actively promotes the development of fuel crops in the country.

Biodiesel development from energy crops such as jatropha, Vernicia Montana, animal fat, and used tires have been piloted by the private sector.

3.3.2 Government organizations

Public organizations involved in the development of renewable energy (RE) are described below; for details refer to REDS.

(a) Ministry of Energy and Mines

Ministry of Energy and Mines (MEM) is the main agency responsible for renewable energy. As its stipulated responsibilities are “to develop overall renewable energy policy and support the achievement of sustainable development goals,” “ to set-up objectives and goals based on resource potentials and develop renewable energy database,” and “to provide mutual- and multi-cooperative assistance on revolving funds for RE programs, enhancing technical capacity, and providing financial support for investment promotion.”

(b) Ministry of Agriculture and Forestry

The Ministry of Agriculture and Forestry should develop production targets for biofuel feedstock in cooperation with MEM. The provincial, district, and village cluster representatives of the Ministry of Agriculture and Forestry should promote biofuel development and provide extension services in cooperation with MEM.

(c) Ministry of Natural Resources and Environment

The Ministry of Natural Resources and Environment is responsible for undertaking research on the use of water resources and will collaborate with MEM on studies concerning the production of biofuels. Furthermore, it is responsible for developing and enforcing requirements and guidelines to minimize environmental and social impacts of RE development by supervising implementation of IEE and EIA.

(d) Ministry of Science and Technology

Ministry of Science and Technology conducts research and pilot tests on science and technologies developed in different countries for RE applications.

(e) Other organizations

Ministry of Industry and Commerce, Ministry of Public Works and Transportation, Ministry of Finance, Central Bank of Lao PDR, and Ministry of Planning and Investment are the organizations involved in RE development.

3.3.3 Renewable Energy Development Strategy and its underlying issues

(1) Renewable Energy Development Strategy

1) Target of the strategy

The GoL announced the “Renewable Energy Development Strategy (REDS)” in June 2010. Despite the legal framework, a Renewable Energy Law has not been announced. The efforts of the GoL to develop REDS were supported financially by the Government of Finland[8]. The main points of REDS are summarized in Appendix 3.1.

REDS emphasizes the following targets.

(a) A target share for renewable energy development of up to 30% by the year 2025.

(b) The tentative vision for promoting and developing biofuels is that they substitute for 10% of transportation fuel demand by 2025.

However, REDS states that the target will be regularly reviewed and revised, upon feeding back the results of special studies, lessons learned from on-going implementation, and international technological developments in the field of RE. This section focuses on the underlying issues of REDS concerning the above target.

2) Achieving a target share of 30% for renewable energy development by the year 2025

Although REDS states a target share of 30% for RE by the year 2025 when total energy demand is assumed to be 4930 ktoe, it does not mention any specific projects. Its Road Map states only that they would be identified as soon as achievable. A document prepared with the assistance of the Finish Government has no mention of the value of 30%. It is a target value for the GoL in REDS based on the potential RE resources of the nation. The GoL is currently reviewing candidate projects to be included in REDS to make the value of 30% a realistic and achievable target.

Table 3.3-2 used in REDS shows the capacity to meet the 30% target for RE development until 2025. Small-scale hydropower accounts for quite a high value of 61% of the amount of

[8] “Lao PDR Renewable Energy; Strategy Development and Capacity Building,” Republic of Finland - Ministry for Foreign Affairs, June 2010

energy expressed in ktoe in 2025. Because the nation has abundant hydropower potential, it is understandable that its development is essential for achieving the target of 30%. However, this goal in REDS should become firmer and more concrete.

Table 3.3-2 Capacity to Meet 30% Target for Renewable Energy Development by 2025

Item	Renewable energy types	Potential	Existing	2015		2020		2025	
		MW	MW	MW	ktoe	MW	ktoe	MW	ktoe
A	**Electricity**			140		243		666	427
1	Small Hydropower	2000	12	80	51	134	85	400	256
2	Solar	511	1	22	14	36	23	48	31
3	Wind	>40		6	4	12	8	73	47
4	Biomass	938		13	8	24	16	58	37
5	Biogas	313		10	6	19	12	51	33
6	Solid waste	216		9	6	17	11	36	23
7	Geothermal	59							
B	**Biofuel**	**ML**	**ML**	**ML**		**ML**		**ML**	
1	Ethanol	600		10	7	106	178	150	279
2	Biodiesel	1200	0.01	15	13	205	239	300	383
C	**Thermal energy**	**ktoe**	**ktoe**						
1	Biomass	227			23		29		113
2	Biogas	444			22		44		178
3	Solar	218			17		22		109
Total									
Energy demand (ktoe)					2504		4064		4930
Renewable energy contribution					172		668		1479
Proportion					7 %		20%		30%

Note: The values for Electricity and Solar in 2025 are corrected by JICA Survey Team.

Source: REDS

3) Renewable energy types in REDS

RE types discussed in REDS are categorized into electricity, biofuel, and thermal energy. Electricity is also categorized into small hydropower, solar power, wind power, biomass, biogas, solid waste, and geothermal power. Biofuel consists of biodiesel and bioethanol, and thermal energy consists of biomass, biogas, and solar energy. The term RE used in REDS is expressed schematically in Figure 3.3-1.

REDS defines small hydropower to be less than 15 MW in accordance with Article 34 of the Electricity Law[9] as shown in Appendix 5.1.

[9] Electricity Law, Vientiane Capital City, date: 20/12/2011

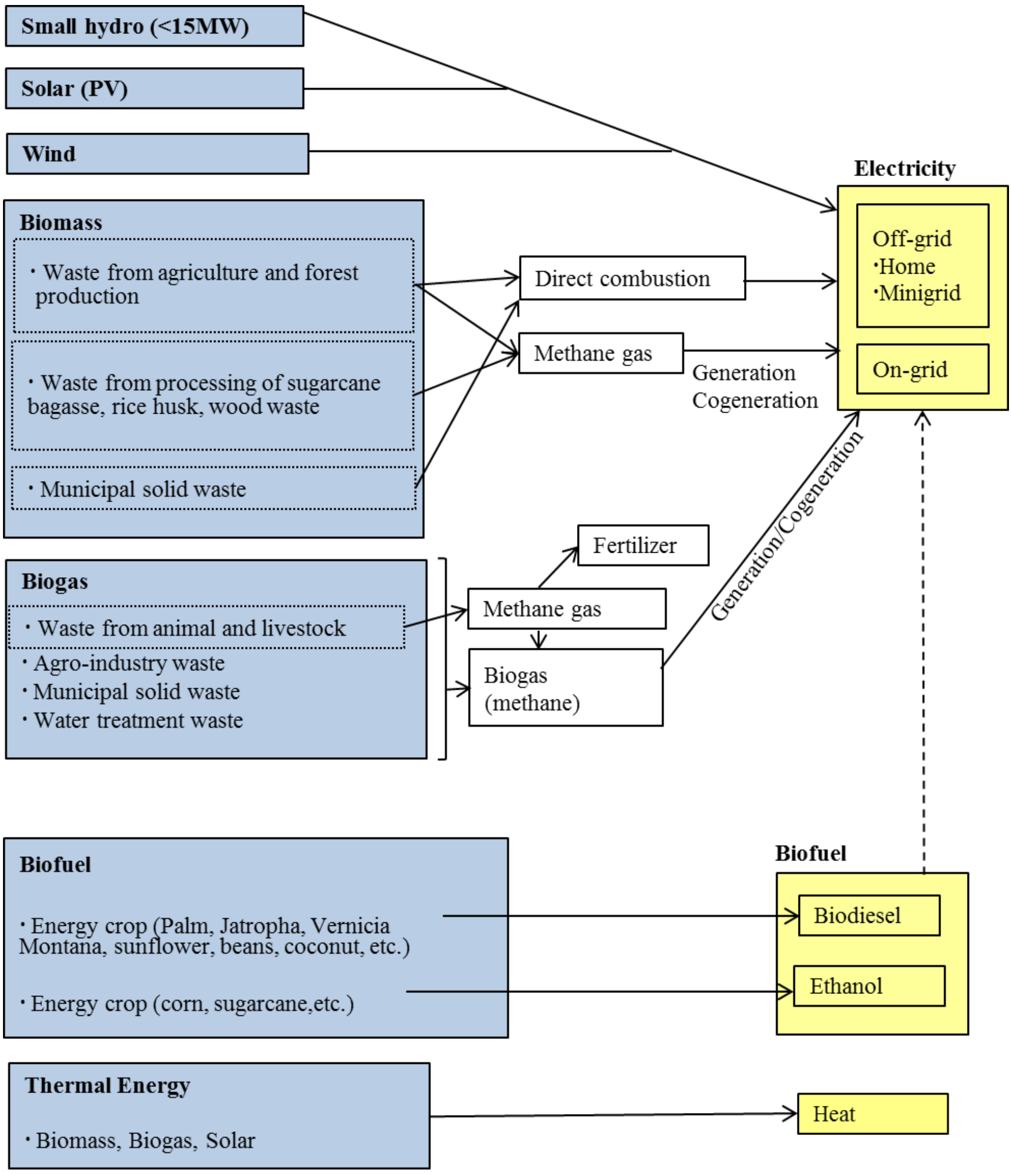


Figure 3.3-1 Renewable Energy Sources and Use in REDS

(2) Renewable energy potential and prospects for development

1) Definition of energy potential

The energy potential of each RE source is given in Table 3.3-2. When energy potential is discussed, it should be considered that the definition of the term depends on RE sources. However, the supporting background for Table 3.3-2 could not be verified with MEM.

(a) Hydropower, solar, wind, geothermal-power

These are natural energy sources determined by natural conditions such as river flow, solar radiation, wind velocity, and geothermal occurrence. Potential is classified mainly into two types, although the technical term is slightly different depending on each RE source. In this JICA study, the term energy potential is defined as follows.

- Theoretical potential: Amount of energy calculated theoretically without taking into account constraints on development and use of energy resources.

- Possibly-introduced potential: Amount of energy taking into account constraints on development and use of energy resources. Constraints consist of technical, economic, and environmental aspects.

(b) Biomass/biogas/municipal solid waste

Energy potential is determined by the amount of agricultural products and livestock and population in big cities. Therefore, the amount in the future, for example, in 2025, should be used for an energy potential estimation.

2) Electricity

The potential and prospects for development are described below.

(a) Small hydropower

The potential of small hydropower (SHP: less than 15 MW) is assumed to be around 2,000 MW. Studies to back up the figure of 2,000 MW have not been conducted. Investigation[10] of small hydropower in eight provinces in northern Lao PDR was conducted by JICA in 2004 - 2005; however, the scope of the study is up to 5 MW. Candidate sites for small hydropower in northern Lao PDR consist of 62 sites with a total capacity of 53 MW, in which five projects of 16 MW for on-grid and six projects of 0.6 MW for off-grid were selected as high-priority projects. The potential investigation covering a capacity of less than 15 MW should be conducted for the whole area of Lao PDR so that the potential of small hydropower and prospective projects for the entire Lao PDR can be identified at a reliable level.

Now, MEM is to develop small hydropower (1-15 MW) by taking an innovative approach under ADB support[11] as follows.

- DoE[12] identifies sites where capacity is needed and prepares projects in batches.
- Direct hydrological documentation from automatic stations
- Standard Concession Agreements and PPAs
- Fixed tariffs
- Implementation-ready Project with EIAs, Resettlement Plans
- Others

(b) Solar power

According to REDS, solar irradiance on Lao PDR is between 3.6-5.5 kWh/m^2 with sunshine of 1,800-2,000 hrs/year. With such solar energy potential, if photovoltaic technology was used (overall efficiency of 10%), it would generate 146 kWh/m^2/year, or $1.5x10^8$ kWh/km^2/year (13 $Mtoe/km^2$/year). The potential of solar energy is estimated to be 511 MW.

Five pyrometer stations were installed at five locations in Lao PDR[13]—Vientiane,

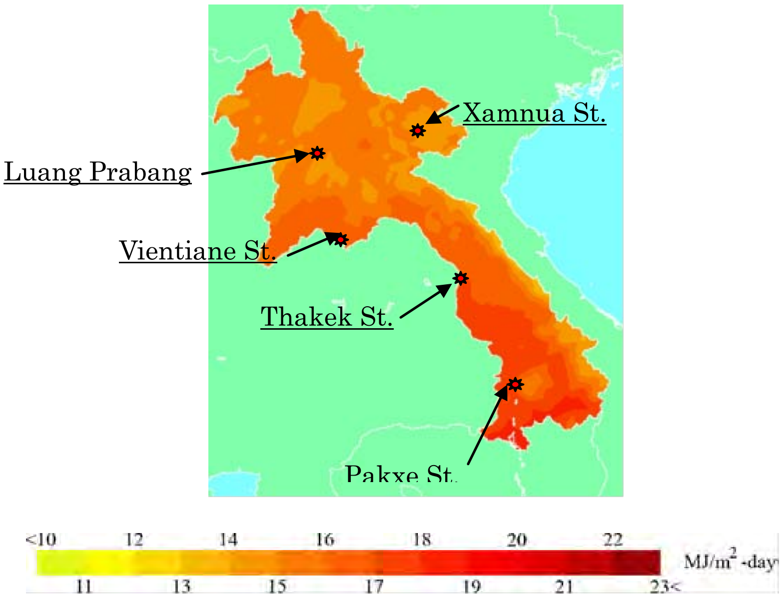
[10] "The Master Plan Study on Small-hydro in Northern Lao PDR," JICA, December 2005

[11] "An innovative Approach to Small Hydropower in Lao PDR: Hydro 2011," Prague, ADB, MEM, GHD

[12] Now the Institute of Renewable Energy Promotion (IREP)

[13] "Assessment of Solar Energy Potentials for Lao People's Democratic Republic: Department of Alternative Energy Development and Efficiency Thailand Department of Electricity Lao PDR, Solar Energy Research Laboratory Department of Physics, Silpakorn University, Thailand"

Luangprabang, Xamnua, Thakhek, and Pakxe—as shown in Figure 3.3-2. Global solar radiation has been measured from these stations. A satellite solar mapping technique was also used to calculate solar radiation over the country. Solar radiation in Lao PDR is influenced by monsoons and the geography of the country. A yearly map of solar radiation is shown in Figure 3.3-2, which shows that areas receiving high solar radiation are in the south of the country.



Source: Department of Electricity Lao PDR, Solar Energy Research Laboratory Silpakorn University, Thailand

Figure 3.3-2 Map of Yearly Average Daily Solar Radiation and Five Measuring Stations for Solar Radiation

Concerning WB projects, REP 1 (2006-2010) installed SHS for 16,000 HHs, and REP 2 (2012-2014) will install mini-grid development by other REs such as biogas generation and small hydropower (less than 15 MW), in addition to SHS for 15,000 HHs. The SHS system has the constraints that (1) ratio of HHs that can afford to use SHS is only about 60% in the non-electrification area, (2) sustainability of SHS in Lao PDR seems to be greatly affected by insufficient supply/maintenance and high price of battery and controller. Taking into account the expansion of distribution lines being carried out rapidly, a mini-grid system using solar PV will play an important role in rural electrification.

(c) Wind power

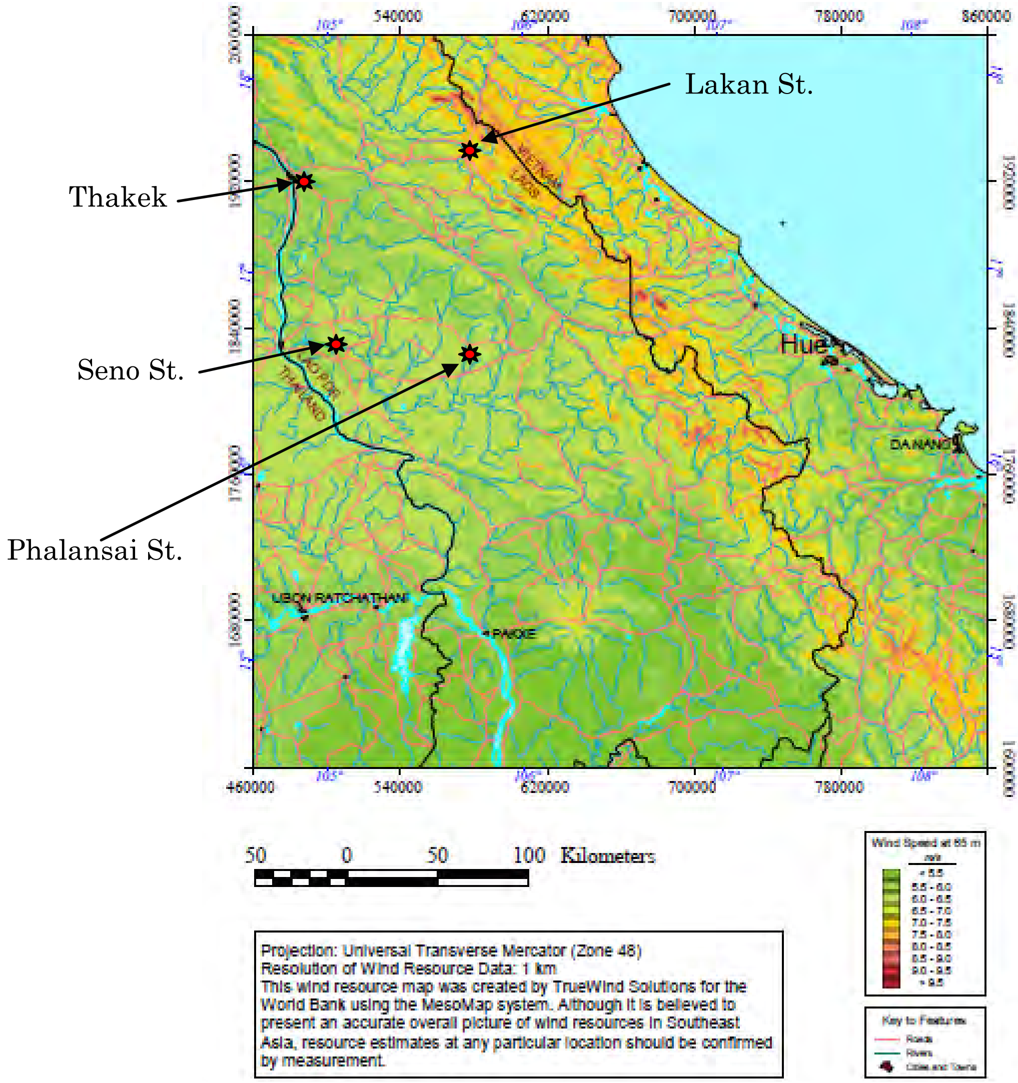
Based on international data sources[14], high potential of wind energy can be expected in central provinces, particularly in high mountainous areas along the Lao-Vietnam border of Khammouane, Savannakhet, Salavan, and Sekong provinces as shown in Figure 3.3-2 in which red and yellow colors indicate strong wind area. The potential of wind power in REDS is more than 40 MW assuming average wind velocity at a height more than 50 m is

[14] "WIND ENERGY RESOURCES ATLAS OF SOUTHEAST ASIA," The World Bank, September 2001

5.8 m/s.

In July 2010, MEM installed four wind data-loggers at Thakek and Lakang stations in Khammouane province, and Seno and Phalansai stations in Savannakhet province as shown in Figure 3.3-3. These stations have anemometers at heights of 50 m, 40 m, and 10 m[15]. It is commonly said that an average wind speed of 5.5 m/sec is required to screen an appropriate area for wind power. Because only one station, Lakang station, is located now in a relatively strong wind area, more stations, for example one station in Savannakhet province and one in Sekong province along the Lao-Vietnam border, should be installed.

Wind observation records for more than two years are necessary to evaluate wind energy reliably. JICA Study Team recommends MEM to maintain wind data-loggers appropriately so that wind data can be obtained without omissions.



Source: Wind Energy Resources Atlas of Southeast Asia, World Bank

Figure 3.3-3 Wind Power Resources in Southern Lao and Sites of Wind Data-loggers

[15] Location of Wind Data Logger Stations in LAO PDR (first attempt), Field Visit Report MAY 2010

(d) Biomass/Biogas

According to REDS, the potential of biomass in Lao PDR includes energy crops and organic wastes. Energy crops comprise oily crops such as jatropha, sugar, and starch, quick-growing trees, and aquatic cultures. Organic wastes include residues of agriculture-forestry production, by-products of agro-forestry industry and municipal wastes. It was estimated that using livestock wastes for biogas production could generate around 2.8×10^8 m3 of biogas per year, or equivalent to 5×10^8kWh electricity (about 216 Mtoe). However, underlying data were not verified by the JICA Study Team.

SNV Lao PDR commissioned a study[16] in late 2008 to assess the technical and commercial potential of larger biogas systems in Lao PDR. However, most of the farms were small scale and were expected to be too small to provide a reasonable basis to generate electricity for sale.

In close cooperation with the WB, MEM commissioned a study[17] to determine the potential and feasibility of using bio-digestion systems in Lao PDR with emphasis on livestock farms. The Energy Research and Development Institute (ERDI), Chiang Mai University in Thailand was awarded a contract to carry out the study. Assuming that on average 600 farms can install a 150-cubic meter digester each with a digester volume totaling 90,000 cubic meters, these biogas systems would be able to generate in total about 90 MWh/day. The report notes that of the amount of electricity generated, roughly 50% will be used by the pig farms themselves for pumping water, lighting, heating piglets, etc., and that the other 50% will be available to other users such as rural electrification systems.

(e) Municipal Solid Waste

Residents in Vientiane, population 730,000, generate on average 691 tons of waste per person, which consists of kitchen waste (34%), wood (30%), paper (7%), plastics (12%), glass (7%), metal (1%), and others (9%). Of the total daily waste discharge of 637 tons, 209 tons are collected and 195 tons go on to final disposal sites. The difference of 42 tons between 637 and 209 tons is due to disposal in individual gardens and backyards (386 tons) and fly-tipping.

There is a 100-hectare open dumping site at a location 32 kilometers from the center of Vientiane. It will exhaust its capacity by 2020, but there is another large site adjacent to the current one. In the event of an acute lack of dumping sites, a waste disposal plant with an electric generation capability provided by direct combustion might be an option. However, this is not the case with Vientiane. Municipal waste basically generates only a small amount of methane gas, biogas, which would only be sufficient for household heating and cooking. A reasonable volume of methane gas may be obtainable provided municipal waste is mixed with waste from pig farms and residues of dairy products. Human waste usually generates

[16] "BIOGAS FOR LARGE(R)PIG FARMS IN LAO PDR; SNV LAO PDR FINAL REPORT" prepared for SNV LAO PDR by Auke Koopmans with assistance from NAST/STRI

[17] "Final report for Feasibility Studies on the Potential Biogas for Off- and On-grid Electricity Generation in Lao PDR; Report to MEM," submitted by Energy Research and Development Institutes, Chiang Mai University, Thailand, March 2010

methane; however, this cannot be expected even if it is mixed with other wastes because the waste from Vientiane city has a higher water content.

Luang Prabang is a world heritage site with a population of about 50,000 persons. Because it is a tourist city, restaurants should be a major source of waste. This would allow the use of compost plants to make fertilizer, which can be used to grow edible vegetables, thereby accomplishing a circle of recycling. The existing waste dumping site, located 8 kilometers from the city center, will be maxed out within five years. Judging from the capacity of the present landfill, the site makes waste power generation a distant possibility. After the present landfill becomes full, waste will be dumped at a location 20 kilometers from the city center. The JICA Study Team did not collect data on waste for Savannakhet, the largest city in terms of population in Lao PDR.

(f) Geothermal power

Because Lao PDR is not in an area where geothermal energy is available for electricity, geothermal power is not discussed in this study.

3) Biofuel

The potential and prospects of biofuel development are described below.

REDS describes the potential of biofuel as 600 million liters for biodiesel and 1,200 million liters for bioethanol.

Biodiesel is expressed as B5 (5% biodiesel and 95% diesel), B100 (100% biodiesel and 0% diesel) and bioethanol is also expressed as E5 (5% bioethanol and 95% gasoline), E100 (100% bioethanol and 0% gasoline) depending on the mixture rate. The biofuel figures noted in Table 3.3-2 refer to B100 and E100.

The following should be considered when the biofuel potential of Lao PDR is discussed. Agricultural land covers only 8% of the total country area; it increased annually by 8% from 1997 to 2007. Agricultural land expansion is constrained by topography with 70% of the land area having a slope of more than 20 degrees. With expected economic and population growth, rice demand is also expected to rise to meet more demand. In this context, land pressure is also likely to increase[18].

Concerning biofuel potential, the Study[19] was done from the viewpoints of land and labor resources availability, potential for biofuel crops, business model, processing facilities, and market chains. The study includes pre-selection of viable feedstock and market chains. A shortlist of feedstock cropping modalities is evaluated to determine the overall viability of each crop. Evaluation parameters are crop demand, suitable area, land use and biodiversity, energy balance and GHG, labor force, employment generation, biofuel yield, yield improvement potential, investment, biofuel price, and overall national potential. The results of the study are attached in Appendix 3.4.

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[18] "Biofuel Assessment Study in Lao PDR, Interim Report:" Lao Institute for Renewable Energy (LIRE), for Department of Electricity, November 2009

[19] "Biofuel Assessment Study in Lao PDR, Interim Report:
Lao Institute for Renewable Energy (LIRE)," for the Department of Electricity (By Robert, Rietzler, Vilavong, Gaillard), November 2009

Main candidate plant species in Lao PDR are as follows, and details are explained in Appendices 3.3 and 3.4.

(a) Jatropha for biodiesel

There are drawbacks to jatropha in that its seeds contain a poisonous substance that could endanger people who harvest the seeds and children who might play with them. Jatropha oil cannot be used for human or animal consumption, and the plant is toxic to livestock. Harvesting jatropha is labor intensive because seeds do not mature at the same time. Jatropha plantations are mostly run by contract farming (99%), so jatropha is cultivated on existing agricultural land. Rice is the national staple food and its mean yield has to increase by 35% by 2020 to achieve national rice sufficiency. Calculations assume that jatropha land cannot compete with lowland rice[20].

(b) Vernicia Montana for biodiesel

Vernicia Montana is the English name for what is also called Stone jatropha, Mak Kao (by Sam Neua people), Mak Nam Man, Mak Yao Hin, or Tung Oil tree in Lao PDR. Because the Vernicia Montana tree is suitable for planting on steep slopes in mountainous areas where the slash-and-burn farming method is mostly adopted, the Montana tree does not compete with rice fields.

- Upland rice can be planted about one to three years after planting Montana trees,
- Nuts of the Montana tree can be harvested four or five years after planting; therefore, farmers who use slash-and-burn farming can make a living.
- The Montana tree can be found mostly in the provinces of Houaphanh, Phongsaly, Luangprabang, and Borikhamxay, and uplands of the Lao-Vietnamese borders.

(c) Palm oil for biodiesel and bioethanol

Palm tree is perennial suited to high-temperature (20- 35°c), high-rainfall (1500 - 3000 mm/yr) regions with deep and well-drained soil, and high nutrient content. Moreover, a certain concentration of salt in the air is needed for optimal development. Therefore, cultivation in Lao PDR would be limited to the Bolaven Plateau and Vientiane Plain.

(d) Sugar and starch crops for bioethanol

Crops with high sugar and starch contents are of interest for ethanol production, and several crops such as sugar cane, cassava, and maize are already grown in Lao PDR. Sugarcane is widely cultivated in Lao PDR, with a yield of up to 38.3 ton/ha in 2007 (South - East Asian mean yield: 61.2 t/ha; FAOSTAT). Harvesting is labor intensive and dangerous, and injuries caused by leaves and snakes are common. Based on the mean yield in 2007 (FAOSTAT), and assuming 70l/ton biofuel conversion factor (USAID 2009), 2,681 liters of bioethanol per hectare is expected. However, the Lao market price is prohibitively high for biofuel (130 USD/t sugarcane translates into 1.86 USD/l bioethanol; FAOSTAT, 2007), unless large-scale plantations are considered.

3) Thermal (Heat)

[20] "Status and Potential for the Development of BIOFUEL and Rural Renewable Energy, The Lao People's Democratic Republic," ADB

Firewood is mainly used in Lao PDR for cooking and heating purposes. At present, it is estimated that 1,514 ktoe for heating accounts for 56%.

(3) Plant factors used in REDS

The REDS indicates investment in renewable energy sector until 2025 as shown in Table 3.3-3.

Table 3.3-3 Investments in Renewable Energy Sector

Item	**Phase Description**	**2015**		**2020**		**2025**	
		MW	**MUSD**	**MW**	**MUSD**	**MW**	**MUSD**
1	Electricity	140	477	243	1041	666	1754
1.1	Small Hydropower	80	288	134	629	400	1010
1.2	Solar	22	41	36	90	48	144
1.3	Biomass	13	24	24	52	58	72
1.4	Biogas	10	21	19	45	51	192
1.5	Municipal solid waste	9	48	17	105	36	168
1.6	Wind	6	55	12	120	73	168
2	Biofuels production	ML	MUSD	ML	MUSD	ML	MUSD
2.1	Ethanol	2	5	41	33	79	63
2.2	Biodiesel	2	9	50	33	79	63
C	Research & Development		5		10		17
Total			**496**		**1117**		**1897**
Public investment			5		10		17
Public Enterprise Investment			10		22		36
Private Investment			481		1085		1844

Note1: MUSD: Million US dollars

Note 2: Research and Development; Ministry of Science and Technology

Note 3: Public investment: by GoL, Public Enterprise Investment: by EdL

Table 3.3-4 shows annual plant factors (PF) for RE sources in 2025 calculated from megawatts of development (MW) and energy generated (ktoe) given in Table 3.3-2 (Section 3.3.2). Because column (3) is energy value (kWh) converted from the relation between toe and kWh, the value of 427 ktoe is the same energy as $4{,}966\times10^6$kWh. Annual PF for each power source is calculated from columns (1) and (3). Apparently, an identical PF of 85% is uniformly applied independently of the source of energy.

The PFs to be used for the investment study of RE were reviewed by the JICA Study Team as follows.

(a) Small hydropower: Small hydropower plants mostly supply power to mini grids isolated from the national grid, and the generating mode is run-of-river type including pondage type with a daily regulation pond. Because a PF of 70 to 80% is the most economical empirically for the conditions above, Pf=75% is adopted in this study.

(b) Solar power (PV): PF should be around 20%[21] if one considers statements in REDS that “Solar irradiance on Lao PDR is between 3.6-5.5 kWh/m^2 with sunshine 1800-2000 hours/year.”

[21] PF=5.5 kWh/m^2×0.7×365/8760=16%, PF=2000hrs/8760hrs=23%, average is about 20%. (note) total design factor is 0.7.

(c) Biomass and biogas:

Examples of Japan, Thailand, and Lao PDR are considered to determine Pf=70%.

(d) Municipal solid waste: Data of Government of Japan (GoJ) are adopted in this study.

(e) Wind: PF should be lower than 20% taking into account a wind speed reaching 5.8 m/s at a height of 50 m and above.

Table 3.3-4 Plant Factors of Renewable Energy Sources for Electricity

Item	**RE Source**	**(1)**	**(2)**	**(3)**	**(4) Plant Factor (%)**	
1	**Electricity**	**Capacity MW**	**Energy ktoe**	**Energy 10^6kWh**	**Calculated from (1)(3)**	**Adapted by JICA**
1.1	Small Hydropower	400	256	2977	85	75
1.2	Solar (PV)	48	31	361	85	20
1.3	Biomass	58	37	430	85	70
1.4	Biogas	51	33	384	85	70
1.5	Municipal solid waste	36	23	267	85	60
1.6	Wind	73	47	547	85	20
Total		**666**	**427**	**4966**		

Note: 1 toe= 11,630 kWh

(4) Preliminary analyses of RE development and investment for Electricity

1) Unit construction cost

Table 3.3-5 shows a study on capacity (MW) and investment (MUSD) in 2025 by applying realistic PFs obtained in Table 3.3-4. Table 3.3-5 shows original values of MW and MUSD (Million US$) in columns (1) and (2), and their modified values in column (5) and (6) by applying realistic PFs. Column (4) shows the breakdown of 427 ktoe, which is equal to 4,966 $\times 10^6$kWh, and the column expresses REDS's condition that RE accounts for 30% of total energy demand in Lao PDR in 2025.

The JICA Study Team reviewed unit construction cost per kW, taking into account currently available data, as shown in column (3). The value for biomass was modified from 1,200 (REDS value) to 2,000 USD/kW, taking into account an actual power plant. Wind value was modified from 2,300 (REDS value) to 1,500 US$/kW taking into account the wind energy market at present.

The unit construction cost of solar (PV) is decreasing significantly in Thailand, and is 1,900 USD/kW according to information from the Thai government (See; Appendix 3.6). However, 3,000 USD/kW is adopted in this study.

Table 3.3-5 Modified MW and MUSD Applied by Modified Plant Factor for 2025

	(1) MW	(2) MUSD	(3) =(2) / (1) US$/kW	(4) ktoe at original Pf	(5) = (1)×α* MW for modified Pf	(6) = (3)×(5) MUSD for modified MW
Electricity						
Small Hydropower	400	1,010	2,500	256	453	1,133
Solar (PV)	48	144	3,000	31	204	612
Biomass	58	72	2,000	37	70	140
Biogas	51	192	3,800	33	62	236
Municipal solid waste	36	168	4,700	23	51	240
Wind	73	168	1,500	47	310	465
Total	**666**	**1,754**		**427**	**1,150**	**2,826**

Note: α = 0.85/0.75 for hydropower, 0.85/0.2 for solar & wind, 0.85/0.7 for biomass & biogas, 0.85/0.6 for municipal solid waste

2) Case studies using PFs adopted by JICA

Table 3.3-6 shows analyses at a preliminary level on the basis of 427 ktoe using Table 3.3-5. Original Plan means the values are those from REDS, which are shown in columns (1), (2), and (4) in Table 3.3-5.

The following cases are studied.

Case 1: Capacity and investment using modified PF for the same ktoe as the original plan

(a) Condition: Modified MW and MUSD are used as shown in columns (5) and (6) of Table 3.3-5.

(b) Study results: Table 3.3-7(1) shows the study results. Difference in investment between original plan and Case-1 is about 1,000 MUSD, which is required to maintain the energy of 427 ktoe of REDS.

Case 2: Small hydropower bearing 50% of other REs' energy

Generated energy and cost of hydropower projects are greatly affected by characteristics of the topography and river flow at project sites, and also affected by project scale such as large, middle, small, mini and micro hydro. Therefore, promising projects are selected from many projects studied in hydropower potential by conducting ranking studies to take into account the power demand, power supply capability / energy cost, etc. Concerning the hydropower projects for on-grid supply in Lao PDR, it can be said that the promising projects including small scale hydropower are more economical than solar and wind power as shown in column "Adopted by JICA" in Table 3.3-6. The following study is conducted under the condition below.

(a) Condition: Energy of 50% for solar (PV), biomass, biogas, solid waste, and wind in Case 1 is shifted to small hydropower, which seems to have a lot of potential and low unit generation cost.

(b) Study results: As shown in Table 3.3-7(2), because the unit construction cost of hydropower is much lower than other RE sources, MW and MUSD are less than those in Case 1.

3) Case study on annual generation cost to achieve RE 30%

(a) In a case where equalized unit cost (US$/kWh) of RE is higher than the expected electricity price of EdL, GoL might have to subsidize IPPs. The subsidy is calculated at a preliminary level. The expected price level of EdL is assumed to be 0.07 US$/kWh in this study.

(b) Condition: Annual energy cost for each RE is calculated assuming the prevailing levelized cost as follows.

- According to the results of an ADB study on small hydropower projects, the levelized cost is about 0.04 US$/kWh; however, 0.07 US$/kWh is adopted in this study. Canals arranged along the mountain slope are 10 – 20 km long, and the layout might have some risk of landslide and unequal settlement of canals. The details are explained in item 3.3.6(3).
- The levelized costs of solar (PV), biomass, solid waste, and wind are obtained referring to relevant information. Information of GoJ comprises values 2010 and 2030. Information of the Government of US (GoU) is the levelized Cost of New Generation Resources from the Annual Energy Outlook 2011 (Start of Operation: 2016). Information of Government of Thailand (GoT) shows the value adding Adder[22] for each RE to the average tariff of 3 Thai Baht. Relevant information obtained from interviews with GoT is attached in Appendix 3.6.

Table 3.3-6 Levelized Cost of RE

Item	GoJ	US Outlook 2011	GoT.	Adopted by JICA
	2010(US$/kWh)	US$/kWh	Baht/kWh(Adder)	US$/kWh
	2030(US$/kWh)		US$/kWh	
Wind	0.10-0.17	0.149	5.0 (2.50)	
	0.09-0.17		0.147	0.15
Mega solar(PV)	0.30-0.46	0.396	9.5(6.50)	
	0.12-0.26		0.279	0.2
Small hydropower	0.19-0.22	0.119	3.8(0.8)	
	0.19-0.22		0.112	0.07
Woody Biomass	0.17-0.32	0.111	3.3(0.30)	
	0.17-0.32		0.097	0.11
Biogas			3.3(0.30)	
			0.097	0.11
Solid waste			5.5(2.50)	
			0.162	0.12

Note 1: Currency conversion 1 US$=100 yen. 1US$=34 Thai Baht

Note 2: GoThai value includes Adder expressed in parentheses for capacities not over than 10 MW and adopted for a seven-year period.

Study results are as follows. Table 3.3-7(3) shows the annual cost of 483 MUSD for 4,966 million kWh required for RE. Assuming a subsidy is necessary for an annual total cost of more than 350 MUSD (=4,966×0.07), the subsidy would be about 130 MUSD per year, without considering other additional benefits such as CDM. It can be emphasized from the results that the subsidy for RE is greatly affected by the development volume of small hydropower.

[22] An additional energy purchase price on top of normal prices that power producers receive when selling electricity to power utilities

Table 3.3-7(1) Comparison between Original Plan and Case 1

Item	Phase Description	Original Plan			Case 1		
		MW	MUSD	ktoe	MW	MUSD	ktoe
1	Electricity						
1.1	Small Hydropower	400	1010	256	453	1133	256
1.2	Solar (PV)	48	144	31	204	612	31
1.3	Biomass	58	72	37	70	140	37
1.4	Biogas	51	192	33	62	236	33
1.5	Municipal solid waste	36	168	23	51	240	23
1.6	Wind	73	168	47	310	465	47
Total		**666**	**1754**	**427**	**11500**	**2826**	**427**

Table 3.3-7(2) Investment with Small Hydropower Emphasized

Item	Phase Description	Case-2		
		MW	MUSD	ktoe
1	Electricity			
1.1	Small Hydropower	605	1350	342
1.2	Solar (PV)	102	306	16
1.3	Biomass	35	70	18
1.4	Biogas	31	118	17
1.5	Municipal solid waste	26	120	11
1.6	Wind	155	233	23
Total		**954**	**2197**	**427**

Table 3.3-7(3) Annual Generating Cost of RE

Item	Phase Description	Case-3		
		10^6kWh	Energy cost USD/kWh	Annual Cost MUSD
1	Electricity			
1.1	Small Hydropower	2,977	0.07	208
1.2	Solar (PV)	361	0.20	72
1.3	Biomass	430	0.11	47
1.4	Biogas	384	0.11	42
1.5	Municipal solid waste	267	0.12	32
1.6	Wind	547	0.15	82
Total		**4,966**		**483**

(5) Development of power projects for off-grid and on-grid supply

RE can be categorized into off-grid supply source and on-grid supply sources. Generally, the generating cost (USD/kWh) of RE is higher than that of non-renewable energy sources such as large hydropower, thermal power, and other power sources used for on-grid supply. Therefore, RE development mostly depends on subsidies from the government and/or additional tariffs borne by electricity consumers. RE development in Lao PDR has been carried out for rural areas far from the national grid under the condition of subsidies from donors.

The GoL has the policy target of raising the national electrification rate to 90% on a household basis by 2020. The WB report confirms that the national target of 90% on a household (HH) basis by 2020 will be achieved from the study results of 85% on-grid coverage and 5% off-grid coverage. On the other hand, REDS states that the RE portion will be 30% of total energy demand by 2025. Considering this situation, RE will be supplied not only off-grid, but also on-grid. An issue will arise as to who will pay the additional RE cost beyond the EdL electricity tariff.

(6) Biofuel production

The tentative vision of REDS is that “Biofuels are to substitute for 10% of transportation fuel demand by 2025.” The production target for 2025 is 150 ML of ethanol and 300 ML of biodiesel.

1) Biodiesel

The biodiesel business is carried out by the private sector using the following oil plants. It is expected to produce more biodiesel (B5) by the end of 2012. Currently, B5 is being sold in Xayaboury province. B5 is 3 percent cheaper than ordinary diesel. Many companies are entering the biodiesel business such as Kolao farm and Bio-Energy Company using jatropha, Luangprabang Teak Tree Import-Export Company using Vernicia Montana, and Lao Agro-Teck Company using oil palm. However, it cannot be said that activities have reached to commercial basis.

2) Bioethanol

Sugarcane, Cassava, Sweet Sorghum, etc., are at the research level and no private firms are involved in production.

Underlying issues related to biofuel are as follows, and business fields are summarized in 3.3.4(5).

- Biofuel production is greatly affected by land use, food security, pricing policy, and subsidies.
- The schedule for biofuel production based on commercial investments is uncertain at present.

(7) Financial measures to develop renewable energy

1) Financial incentives

Because the development cost (US$/kWh) of RE is generally much higher than thermal power and hydropower projects, most countries provide financial measures to make RE economically viable such as Feed in Tariff, Adder adopted in Thailand, etc.

The GoL also has a plan to provide various financial incentives to RE projects and investors as described below. The GoL has already provided (a) and (b) to sugar companies and biodiesel developers.

(a) Free import duty for production machinery, equipment, and raw materials;

(b) Free import duty for chemical materials necessary for biofuels production within seven years;

(c) Profits are taxed at three levels: 20%, 15%, and 10%. Exemption from taxes on profits is possible for a certain period depending on activities, investment areas, and scale;

(d) Subsidies for unit product price depending on energy type and period.

Investors can also obtain non-fiscal incentives, such as:

(e) Leasing period up to 75 years (for enterprise construction land);

(f) Permission to expatriate earnings to home or third countries;

(g) Right to employ foreign workforce (not more that 10% of enterprise's total labor).

Concerning Carbon Financing, the GoL ratified the Kyoto Protocol in 2004, appointed the Water Resources and Environmental Administration to be the Designated National Authority, developed sustainable development criteria, and established approval processes for CDM projects. With the recent progress of CDM, the Government ensures small-scale projects such as SHS, pico hydropower, biogas, improved cook stoves, and solar water heaters will be developed under the CDM Program.

2) Development of small hydropower

Decrees and draft decrees relating to each RE describe measures and policies for promoting RE development, and applying the Rural Electrification Fund (REF). Because energy produced by small hydropower accounts for about 60% of the total electricity supplied by REDS, small hydropower is the focus here.

MEM has applied a new tariff system[23] to small hydropower projects supported by ADB as shown in Table 3.3-8. The new tariff is adjusted by the inflation rate every year, and is applied on a seasonal and hourly basis.

Concerning the financing of projects, the draft decree for small hydropower development stipulates the following:

Government financial institutions are encouraged;

(a) priority given to small hydropower loans,

(b) preferential financial packages provided for developing small hydropower plants by the private sector.

(c) The Ministry of Finance examines the feasibility of securing grants and/or concessionary loans from international donor organizations to on-lend to commercial banks to finance small hydropower projects, and/or to provide guarantees for small hydropower project loans.

Table 3.3-8 New Tariff - Price Level 2011

Installed Capacity per Feeder	Voltage	% of 22 kV Tariff	Jul - Dec Off-Peak	Jul - Dec Peak	Jan - Jun Off-Peak	Jan - Jun Peak
MW	kV	%	USD/kWh	USD/kWh	USD/kWh	USD/kWh
P<1	22 kV	95%	0.0420	0.0660	0.0543	0.1326
1<P<5	22 kV	90%	0.0399	0.0625	0.0515	0.1256
5<P<10	115 kV	85%	0.0459	0.0612	0.0503	0.1069
10<P<15	115 kV	80%	0.0431	0.0576	0.0475	0.1006

Note: Tariff in USD on 8050 LAK to 1 USD- Peak: 16 hours a day Monday to Saturday

Source: "An innovative Approach to Small Hydropower in Lao PDR: Hydro2011," Prague, ADB, MEM, GHD

[23] "An innovative Approach to Small Hydropower in Lao PDR: Hydro2011, Prague," ADB, MEM, GHD

3.3.4 Business potential and private companies in Lao PDR involved in renewable energy

(1) Small Hydropower

Small Hydropower plants (< 15 MW) are mainly owned by EdL and provincial governments at present. However, GoL now has a policy for IPPs to develop small hydropower (< 15 MW) . Table 3.3-9 shows a list of projects owned by IPPs.

Small hydropower (less than 15 MW) is generally less economical than medium- to large-scale projects because small hydropower cannot benefit from economies of scale. Credits for developers/producers and engineering ability of construction companies might be low, compared to players involved in medium- to large-scale hydropower projects. Because banks are unwilling to supply loans at low interest rates due to above situation and if foreign contractors/consultants are involved, construction costs might increase significantly. The engineering level required for small hydropower is much higher than that of micro-hydropower in the 100 kW class. If design/construction/O&M are conducted with the sense that small hydropower equals low quality, power plants will face serious problems during plant operation. To make the small hydropower business profitable, the following should be considered in addition to measures taken for ADB projects described in 3.3.3(2)2).

(a) Plural plants located nearby are owned and operated, for example in the same river basin.

(b) Engineering levels of local contractors and consultants should be maintained to enable them to construct power plants of an appropriate engineering level.

Table 3.3-9 List of IPPs for Small Hydropower

Name of IPP	Name of Power Plant	Capacity (MW)	Stage of Project
Nam Ngone Power Co, Ltd	Nam Nhon	3	Existing
DPS Roads & Bridge(Lao PDR)	Nam Tha 3	1.25	Existing
Lao Company /SMG	Nam Phao	1.6	PPA
SIC Manufacturer Co. (Thai)	Tadsalen	3.2	UC
Nam Long Power Co.,(Lao PDR)	Nam Long	5	UC

Note1: Excluding EdL, Note2: UC: Under Construction

(2) Solar power

1) Solar (PV)

(a) Solar home system (SHS)

Sunlabob Renewable Energy Co., Ltd., is a Lao private energy services company offering a range of energy products and services, and is a pioneer of the franchise approach to rural electrification. To deliver off-grid power to poor villages, Sunlabob has designed an innovative model through which villagers buy light as a service through community-owned lanterns, which are charged every few days by a village-based solar station rented from Sunlabob and operated by a village franchisee. Because staff are required for the activity in villages, a village energy committee and village technician are established, then engineering is transferred to the staff following 6 – 9 months training.

However the village staff are not employees of Sunlabob. The company is now involved in a solar mini-grid of 10 kW to supply 150 HHs for rural electrification. The role of Sunlabob for the solar mini-grid is design, installation of solar system, training operators, and supplying spare parts.

(b) Solar power (for on-grid)

Concerning mega solar power development for on-grid, it is difficult for private companies to enter the business without strong support from the GoL.

2) Solar thermal power system

It is said generally that suitable areas for solar thermal power system are where there is abundant direct solar radiation, for example, annual irradiation of more than 2,000 kWh/m^2 with low levels of moisture and dust. From this viewpoint, Lao PDR is not located in a very suitable area for solar thermal generation, although there is potential.

(3) Wind power

No private companies have commercial wind power plants, however GoL has recently concluded a MOU with a foreign investor.

(4) Biogas

MEM is promoting a biogas project using four pig farms supported by the WB. One of the four pig farms is called Bio Farm, the purpose of which is to join the biogas project by treating odors, treating water to ensure quality, reducing electricity bills, and effectively using livestock manure. GoL is preparing to apply the standard Waste Treatment System to cattle breeding; however, it has not been applied yet to larger pig farms.

Bio Farm raises 2,400 pigs at maximum and wastewater of 60 m^3/day flows into an open pond next to the pig farm building without treatment. Bio Farm uses 6,139 kWh/month of electricity, and its electricity bill is 497 USD/month. After installation of gas plant and generating plant, the electricity generated is for farm use. The project consists of a digester ($300m^3$) and a power plant (40 kW), which generate 105,600 kWh/year. Players and their roles in the project are as follows.

(a) WB supports MEM technically and financially.

(b) MEM implements the project (selects farms, D/D)

(c) Procurement (construction and equipment) done by MEM following the WB procedure.

(d) O&M is done by the farm owner (two to three staff).

(e) Energy generated is sold to the farm under a reasonable tariff.

(5) Biomass

At present, Mitr Lao Sugar Co., Ltd owns 9.7 MW power plant using bagasse for electricity generation. However, the current capacity of only 3 MW due to insufficient feedstock supply. The energy generated by the power plant is sold to EdL. Nitr Lao is a typical case facing fuel risk. To avoid fuel risk, the owner of the power plant has to study risks and prepare countermeasures such as conducting a feasibility study/concluding a contract before starting the business.

(6) Biofuel

1) Companies in the biofuel business

No biofuel production plants are being operated commercially in Lao PDR, with the exception of a biodiesel pilot plant. However, Lao PDR exports energy crops as biofuel feedstock to Thailand, Vietnam, and China. These countries already have production plants in commercial operation. Therefore, business activities of Laotian companies in the biofuel field should consider business trends in these countries. Lao companies[24] that have been trying to enter the biomass business are listed in Appendix 3.5.

The following companies are active at present in the biodiesel business; however, no companies are active in the bioethanol business.

(a) Lao Fuel State Enterprise (LFSE):

LFSE is a 100% state enterprise of the Ministry of Commerce.

(b) Kolao farm and Bio-Energy Co., Ltd[25]:

Production of Biodiesel from jatropha. Experimentation on B5[26] and B10 is to be carried out by 2015, and will be completed in 2025. According to an interview with Kolao, jatropha trees are planted at the borders of residential housing lots as fences, and farmers gather the fruit, which are then collected by the company. Considering the method of raising and collecting jatropha seeds, it is unlikely that jatropha will become a major feedstock for biofuel. Kolao Company has a business plan to handle 40 tons of jatropha seed a day.

(c) Luangprabang Teak Tree Import-Export Co, Ltd:

Vernicia Montana (Tang Oil tree) has been planted in an area of Luangprabang; however, no oil has been produced. The company promoted planting using areas that had been logged, where cultivation had been shifted, and where there had been other disruptive activities, and also promoted a 2+3 contract farming arrangement (See: Business model of biofuel cultivation below). The company has started applying this cooperative system with the population based on:

- Family unit as foundation for reducing poverty;
- Programs for reducing poverty, and strategies aimed at stopping slash-and-burn agriculture.
- Plantation area is located mainly in Luangprabang and Houaphan provinces.

(d) Lao Agro-teck Co., Ltd:

Production of Biodiesel from palm trees and jatropha.

[24] "Biofuel Assessment Study in Lao PDR, Interim Report:" Lao Institute for Renewable Energy (LIRE), for Department of Electricity, November 2009

[25] Subsidiary company of Kolao Co. Group, Korean-run company in Lao; auto and motorcycle manufacturer and banking business in LaoPDR

[26] Upper limit of biodiesel blend ratio against diesel oil is 5%.

Cultivation in Lao PDR would be limited to the Bolaven Plateau and Vientiane Plain. This company is active in producing biodiesel from palm oil tree and is to build a commercial plant for biodiesel production in Vientiane province this year. A total of 100 tons of palm fruit is pressed a day. Production is 20,000 liters a day and 30,000 liters a day for phase 1 and phase 2, respectively.

The National Agriculture and Forestry Research Institute (NAFRI) supports private companies producing jatropha oil; however, due to conflicts between agriculture and jatropha production, private companies producing biofuel using jatropha might solve any difficulties in their businesses.

2) Business model of biofuel cultivation

The following contract models[27] are adopted for biofuel cultivation such as jatropha in Lao PDR. At present, (2+3 model) and (1+4 model) account for 86% and 13%, respectively.

(a) 2+3 model:

This model is aimed at balancing responsibilities and benefits between stakeholders, where farmers contribute land and labor (2 items), while investors supply inputs, technical advice, and access to market (3 items). In some cases the 2+3 model is carried out as a joint venture, where the two parties split income with fixed shares, depending on agreed input of labor, land, and capital.

(b) 1+4 model:

This model can also be described as land lease. The farmer leases his land to the investor (1 item), and the investor provides inputs, technical knowledge, market access, and labor in the form of hired farm workers (4 items). The investor is responsible for the entire management and keeps the biggest share (in Lao PDR this is about 70 percent) of income after harvesting.

3.3.5 Trends of renewable energy advanced technologies in Japan

This section introduces some advanced and leading-edge technologies in Japan. These include those (i) that are not proven, but are expected to become commercial within a few to several years, (ii) that already have been developed as analogous products. This is not intended to advertise any specific products of individual companies.

(1) Solar (PV) power

Because the electric power system of Lao PDR consists of hydropower plants, its supply capability decreases in the dry season. On the other hand, because the intensity of solar radiation in the dry season is high and a mega solar power system acts as an effective power supply source, mega solar (PV) power can contribute significantly to the power system from

[27] "Biofuel Assessment Study in Lao PDR, Interim Report: Lao Institute for Renewable Energy (LIRE)," for Department of Electricity (By Robert, Rietzler, Vilavong, Gaillard), November 2009

the viewpoint of not only renewable energy, but also ensuring an effective power supply capacity.

1) Addressing potential technical issues resulting from introduction of large-scale photovoltaic (PV) system

The output of a photovoltaic system is inherently unstable due to weather. The proliferation of large photovoltaic systems could disrupt the grid to which they are connected in the following ways.

(a) Distribution grid voltage disruptions

A large-capacity PV system could disrupt the voltage of the grid to which loads are connected beyond the normal range of voltage regulation.

(b) Deterioration of electrical grid stability

A sudden disruption of the electrical grid system, caused by lightning or separation of loads, could lead to progressive separation of large-scale PV systems from the network, creating a demand and supply discrepancy. This could potentially lead to a major blackout in the grid.

(c) Supply and demand unbalance

A rapid change in the outputs of large-scale PV systems, caused by sudden changes of weather, could cause unbalanced supply and demand in the grid. This might lead to an unacceptable frequency disruption if the gap is outside the range that is adjustable within the existing electrical network system

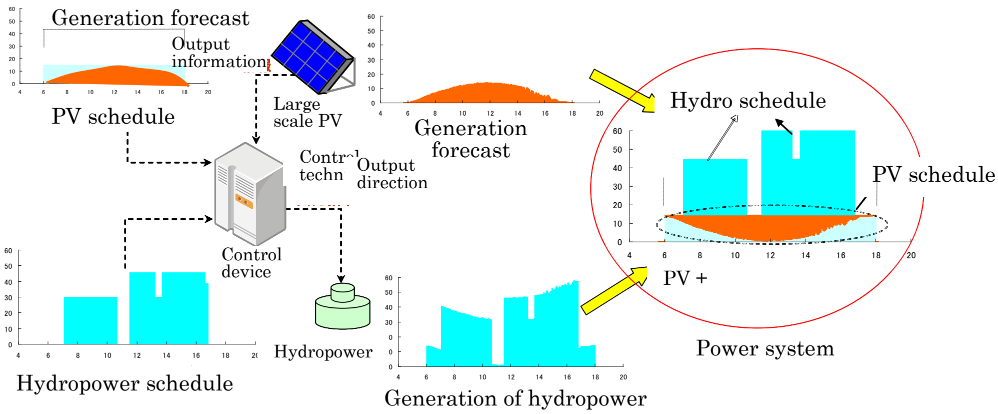
The above potential technical problems associated with connecting large-scale PV systems to the grid are being investigated in Japan to prepare for large-scale PV power introduction in the future. On-going development and demonstration of distribution grid voltage regulation includes the use of Static Voltage Compressor (SVC), Static Voltage Regulator (SVR), and Power Conditioner (PC). Deterioration of the grid is to be overcome using a PC with a stability control capability. Necessary development work, experiments, and evaluations are in progress. Supply and demand imbalance is to be controlled by frequency fluctuation reduction technology, which combines interactive operation of pumped storage power stations and batteries. Large-scale PV systems could be operated under a PV operation program now being developed. This takes into account expected PV outputs from weather forecasts and other factors.

2) Combined use of mega solar PV and reservoir-type hydropower plant

Power output of mega solar system varies depending on weather conditions. The power output required by commercial-scale customers such as factories is quadrilateral shaped (light blue color) as shown in the figure captioned “PV schedule.” However, actual generation is expressed by a shape (orange color) that is affected by weather. This is a demerit of PV, even though customers would like to use solar energy with a high tariff. If the system has hydropower plants with large reservoirs, this demerit of PV can be solved or mitigated by combining hydropower with a reservoir and a large PV system as shown in Figure 3.3-4.

This is a combined operation method for reservoir-type hydropower plants and large-scale PV plants through information transmission between the two plants (figure to left). This system (a) formulates the required operation pattern of the PV power plant in advance using weather forecasting technology, (b) selects part of the schedule of PV and hydropower power plants, and automatically adjusts their actual operation to compensate for output variations of PV plants (figures to right and at center). Introducing this method further improves the value of large-scale PV systems.

Abundance of hydro hydropower and solar power resources in Lao PDR makes this approach an attractive option.



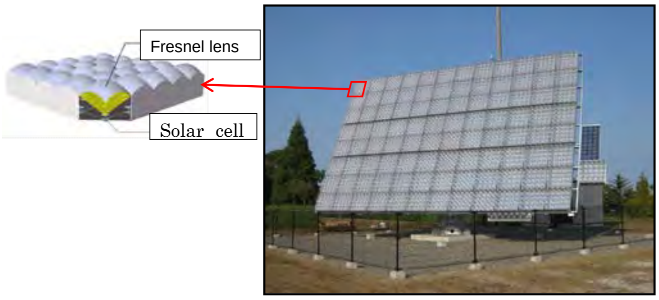
Source: J-Power

Figure 3.3-4 Effective Use of Mega Solar PV and Reservoir-type Hydropower Plant

3) Solar-tracking PV systems

As shown in Figure 3.3-5, this is a type of PV system in which a tracking mount rotates slowly to track the orbit of the sun and collects as much solar energy as possible for the entire period of operation. Solar energy is collected by collecting lenses and is captured in high-efficiency stacked PV modules placed in a tubular vessel. Efficient solar energy collection with collecting lenses permits large reductions of cell areas otherwise needed.

Future technological advances are expected to result in large reductions of system cost and further improvements to generation efficiency. Although there are only limited examples of the system in Japan, manufacturers state that its generating efficiency is higher than conventional systems. At present, some businesses, which are planning full-scale introduction of the system, are undertaking demonstration and other preparatory work to increase system capacity.



Installed capacity: 151 kW (21.6 kW×7unit)

Source: J-Power

Figure 3.3-5 Solar Tracking-type PV Systems

(2) Wind power

Many advanced technologies are used for wind power systems, and wind energy evaluation method and small-scale wind turbine are described in this report considering the wind power situation in Lao PDR.

1) Wind energy evaluation method

It is important to determine the candidate area and to estimate the energy produced by wind power. Then potential project sites are selected in a candidate area after evaluating the estimated wind energy at the site. To estimate the amount of wind energy, wind speed and wind direction have to be observed for a certain period at the site in the candidate area. Installation of a large number of observatory stations in the candidate area makes observation data and its analysis more accurate. However, the number of observatory stations is limited due to budget constraints. Therefore, the wind energy evaluation method is important. In addition, wind speed is affected greatly by topography, and a quantitative evaluation of wind conditions is necessary, taking into account topography, especially in mountainous areas such as those in Japan. In particular, average wind speed at the height of a wind turbine and annual energy generated are analyzed using data on land utilization and various meteorological data. Advanced technologies employing the Numerical weather prediction (NWP) method and GIS information are useful for analyzing wind power potential.

Because the wind potential in Lao PDR exists in a mountainous area along the border with Vietnam, knowledge and experience of Japan can contribute to the project in Lao PDR.

2) Small-scale wind turbines

It has been recognized that small-scale wind turbines (1 kW-10 kW) are not yet suitable for practical application with respect to economy, technology, safety, construction, maintenance, and operation. Technological innovation has been pursued to improve economy and achieve cost reductions.

Recent advances in fluid dynamics, digital and control technologies, and new materials, and their combinations, have increased performance and reduced costs. More specifically:

(a) Even in light winds rotation is started by maintaining deep blade angles against the wind, and an integrated flywheel improves the stability of turbine output and stabilizes power supplied.

(b) The turbine is equipped with an automatic blade angle adjustment capability, which allows stable power generation to be influenced less by wind-speed variations.

(c) Turbine noise levels are kept low. The blade has sufficient strength to withstand very strong winds up to about 60 m/s and to prevent scattering of damaged blade parts if it is broken by impact from a flying object.

(d) Surplus generator output is rectified and voltage is adjusted by a control unit and charged batteries.

(e) Little maintenance is required, and is limited to replacing bearings and carbon brushes every 10 years, for example.

There are local communities located far from the main electricity networks in Lao PDR. Because electrification of such communities requires substantial resources for network extension, electrification using the kind of technology introduced here would be suitable for off-grid electrification. It can be conceptualized from a wind power resources map (Figure 3.3.3) that there are suitable villages in off-grid areas for using wind power.

(3) Small hydropower

There are many advanced small hydropower technologies in Japan, and a micro-tubular turbine is introduced in this report.

(a) Micro-tubular turbine

A power generation system with a low water head can generate 3 – 250 kW using energy from a pressure-reduction valve, irrigation channel, etc. The micro-tubular turbine can be used with water supply and sewerage systems, water released from dams, and irrigation channels. The applicable ranges for plant discharge and water head are 0.1 - 3.0 m^3/s and 2 – 3 m, respectively. The plant discharge can be adjusted over a wide range using a movable runner vane. Because the turbine is inserted into an existing steel pipe directly as shown in Figure 3.3-6 (photo to left), the construction cost of the small hydropower plant can be kept down.

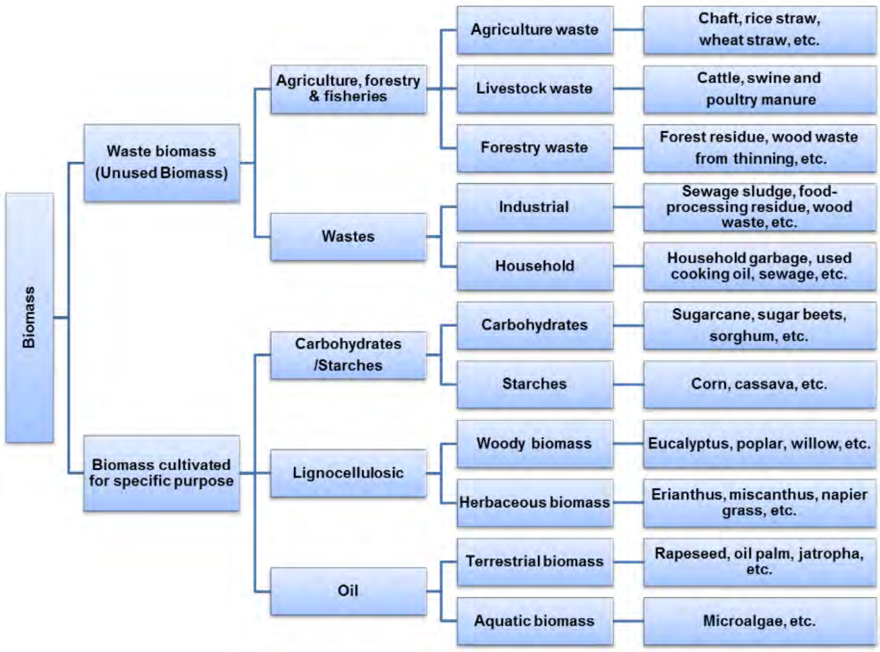
Source: New Energy Foundation

Figure 3.3-6 Micro-tubular Turbine

(4) Biomass

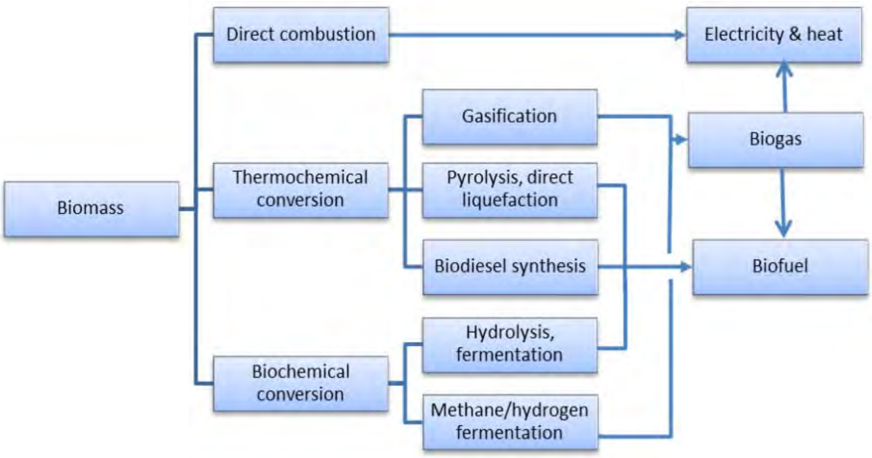
1) Biomass classification and energy conversion technology

There are many types of biomass from a wide range of sources and with various properties. From the perspective of bioenergy utilization, biomass can generally be divided into waste biomass (unused biomass), which uses byproducts from primary industries such as agriculture and forestry and the food industry, and cultivated biomass, which is produced for energy utilization (See Figure 3.3-7). Energy conversion technology for biomass can generally be divided into direct combustion, thermochemical conversion, and biochemical conversion as shown in Figure 3.3-8.



Source: NEDO

Figure 3.3-7 Biomass Classification

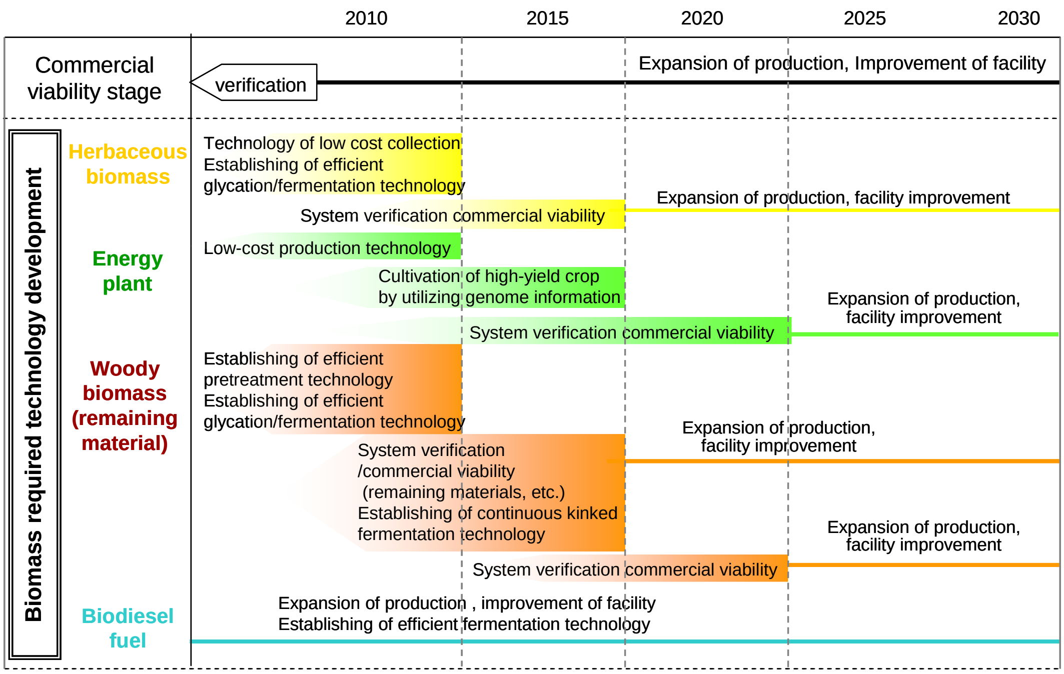


Source: NEDO

Figure 3.3-8 Energy Conversion Technologies

2) Technology Innovation Program for Application to Biofuels

In 2010, the Ministry of Economy, Trade and Industry (METI) and the Ministry of Agriculture and Fisheries (MAF) of the Japanese government started a joint program called the Technology Innovation Program for Application to Biofuels. This program involved concrete targets, technology development, and road map for cellulosic biofuel production as shown in Figure 3.3-9. The following technologies are part of this program.



Source: METI

Figure 3.3-9 Technology Innovation Program for Application to Biofuels

(a) Improving biomass cultivar and cultivation technology for energy plant

The program for an energy plant consists of low-cost production technology/efficient saccharification/establishing fermentation technology (target year 2010), cultivating high-yield crops using genome information (target year 2015), and system verification commercial viability (target year 2020). The program focuses on research on high-yielding varieties using genome information. In particular, there are high-yield plants having characteristics such as perennial/high environment adaptability/ease of cultivation that can be grown on low-quality land with acidic soil and with less fertilizer. Cultivar improvement is being carried out for the most suitable energy plants such as sugar beet, potato, sorghum, ocarina, sugarcane, and corn. Cultivar improvement is carried out on the basis of genome research, for example, a cultivar able to contain plio-sugar that is disease resistant, and has a second life after harvesting.

The Road map of REDS gives high ratings to jatropha, Montana, oil palm, cassava, and sugarcane, which were selected mainly on the basis of the study[28] results shown in Appendix 3.4. A moderate rating rather than a high rating was given to sweet sorghum. Sweet sorghum cultivar grows to a height of more than 4 m, and is a promising feedstock for ethanol requiring large quantities of sugar and cellulose. Cultivar improvement of sorghum is now being conducted in Japan, and it is advisable to add the plant as a candidate energy crop in the REDS road map.

(b) Bioethanol production from woody biomass

To further diffuse bioethanol, it is necessary to develop production techniques/engineering for bioethanol. Ethanol is produced from woody biomass (unused branches and leaves, waste material of paper manufacturing feedstock, trimmings of fast-growing trees), which does not compete with food. To efficiently produce low-cost bioethanol from woody biomass that does not compete with food, NEDO and private companies are developing a coherent production technology from cultivation to harvest/transportation/storage, glycation fermentation/distillation to bioethanol.

A test pilot plant can produce 250 - 300 liters of bioethanol by treating a maximum of 1 ton of woody biomass per day. As a result of test production, it is expected that commercial production of bio-ethanol will be started on a scale of several hundred thousand kiloliters around 2020, and production will increase further by 2030. This technology is in the validation phase and can contribute to the future development of energy in Lao PDR, which has extensive forest resources.

3) Agricultural biomass utilization system (cascade type)

Cascade-type biomass is used by urban neighborhood livestock businesses in Japan, and many organizations have joined the project. This project uses cascade-type technology combining conversion technology such as methane fermentation and carbonization composting.

Taking the example of the Yamada biomass plant[29] shown in Figure 3.3-10, energy is extracted from the main feedstock of agricultural byproducts such as livestock manure, food byproducts, rice straw, etc. The byproducts from the conversion step are used as fertilizer. After separating solids, about 5 tons of liquid (from about 100 cattle) a day is processed at a methane fermentation plant, which is the main facility. In this methane fermentation plant, cow excreta and food byproducts (liquid produced from vegetable waste) are mixed. Separated solids are used as fertilizer and returned to agriculture land.

Methane fermentation is carried out at a temperature of 3°C, and exhaust heat from a gas engine and carbonization boiler is used for heating. The concentration of biomass generated is 60%; however, separation enrichment of 98% and adsorptive storage is carried out because methane is used as an automobile fuel. The methane is used as fuel for agricultural vehicles and gas engines. It is also used for generating 25 W and as fuel for a carbonization boiler.

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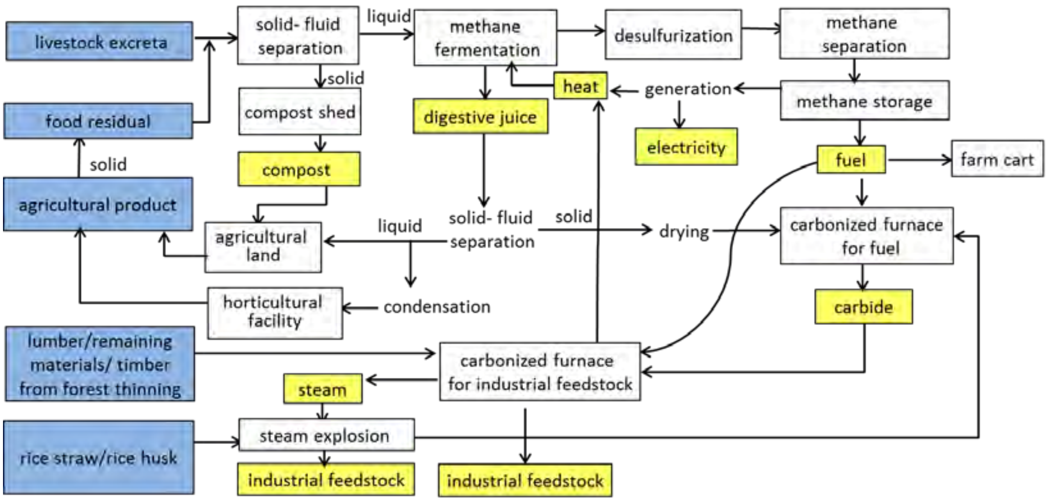
[28] "Biofuel Assessment Study in Lao PDR, Interim Report:" Lao Institute for Renewable Energy (LIRE), for Department of Electricity, November 2009

[29] The plant is owned and operated by WAGO Co., Ltd., which is an agricultural co-operative corporation.

Digestive fluid from the methane fermentation process is used directly as liquid fertilizer. Solids separated from fermentation residue are treated by carbonizing, and then used as fuel for industrial carbonization boilers. In the boiler, woody biomass in the local area is treated to carbonization by superheated steam of 300 – 400°C, and industrial feedstock such as pyroligneous acid is produced. This facility doubles with boiler and supply water vapor as a steam explosion facility. The steam explosion facility heats rice straw, rice husk, etc., with water vapor at elevated pressures and temperatures, which is suddenly released.

Large pig farms in Lao PDR are located in the vicinities of big cities, where the cascade type could be applied for energy generation.



Source: National Agriculture and Food Research Organization, Institute of Industrial Science, University of Tokyo; Ebara Corporation; Biomass energy, Yokoyama/Imou 2009

Figure 3.3-10 Biomass Plant Using Cascade System

(5) Basic concept for electrification of non-electrified villages

There are areas where electricity grids cannot be built due to cost effectiveness, etc. It is desirable to promote a system to use renewable energy to the maximum extent to electrify these areas. Promising renewable energies include solar power generation, small-scale wind-power generation, biomass power generation, biogas power generation, small-scale hydroelectric generation, small-scale geothermal power generation, and binary power generation (using solar heat, geothermal heat, etc.), etc. It is effective to choose from among these renewable energies considering individual characteristics of an area, and combine different kinds of energy.

Electrification depending only on solar power generation is being promoted. But, the volume of electricity generated is limited and there are many examples of failures. Therefore, power generation is required to be hybrid in nature. Furthermore, with these renewable energies, supply and demand need to be optimized by an Energy Management System (EMS) as shown in Figure 3.3-11. Introducing small-scale renewable energies opens the door to various possibilities. Using these energies in public facilities and accommodations such as hospitals, clinics, schools, and local government buildings, households (for light, battery charge of mobile phone, TV, and radio, etc.) and electric motorcycles is conceivable.

The biggest issue is to minimize O&M costs including initial cost and use of maintenance-free systems. To minimize costs, production in Asia is required, as well as adoption of generic components, and procurement of components through price competition, etc. Use of grants and active government support are effective. Horizontal development with revolving funds is important, as well as setting electricity tariffs that inhabitants of non-electrified areas can afford.

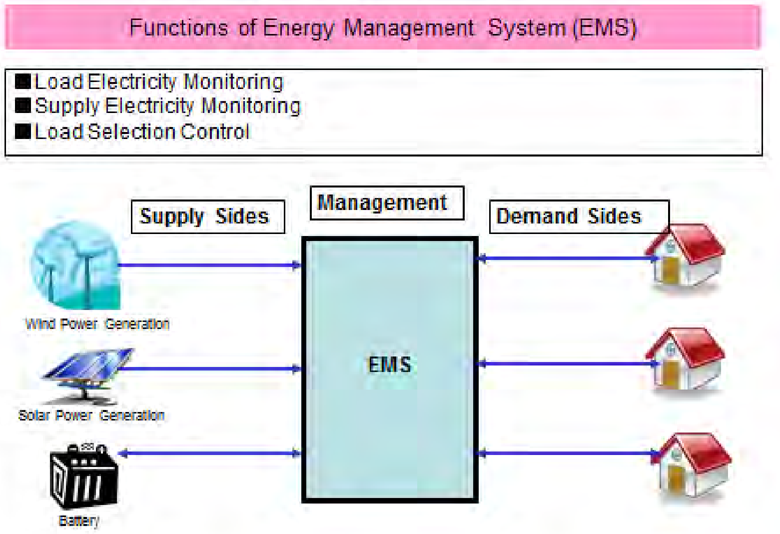


Figure 3.3-11 Functions of Energy Management System (EMS)

(6) Quality control/management technology for biofuel

To achieve the target of REDS for biofuel production, biofuel produced in Lao PDR must meet the required quality standards. Consequently, MEM has started to standardize biodiesel and to carry out marketing campaigns and information dissemination. ADB supports the GoL movement through its activities.

Research Center for New Fuels and Vehicle Technology/National Institute of Advanced Industrial Science and Technology provide the working group. It aims to introduce high-quality biodiesel fuel to the East Asia region as a project of the Economic Research Institute for ASEAN and EAST Asia (ERIA).

The WG published the "EAS-ERIA Biodiesel Fuel Trade Handbook 2010," which described the production, trade, and use of high-quality biodiesel fuel. The handbook has the following features:

(a) It is applicable to the East Asia and ASEAN region

(b) It effectively distributes information

(c) It is anchored by fatty acid methyl ester (FAME), which is first-generation biodiesel

The WG has the target of establishing a quality control technique/management method to reflect the technology in the handbook in the actual market.

3.3.6 Preliminary study on model projects

Model projects on mega solar (PV) power, wind power, small hydropower, and biodiesel production are studied at a preliminary level.

(1) Mega solar (PV) power

The site is located in Savanakhet province as shown in Figure 3.3-12 and along Route 9. Solar radiation at this site is high because the area is located between Thakek and Pakxe, as shown in Figure 3.3-2 (Section 3.3.3). Table 3.3-10 shows the project features for an installed capacity of 1 MW. The levelized unit cost is estimated to be 0.21 USD/kWh, and it should be reduced to an assumed price level of 0.07 USD/kWh by appropriate measures for project development.

Table 3.3-10 Palan Solar Power Project

Location	Savanakhet Province
Installed capacity:	1 MW
Average solar irradiation	5 kWh/m^2/day
Plant factor	21%
Annual energy production	1.84×10^6kWh
Construction cost	3 MUSD
Construction period	0.5 year
O&M cost	0.03 MUSD/year
Service life	20 years
Levelized unit cost	0.21 USD/kWh
Transmission line	22 kVA line available
Road availability	Route 9
Land acquisition	government owned

Figure 3.3-12 Location Map of Mega solar and Wind Power Sites

Note: The planned site of the PV plant is beside Route 9 and the land is Government owned. Transmission line of 22 kV is available along the road.

Figure 3.3-13 Site of Mega-Solar Project

(2) Wind power project:

The site is located in Khammouane province as shown in Figure 3.3-12 along Route 12. This area was selected for the following reasons.

(a) Wind conditions are expected to be good because wind velocity might be more than about 6 m/s, which is the lower limit for wind power operation as shown in Figure 3.3-3 (Section 3.3.3).

(b) Considering the possibility of using a large-scale wind turbine, Route 9, which is two-lane road, is available.

(c) As availability of a transmission line affects a wind power project's viability, the possibility of using a 22 kV transmission line contributes to the project.

(d) The government owns the land on which the wind logger is installed. Although the surrounding area does not belong to the government, it is sparsely inhabited, so it is judged that the project does not pose serious issues (MEM comment).

Table 3.3-11 shows project features for an installed capacity of 1.2 MW (600 kW, 2 units). The levelized unit cost is estimated to be 0.14 USD/kWh, and it should decrease to the assumed price level of 0.07 USD/kWh by applying appropriate measures for project development. MEM has been monitoring wind velocity at the site for two years, and the results will be reflected for further study.

Table 3.3-11 Lakan Wind Power Project

Location	Khammouane Province
Installed capacity:	1.2 MW
Average wind speed	5.8 m/sec
Plant factor	20%
Annual energy production	2.1×10^6kWh
Construction cost	2 MUSD
Construction period	1 year
O&M cost	0.02 MUSD/year
Service life	20 years
Levelized unit cost	0.14 USD/kWh
Transmission line	22 kVA line available
Road availability	Route 12
Land acquisition	N/A

Figure 3.3-14 Wind Data Logger Station and Project Site

(3) Small hydropower

1) Nam Hong hydropower project

The site is located in Vienthong district, Bolikhamxai province. The site was selected from economic viewpoints, and most of the land is owned by the government. MEM has the right to approve ADB projects. The transmission line is connected to an existing 22 kV transmission line. The installed capacity is 12 MW with a design flow of 8.3 m3/s and net head of 224 m. Table 3.3-12 shows project features and the levelized unit cost is estimated to be 0.032 USD/kWh, which it is lower than the assumed price level 0.07 USD/kWh.

Table 3.3-12 NH Hydropower Project

Location	Bolikhamxai province
Installed capacity:	12 MW
Average river flow	12 m^3/s
Plant factor	76%
Annual energy production	80×10^6kWh
Construction cost	23 MUSD
Construction period	2 years
O&M cost	0.03 MUSD/year
Service life	35 years
Levelized unit cost	0.032 USD/kWh
Transmission line	28 km
Road condition	9 km
Land acquisition	Considered

Note: Some figures above were adjusted by JICA Study Team

Source: MEM

Figure 3.3-15 Layout of Nam Hong Project

2) Project risk and application for hydropower potential study

An open canal about 11 km long is constructed along the mountain slope as shown in Figure 3.3-15. Although the construction cost is low, the layout might have some risks for the following reasons.

(a) Weak points of structure

- Landslide: A long canal has a higher probability of experiencing landslides. Once landslides caused by unexpectedly heavy rainfall occur, the canal might be damaged and the power plant will not be able to generate electricity for a long period during repairs. In Japan, during last five years, unexpectedly heavy rainfalls (rainfall intensity, volume, and period) have occurred often and many hydropower plants as well as roads connecting towns were damaged. It is expected that similar phenomena might occur at any time in Lao PDR because both countries belong to a climate area that is affected by monsoons, and because the geology of mountain areas mainly consists of thick weathered layers. Besides, such rainfall might be caused by global warming.
- Unequal settlement: Because a canal is long and geological conditions along the canal are not uniform, there is a possibility that the canal could be partially deformed by unequal settlement caused by weak geological conditions and poor construction. In this situation, water might leak, damaging the functions of the canal and ultimately suspending power generation. It is recommended to construct a road along the canal for operation and maintenance works.

(b) Alternatives to reduce risks

In the case of a project with a long canal, dividing it into two (or more) projects is an alternative to reduce anticipated damage to the canal. Shorter canals may reduce risks; however, the total construction cost for two (or more) sets of civil structures and electrical equipment would increase and affect the economy of the project.

(4) Biodiesel production project

A study was conducted on a biodiesel production project using Vernicia Montana (stone jatropha/Kao oil tree). A large part of northern Lao PDR has been affected by slash-and-burn cultivation, as shown in Figure 3.3-16.

The study was conducted with the following conditions

(a) The oil production company builds a plant to press Montana nuts and produce crude oil, from which B100 is produced. B10 is produced by mixing 10% B100 with 90% diesel oil, which the company purchases (unit price; 7137 kip/l).

(b) The company purchases oil nuts collected by farmers.

(c) Young trees cannot produce berries at the expected level and the yield of the plantation is initially low; however, this condition is ignored in the study.

(d) Equipment cost is not considered because the cost accounts for a very small proportion of total production cost.

(e) Selling price of B10 is assumed to be 7137 to 9560 kip/l.

Figure 3.3-16 Slash-and-Burn Area in Luangpravang province

As a result of the study, annual cost is 35 MUSD, and annual revenue is 33 to 45 MUSD, depending on the selling price of B10, as shown in Table 3.3-13.

Table 3.3-13 Model Study on Biofuel Production

Location	Luangpravang Province
Name of plant	Vernicia Montana (Kao oil tree)
Biodiesel (B10) production	30,000 tons/year
Plantation area	4500 ha
Production of B10	
Production of B100	3,000 ton/year
Diesel oil	27,000 ton/year
Period of economic analysis	15 years(*)
Annual cost	35 MUSD
Annual revenue	33 - 45 MUSD

Note: * including preparatory period: 3 years

The example of the Yamada biomass plant is explained in 3.3.5(4)3). The model project is intended to produce not only biofuel but also by-products such as electricity, fertilizer, and activated carbon. The by-products contribute to making the project more beneficial and to improving the living conditions of farmers. From these points of view, the following studies should be conducted.

(a) Study of potential of Vernicia Montana nut production in slash-and-burn areas

(b) Feasibility study (FS)

- Project Company owns and operates all facilities from plantation to production of B10
- Project Company owns a facility to extract oil and sell crude oil to neighboring countries.
- Project Company does not own and operate any facility except the plantation, and sells oil nuts to neighboring countries.

3.3.7 Considerations for further study, and technical and financial assistance

(1) Review and Revision of REDS

The GoL announced the “Renewable Energy Development Strategy” (REDS) in October 2011 and is promoting preparations for renewable energy development in accordance with the road map of REDS. However, REDS has the following important underlying issues.

(a) The target share for renewable energy development is 30% by the year 2025. There is no rationale for the target share of 30% and share of each renewable energy source.

(b) Unrealistic values to evaluate capacity (MW) and investment (MUSD) are used in REDS.

(c) Because no the definition of “Potential” is given, confusion might arise in renewable energy policy-making.

REDS should be reviewed and revised at an appropriate time to make it more realistic by compiling updated data and more reliable study/investigation results.

(2) Considerations for further study

The projects below are candidates for technical and/or financial assistance, taking into account the underlying issues of REDS, trends of advanced technologies, and model projects.

1) Potential study

It is considered that most of the energy potential in Lao PDR exists in hydropower, solar power, and wind power. Because project development for on-grid supply is expected to be done by private companies, the potential study (possibly introduced) should have the role of supplying basic information to the private sector. Then, the private sector can find appropriate project sites and conduct detailed studies for project development. The information obtained by the potential study should also be used for the GoL to make a support system to develop RE. From these viewpoints, the following potential studies should be carried out nationwide.

(a) Small hydropower

It is recommended to conduct a potential study after examining the following basic concepts of waterway installation according to current site conditions and references below.

- Single development scheme with a long canal or divided development scheme with short canals
- Waterway structure with open-channel (or steel pipe) along mountain slope or through a tunnel

<Reference> Effectively using hydropower potential study

In the case of the first development stage for a main river, it is important to give high priority to development schemes that can use hydropower most effectively. Generally, schemes having high priority are medium- and large-scale hydropower development rather than small-scale hydropower development. Therefore, small hydropower is applied to developing tributaries of relevant main rivers and remaining unused water head after planning medium- to large-scale hydropower development. For example, it is assumed that there are two ways to develop the same river with a small-scale hydropower scheme and a medium-scale hydropower scheme, which has greater potential than the small-scale scheme. If the small-scale hydropower scheme is developed first, it is generally difficult to develop the medium-scale hydropower scheme as the second phase. Therefore, the potential study for small-scale hydropower should be conducted taking into account the potential study of medium- to large-scale hydropower.

(b) Solar power (PV) and wind power

A potential study is conducted to develop actual projects from the following viewpoints.

- Advanced technologies to evaluate solar (PV), and wind power such as Numerical Weather Prediction (NWP) method
- GIS information such as land utilization, national parks, etc.

(c) Biomass/biogas/municipal solid waste

The energy potential of each RE is reviewed and re-estimated from relevant information on the production of agricultural products and livestock and populations of major cities in the future (for example in 2025).

2) Feasibility study

(a) Small hydropower projects for on-grid

FS should be carried out for prospective projects identified in the potential study.

(b) Mega-solar (PV) power and wind power projects for on-grid

FS should be carried out for model projects. The electric power system of EdL faces the problem of insufficient power supply capability in the dry season. Although the scale of model projects such as solar (PV) power and wind power is small, development can contribute to the power system. Concerning wind power, because two-year records of wind velocity are required for FS, a model project can use the two years of data observed with a wind data logger at a site.

(c) Biofuel production:

Potential area (slash-and-burn area) to plant Vernicia Montana trees should be investigated first. Then FS or Pre-FS should be carried out for the model project; the study level depends on data collected. The FS should include the following cases.

- Project Company owns and operates all facilities from plantation to production of B10
- Project Company owns a facility to extract oil and sells crude oil to neighboring countries.
- Project Company does not own and operate any facilities except the plantation, and sells oil nuts to neighboring countries.

3) Rural electrification for isolated villages (for off-grid)

The FS should be carried out for hybrid systems by adopting solar (PV), micro-hydropower, small wind power, etc.

4 Energy Statistics and Database

4.1 Current Situation of Energy Statistics in Lao PDR

Lao PDR's energy statistics were collected and compiled by the former Department of Electricity (DOE) of the Ministry of Energy and Mines (MEM). Data on production, importation, export, and consumption of coal, oil, electricity, and biomass comprise current energy statistics in the country. The data coverage is from 1990 to 2010. These data were collected from relevant organizations such as Department of Mines (DOM), association of oil companies, Lao State Fuel Company (LSFC), airline company, Electricité du Lao (EdL), etc.

4.1.1 Coal

Data are obtained from the DOM and also from MEM. These data include production from each coal-producing field and corresponding gross calorific values. Exports and deliveries to local consumers are also available from the DOM. Coal imports are also collected. However, gross calorific values of imported coal are not yet available.

4.1.2 Oil

Oil data are collected by DOE from the association of oil companies in Lao PDR (Lao Petroleum and Gas Association), the Lao State Fuel Company (LSFC), a 100% state-owned corporation responsible for importing oil products and distributing them to local consumers, and Air Lao, the airline company of Lao PDR. Available data are imports and sales to various consumers including those to international and domestic aviation. Data on stocks are not collected by DOE.

4.1.3 Electricity

Electricity data are obtained by the DOE from Electricité du Lao (EdL), the country's state-owned electric power utility. These data include production, exports, sales and losses. Data of electric companies not affiliated with EdL or Export IPPs could have been reported directly by these IPPs to the DOE.

4.1.4 Renewable Energy

Lao PDR's data on renewable energy only cover hydro and biomass, which comprise only fuel wood and charcoal. There are indications of the use of bagasse for energy purposes in a sugar mill in the country, but information on this are not available. Data on production of electricity from solar and wind energy are also not available.

The methodology for estimating sectoral consumption of biomass and the department of MEM that makes the estimates are not clear.

4.1.5 Energy Balance Tables

From the above data, annual energy balances are produced with the assistance of the Energy Data and Modeling Center (EDMC) of the Institute of Energy Economics, Japan (IEEJ) as part of its role in implementing Energy Supply Security Planning for the ASEAN (ESSPA) project. When converting physical to energy units, the EDMC uses the following calorific values:

- Coal: weighted average of net calorific values of coal produced from each field
- Oil: typical densities and net calorific values used by the International Energy Agency
- Electricity: 860 kcal/kWh
- Biomass: typical net calorific values used by the International Energy Agency

At present, energy balance tables from 1990 to 2010 are available. These energy balances are fed back to the DOE for review and use. A graph of Lao PDR's total primary energy supply (TPES) and total final energy consumption (TFEC) obtained from the energy balances is shown in Figure 4.1-1. The unusual data in 2006, which shows that TFEC is larger than TPES, is due to a major statistical discrepancy during that year.

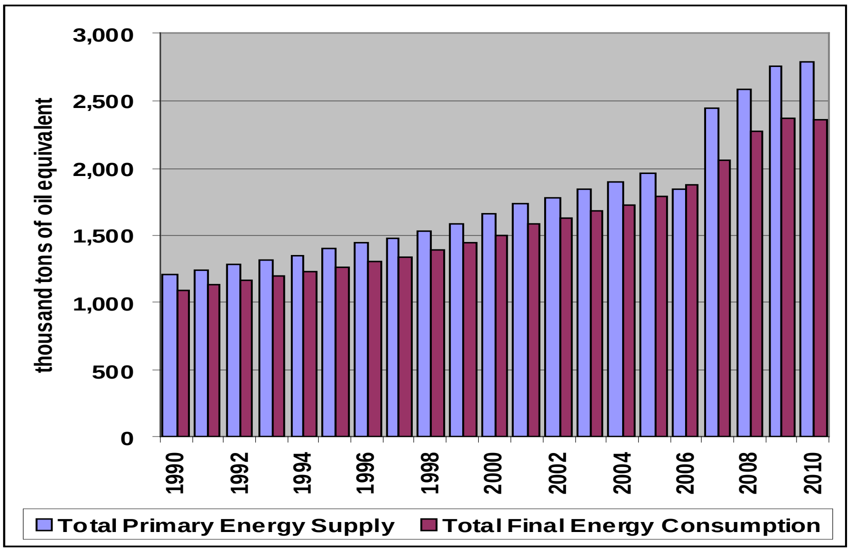


Figure 4.1-1 Total Primary Energy Supply and Total Final Energy Consumption

4.2 Issues Related to Energy Statistics

4.2.1 Inaccuracy of Energy Statistics

There are still several inaccuracy issues related to the energy statistics of Lao PDR. For instance, coal production and exports do not tally from 2006 to 2010, as shown in Figure 4.2-1 below. In 2006, the discrepancy was more than -600 thousand tons, indicating that reported exports exceeded production significantly. In 2007, the discrepancy was 200 thousand tons, showing possible underreporting of exports during the year. There is still a need to reconcile the data.

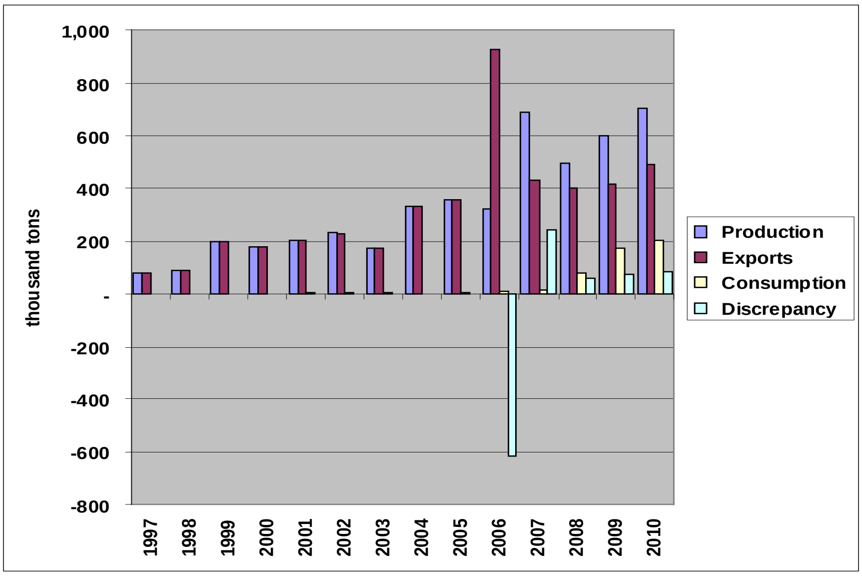


Figure 4.2-1 Coal Production, Exports, and Consumption

Electricity data also have inaccuracy issues, despite the fact that there is only one source in Lao PDR, EdL. Available data from the DOE have no record of electricity losses from 1990 to 1999. As a result, the discrepancy between supply and demand during these years varied from 24.1% to 35.0%. From 2000 to 2010, data on electricity losses became available and ranged from 2.0% in to 9.4%. Discrepancies were also smaller during this period at 2.1% in 2003, -13.4% in 2000, and 13.4% in 2010. These supply-demand discrepancies are shown in Figure 4.2-2.

Judging from electricity losses during the period 2000-2010, it can be inferred that losses during the period 1990 to 1999 may be in the range of 6% to 10%. It would be ideal if a review of the electricity data in EdL were carried out to revise the data accordingly.

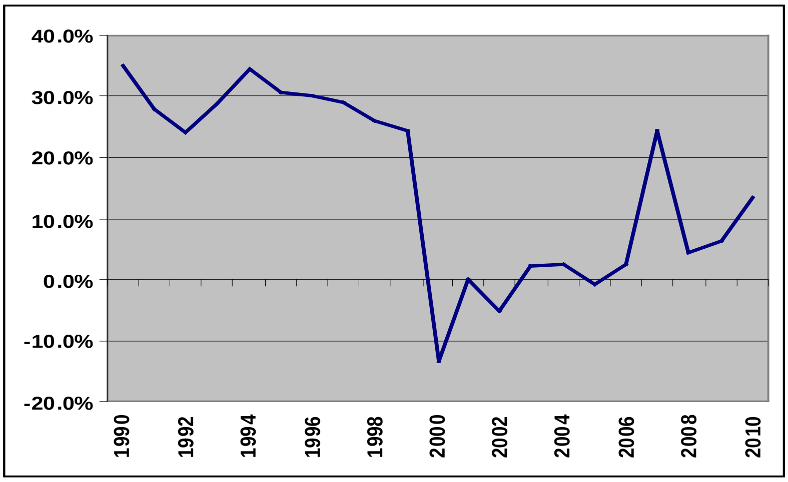


Figure 4.2-2 Annual Discrepancies of Electricity Supply and Demand

As with coal and electricity, there are also inaccuracies with oil data, particularly in the consumption of jet fuel. As can be seen in Figure 4.2-3 below, the consumption of jet fuel dropped significantly from 2006 to 2007, and again from 2008 to 2009. The DOE explained that this could be due to the change of data source. Previously, the source of consumption data for jet fuel was Air Lao. The source of information was changed from Air Lao to Lao Petroleum and Gas Association. It is, therefore, necessary that cross-checking of data from the two sources be carried out to correct this problem.

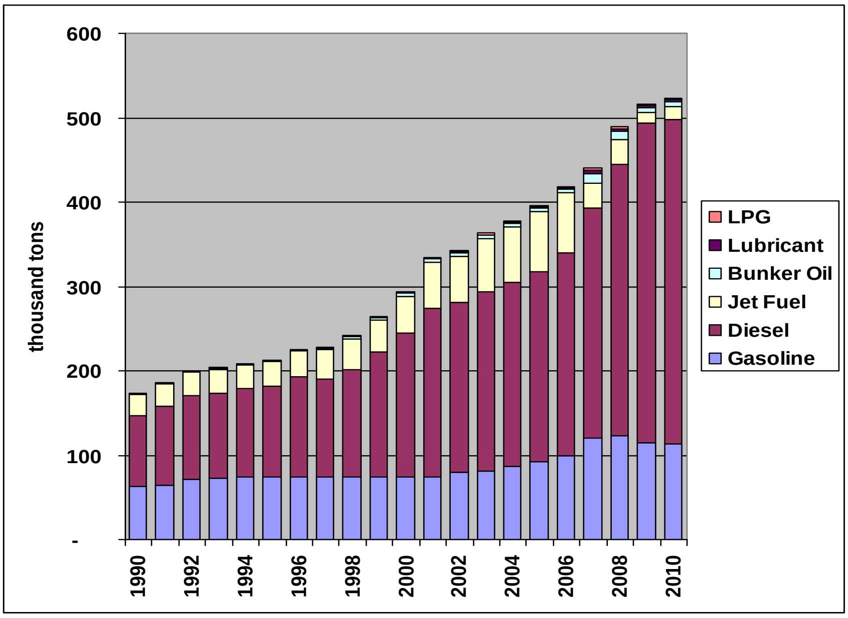


Figure 4.2-3 Consumption of Oil Products

4.2.2 Completeness of Energy Statistics

Another possible issue in Lao energy statistics is the completeness of data. While it can be expected that coal and electricity data are complete because the main source of these data are the state agencies that supervise and administer the sectors, it is also possible that not all data are reported by operating companies to these government agencies. An example of this is a coal producer failing to report production and sales to the DOM. For oil, there might be imports along the borders of the country that might not be recorded and collected.

4.2.3 Processing of Energy Statistics

The DOE can collect data from various sources, but is not yet able to process the data into energy balances. While processing data involves the simple exercise of unit conversion and tabulation, it would be necessary for the person processing the data to have a more detailed understanding of energy data (definitions of energy products and flows), as well as additional data requirements (calorific values and product densities) when processing the data. A short period of training for Department of Energy Policy and Planning (DEPP) staff on data processing would be necessary.

4.2.4 Storage and Use of Energy Statistics

Energy Statistics are very important inputs for energy policy analysis and formulation. Thus, an energy database that can be used by energy analysts for policy analysis and energy forecasting should be established and maintained in Lao PDR. The database should be stored with security features to avoid accidental revisions or deletions by data users. The database should have a query feature so that users can download the data they require conveniently.

4.3 Data Collection System

Energy data is important for preparing energy policy and developing energy demand forecasting models. It is impossible to make energy policies and energy demand forecasts without past energy data. Many developing countries in Asia have tried to collect energy data from energy consuming companies through regulation. However, this activity does not work well for the following reasons.

(a) No penalty for energy consumer
(b) Poor energy knowledge of reporter
(c) Complicated document form
(d) Lack of government staff
(e) Lack of announcement on regulation

In the following section, the Japanese data collection system is described.

4.3.1 Data Collection System in Japan

(1) Factories and business operators

According to Energy Conservation Law in Japan, factories and business operators such as department stores, schools, office buildings, and hotels (hereinafter referred to as factories) with an annual energy consumption exceeding 1,500 kl oil equivalent have to submit "Notification on Status of Energy Consumption" to The Minister of Economy, Trade and Industry (METI) by the end of April. Factories that consume energy of more than 3,000 kl are designated as Type 1 Designated Energy Management Factories and factories that consume energy of more than 1,500 kl and less than 3,000 kl are designated as Type 2 Designated Energy Management Factories by METI.

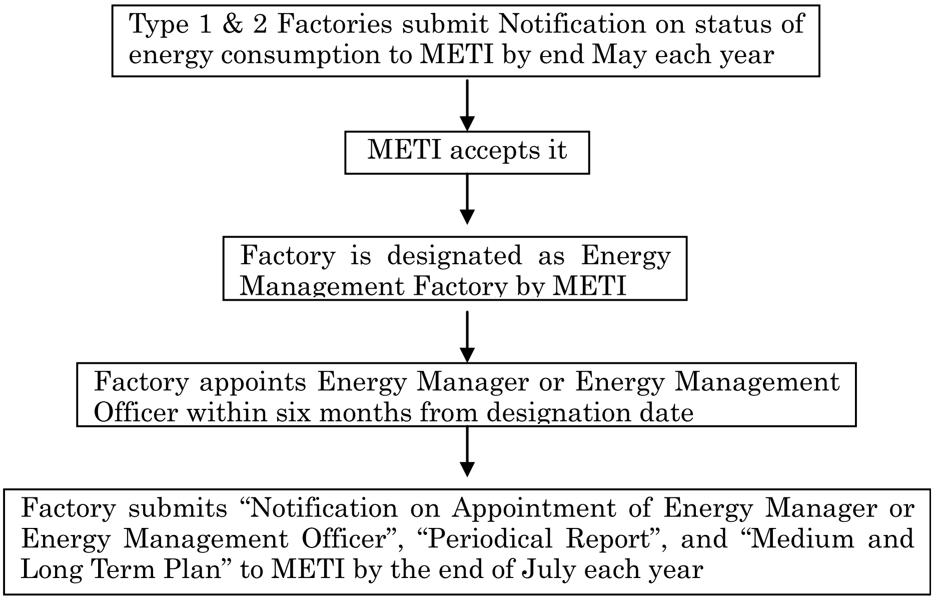
Designated factories have to appoint an Energy Manager or an Energy Management Officer depending on their type within six months from the designation date and submit "Notification on Appointment of Energy Manager" or "Notification on Appointment of Energy Management Officer" to METI by the end of July. Type 1 Designated Energy Management Factories submit

"Periodical Report" and "Medium- and Long-term Plan" and Type 2 Designated Energy Management Factories submit "Periodic Report" by the end of July every year to METI. Energy consumption data are contained in the "Periodic Report."

If Designated Energy Management Factories neglect their duty, the following penalties are imposed under the law.

(a) Neglect Notification of Status of Energy Consumption — Fine up to ¥500,000
(b) Neglect appointment of Energy Manager/Management Officer — Fine up to ¥1,000,000
(c) Neglect appointment of Energy Manager/Management Officer — Fine up to ¥200,000
(d) Neglect to submit "Periodic Report/Medium- and Long-term Plan" — Fine up to ¥500,000

Figure 4.3-1 shows Procedures of Designated Factories.



Source: METI

Figure 4.3-1 Procedures for Designated Factories

(2) Transportation

According to the Energy Conservation Law in Japan, cargo owners who order cargo shipping of 30 million ton-km or more are obliged to submit "Notification on Status of Shipping Volume" to the local office of METI by the end of April. A designated cargo owner also has to submit "Periodic Report" and "Energy Conservation Plan" to METI and its executive Minister. Contents of "Periodic Report" are as follows.

(a) Total shipping volume (ton), total transportation distance (km), and total freight (ton-km)
(b) Total energy consumption
(c) Actual implementation of energy conservation activities
(d) CO2 emissions

On the other hand, transportation business owners who exceed transportation performance of a certain scale (300 rolling stock cars, 200 trucks, 200 buses, 350 taxies, vessels of 20,000 tons, or aircraft of 9,000 tons) are designated as Designated Transportation Business Owners by The Minister of Land, Infrastructure, Transport and Tourism. Designated Transportation Business Owners have to submit" "Notification on Status of Transportation Capacity" to the District Transport Bureau by the end of April. Designated Transportation Business Owners also have to submit "Periodic Report" and "Energy Conservation Plan" to The Minister of Land, Infrastructure, Transport and Tourism. The contents of the "Periodic Report" are as follows.

(a) Energy consumption
(b) Energy intensity
(c) Actual implementation of energy conservation activities
(d) CO2 emission

(3) Residences and Buildings

Business and household owners who newly construct, reform, or extensively repair non-residential buildings and housing of 2,000m^2 or more are obligated to report their energy conservation measures to the supervising administrative body up to 21 days prior to construction work and submit "Periodic Report" every three years.
Figure 4.3-2 shows Flow from notification to periodic reporting.

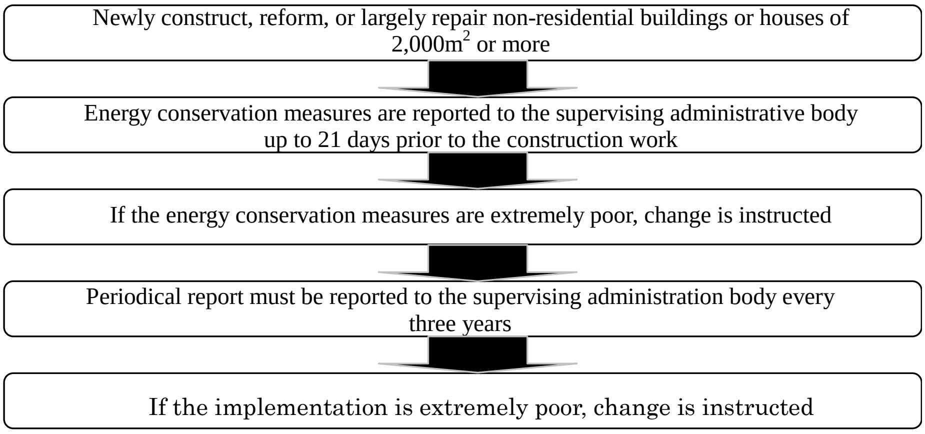


Figure 4.3-2 Procedures for Residences and Buildings

If Designated enterprises neglect their duty, the following penalties are imposed under the law.

(a) Energy intensity not improved	Order
(b) Neglect order	Disclose owner name
(c) No action without good reasons	Adjuration
(d) Neglect adjuration	Fine up to ¥1,000,000

(4) Data Collection

In Japan, designated enterprises submit periodic reports by filling report forms. After receiving the report, staff of METI input the data into a database. METI analyzes reports and gives instructions if necessary. The number of designated enterprises in 2010 reached 14,732. The above work is substantial. At present, the share of energy consumption of designated enterprises covers 90% of industrial sector and 13% of buildings. METI is planning to increase the share of buildings by 50%. Collection rate of periodic report and medium- and long-term plan is 100%.

To check reports, on-site inspection is carried out by outsourcing (Energy Conservation Center, Japan) in random order.

4.3.2 Estimation of Energy Demand

To make the national energy plan, it is necessary to analyze actual energy consumption in all sectors. However, it is difficult to obtain energy consumption data from all sectors. Therefore, energy consumption data are estimated using energy supply data from energy supply companies and energy demand survey. It is also necessary to request submission of energy supply data and energy consumption data from major energy consumers under the statistics law.

(1) Supply data

To estimate energy demand, supply data are important and easy to obtain from energy supply companies compared to energy consumption data. In the case of petroleum products, trade statistics are useful for improving accuracy because Lao PDR imports all petroleum products. Stock changes are important for estimating energy demand.

(2) Consumption data

In the case of industry, commercial, and transport sectors, enterprises that consume a lot of energy should be designated and submit their energy consumption on a mandatory reporting basis to the government. Based on energy consumption data from designated enterprises, total energy consumption is estimated.

4.3.3 Proposed Data Collection System in Lao PDR

(1) Short-term target

MEM can request energy statistics in the Statistics Law as mandatory reporting. If all energy consumers have an obligation to submit energy consumption data to the MEM, the MEM needs to handle huge quantities of data. It is difficult to establish the framework for handling data in a short time. Therefore, during the early stages, mandatory data submitters would mainly be large factories that consume a lot of energy. After that, the MEM can confirm the workload for handling and analysis, and expand target factories. Most commercial energy consumed by office buildings is in the form of electricity. These data can be collected from

EdL. Therefore, office buildings are not included in the short-term target. The transport sector is also not included in the short-term target because fuel consumption for the transport sector can be estimated from data of oil suppliers and import statistics.

The MEM should prepare the format of the periodic report for energy consumption. Periodic reports in Japan are complicated. We cannot propose the format of the Japanese periodic report because it is difficult to complete without experience. So, at the early stages, a simple format such as annual energy consumption by fuel alone is recommended. Then, information needed is gradually increased each year.

Regarding the data collection system, there is the option of adding an energy questionnaire to the existing questionnaire of the Ministry of Industry and Commerce (MIC) for factories. But, the collection rate of the MIC's questionnaire is still low.

(2) Long-term target

As a long-term target, a data collection system using an online system is recommended. As mentioned previously, in Japan, designated enterprises submit periodic reports by filling in a report form. Handling these data is a large task. To reduce data-handling work, we propose an online system for data collection. The configuration of the online system is as follows.

1) Enterprises access online system and input data through a menu screen
2) Enterprises that cannot access the online system submit a report to a local office by filling in a report form,
3) Local office inputs data using the online system.
4) Input data into Database Server at a central office.

Figure 4.3-3 shows the configuration of the online system for data collection.

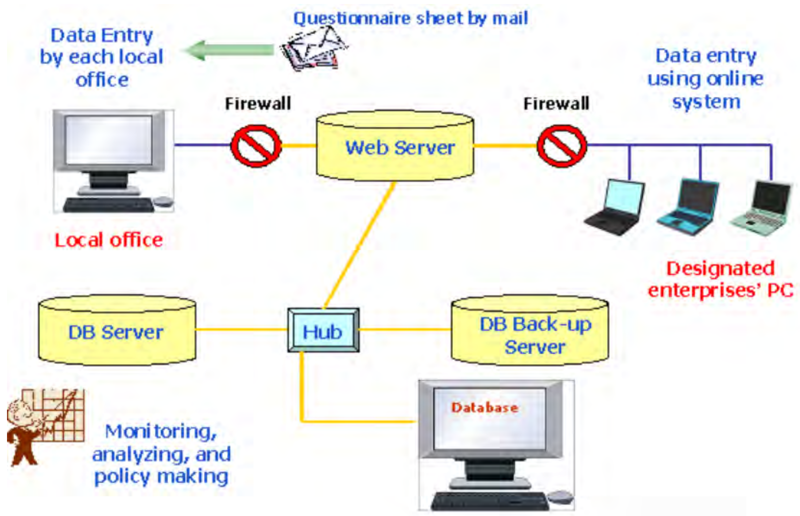
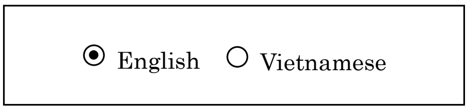


Figure 4.3-3 Configuration of Online System for Data Collection

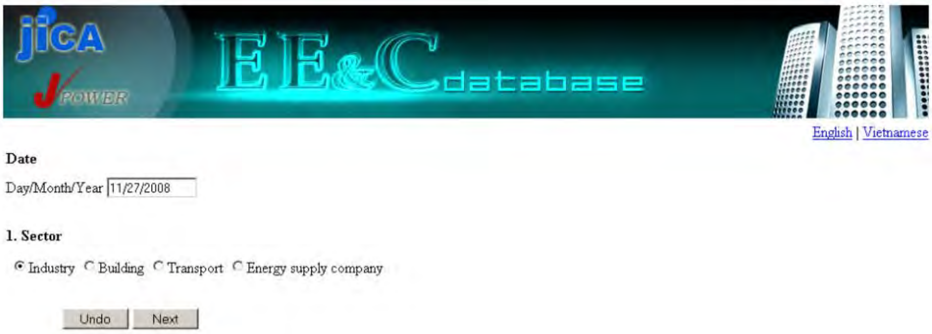
The following figures show the online system screen developed in JICA's Vietnam Project in 2009. This is a good example of an online system. This system was developed by a local consultant in Vietnam. The development cost of the system was only USD 6,330.

Applicants can select the language, English or Vietnamese. E.g.: English.

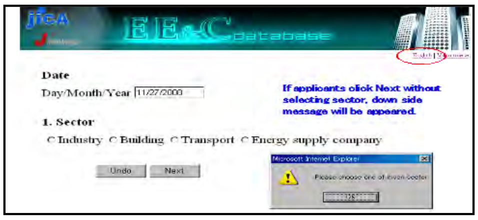


Anybody who has an ID and password can access the system and enter required data and information. ID and password are provided by Ministries:

Input date and chose one of given sectors. Applicants click only one sector. E.g.: Industry



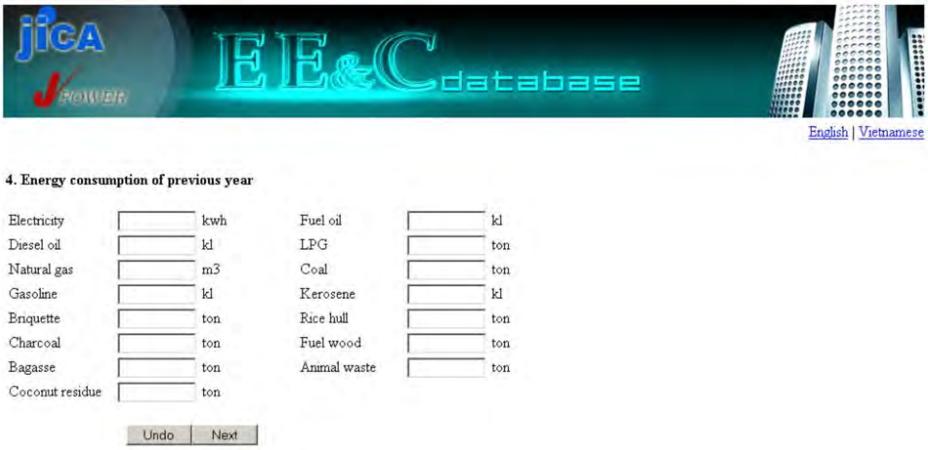
If applicants click Next without selecting one sector, a popup window message appears as follows.



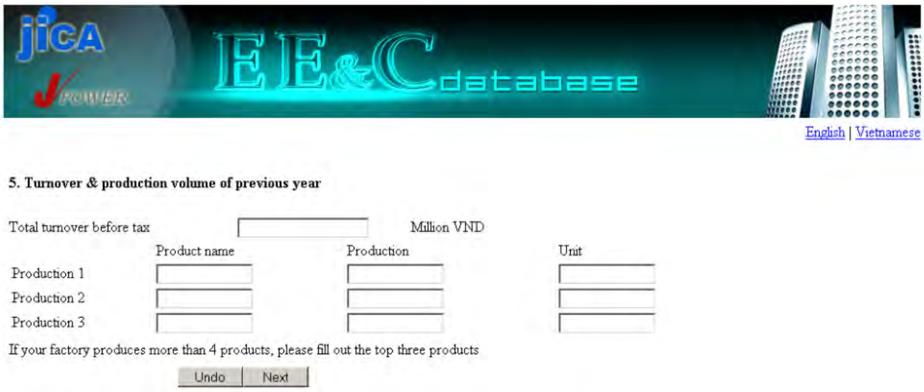
Applicants choose one of the given categories:

Applicants input information in each column:

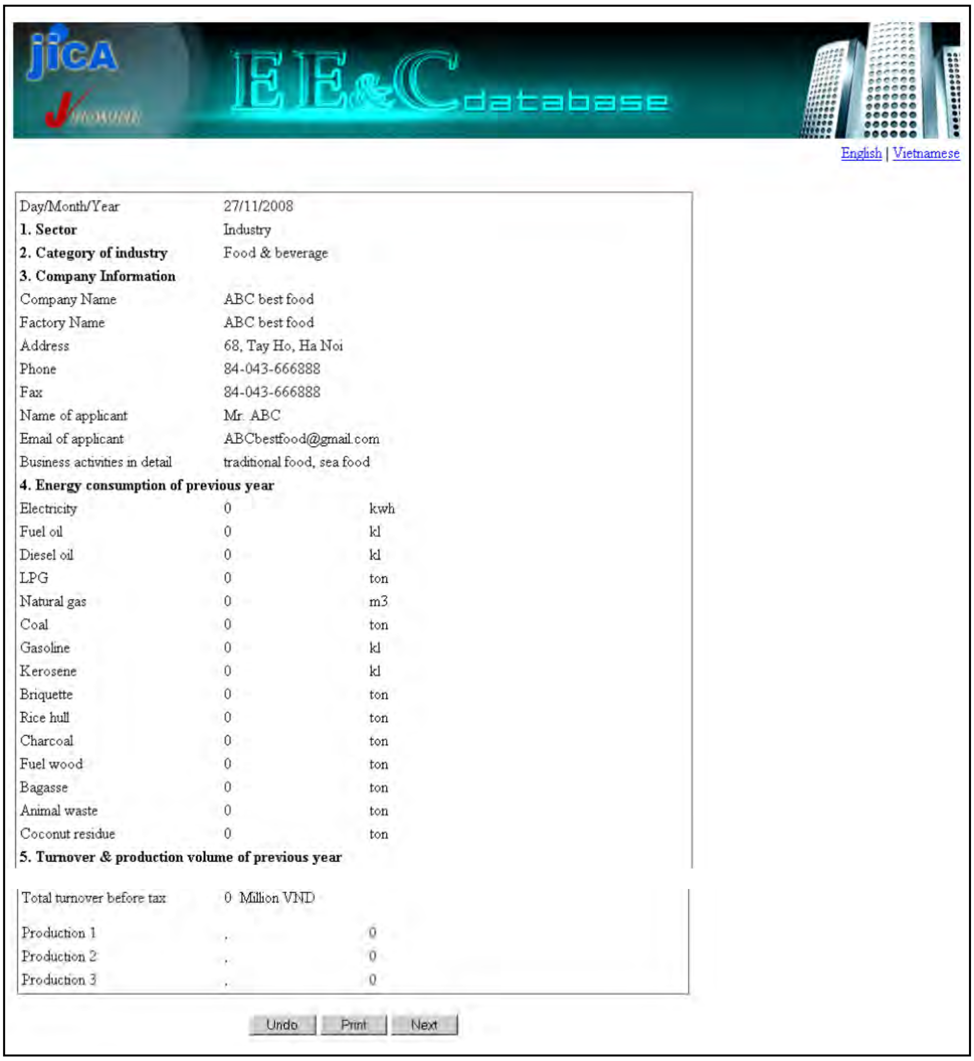
Applicants input information in each column:



Applicants input information in each column:

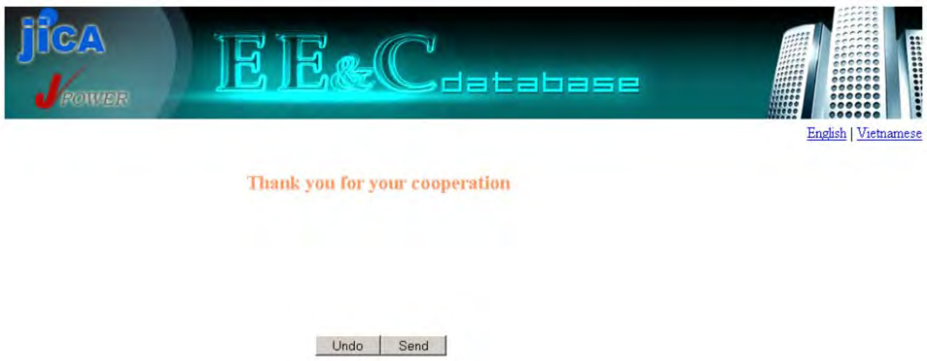


Checkout input data form. This is an example of an output data sheet. Applicants can print out data as a copy for their records:



Day/Month/Year	27/11/2008	
1. Sector	Industry	
2. Category of industry	Food & beverage	
3. Company Information		
Company Name	ABC best food	
Factory Name	ABC best food	
Address	68, Tay Ho, Ha Noi	
Phone	84-043-666888	
Fax	84-043-666888	
Name of applicant	Mr. ABC	
Email of applicant	ABCbestfood@gmail.com	
Business activities in detail	traditional food, sea food	
4. Energy consumption of previous year		
Electricity	0	kwh
Fuel oil	0	kl
Diesel oil	0	kl
LPG	0	ton
Natural gas	0	m3
Coal	0	ton
Gasoline	0	kl
Kerosene	0	kl
Briquette	0	ton
Rice hull	0	ton
Charcoal	0	ton
Fuel wood	0	ton
Bagasse	0	ton
Animal waste	0	ton
Coconut residue	0	ton
5. Turnover & production volume of previous year		
Total turnover before tax	0 Million VND	
Production 1	.	0
Production 2	.	0
Production 3	.	0

Send input data to database:



The same input data steps are used for the remaining three sectors: Building, Transport, and Energy Supply Company.

Applicants can review all input data in the database by clicking the "Click here to review input data" link at the top of the page. All records are temporary as shown below:

Applicants also can use Export to Excel button to export data in Excel format.

4.3.4 Collaboration among Ministries and Relevant Organizations

Energy data are collected by the MEM from other ministries and organizations. It is necessary to collaborate with other organizations under the regulation. At present, data collection is not legally binding. Energy data and economic data are useful for not only the MEM, but also other ministries and organizations for analyzing the current situation and preparing future plans. Data are the property of the country. Data sharing contributes to the development of the country. Data should be disclosed to interested users using a website.

4.4 Database System

4.4.1 Overview

The proposed system comprises data collection system (discussed in previous section), data integrity check system, structured data (data model) storage system, and data retrieve system (database management system or DBMS). The last two components are collectively called *database system* (Figure 4.4-1).

Data receivers can retrieve not only historical data but also processed data, such as supply and demand projections using *the Lao Energy Model* developed by the Institute of Energy Economics, Japan (IEEJ) in this study.

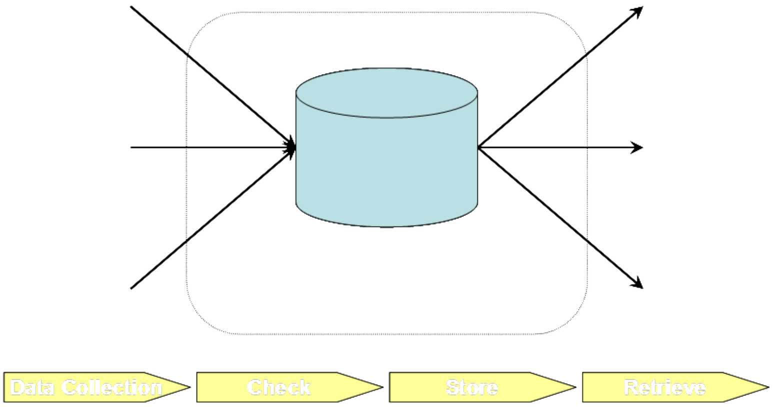


Figure 4.4-1 Overall System

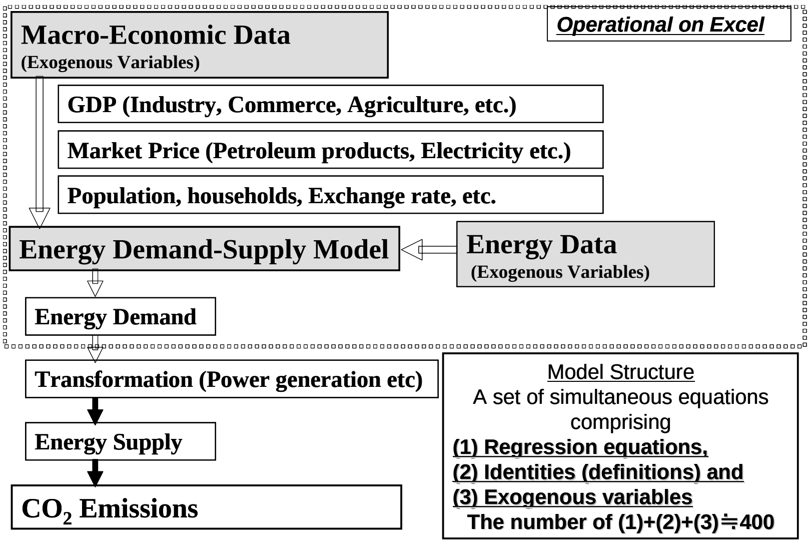
4.4.2 Functions of Energy Database

(1) Essential Functions Required of Energy Database

It is considered desirable for the energy database to have the following three functions: a function to enable construction of an energy demand forecast model, a function to facilitate expansion and modification of the model in the future, and a function to permit the general public to access energy data.

1) Function to Enable Construction of Energy Demand Forecast Model

To enable construction of an energy demand forecast model, the proposed energy database should be able to provide the model with essential inputs as illustrated in the chart below.



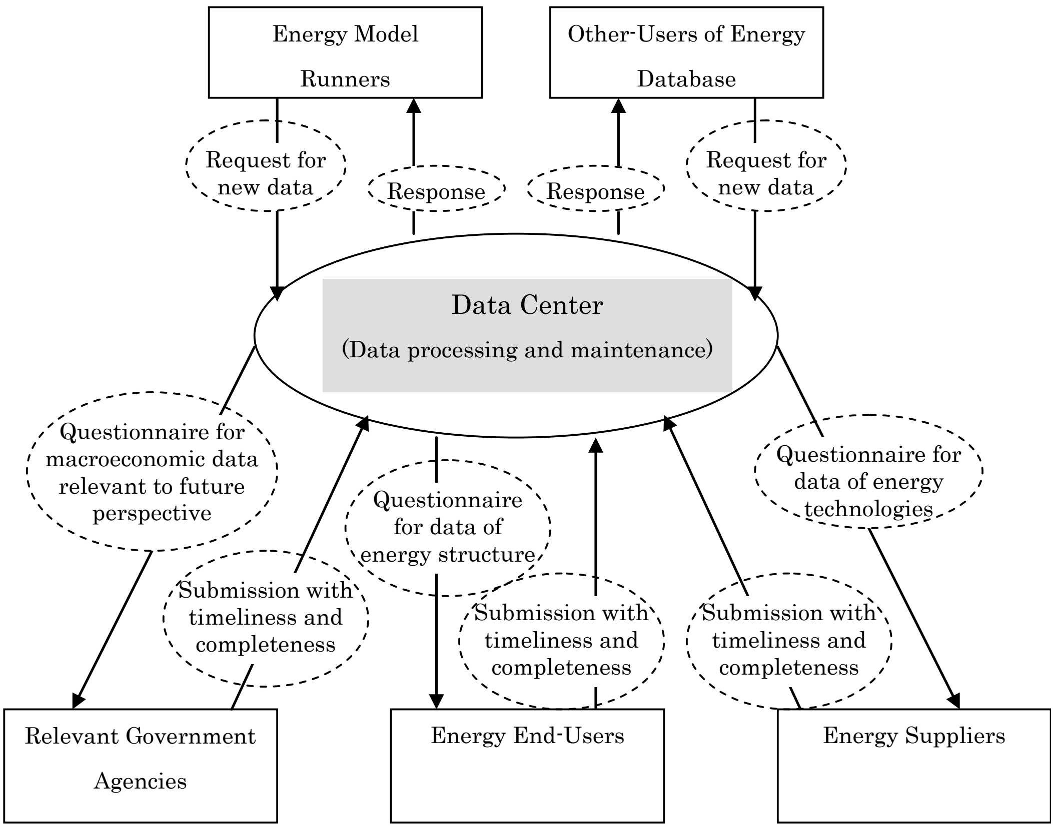
Source: JICA Study Team

Figure 4.4-2 Inputs Required by Proposed Energy Model

As can be seen from the chart, the energy model proposed by the JICA Study Team requires inputs including macro-economic data such as GDP (industry, commerce, agriculture, etc.), market prices (petroleum products, electricity, etc.), population, households, exchange rates, etc., and energy data. Providing all these data is a prerequisite for constructing the proposed energy model.

2) Function to Facilitate Expansion and Modification of Model in the Future

Naturally, an energy model should possess the quality of being easily expanded and modified when necessary with changes in global, regional, or national development trends. This requires the energy database to be sustainable and consistent, and be flexible and adaptable for frequent adjustment of the energy model. The key point of this characteristic is to establish an effective and efficient data submission mechanism. The essential elements and structure of this data submission mechanism are shown in the following chart, and the timeliness and completeness of data submission are vital elements of this mechanism.

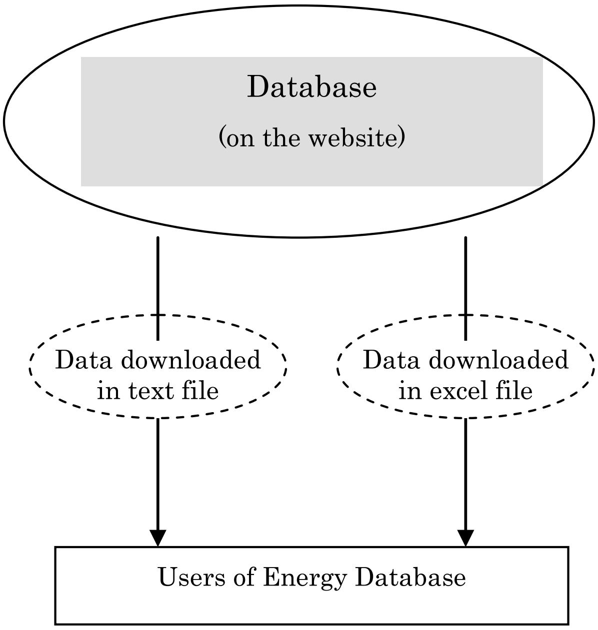


Source: JICA Study Team

Figure 4.4-3 Concept of Data Submission Mechanism

3) Function to Permit General Public to Easily Access Energy Data

In addition to the functions above related to the service for energy specialists, the proposed energy database should also be available to the general public. Therefore, user-friendly characteristics of the energy database are required so that an ordinary user can easily access data desired. Specifically, for example, it is desirable that the respective items of data can be easily identified on the website, and be easily downloaded in the form of text file or Excel file by a user from the website.



Source: JICA Study Team

Figure 4.4-4 Using Energy Database

(2) Examples of Energy Databases

Regarding the proposed energy database for Lao PDR, there are good examples for reference. The following are examples of databases set up and maintained by the International Energy Agency (IEA), the Expert Group on Energy Data and Analysis (EGEDA) of the Asia Pacific Energy Research Center (APERC) and the Institute of Energy Economics, Japan (IEEJ).

1) Energy Statistics of the Energy Data Center of IEA

An overview of the IEA energy database is presented below in terms of the structure of the database, data submission and processing mechanism, and data access method.

(a) Structure of Database

The IEA energy database consists of the following 14 types of data:

- Annual electricity
- Annual oil
- Annual gas
- Annual coal
- Annual renewables
- Quarterly coal, oil, gas, and electricity

- Monthly electricity
- Monthly oil
- Monthly gas
- CO2 emission
- Energy prices and taxes
- Projections: energy policies of IEA countries
- OECD energy statistics and balances
- Non-OECD energy statistics and balances

2) APEC Energy Data Base by EGEDA of APERC

The APEC Energy Database is managed and operated by the Expert Group on Energy Data and Analysis (EGEDA) set up by APERC during the 2nd APEC Energy Working Group (EWG) Meeting in March 1991 in Jakarta. The structure of the database and activities of EGEDA to improve the quality of the energy database are presented as follows.

(a) Structure of Database

The database consists of the following eight types of data:

- Annual supply and demand of commercial and non-commercial energy
- Electricity generating capacity
- Energy prices
- Quarterly energy supply
- Monthly oil (JODI) and natural gas
- Annual CO2 emissions from energy combustion
- Socio-economic data from World Development Indicators and national sources
- Energy related statistics

4.4.3 Proposed Database

The proposed database system has three major functions: data retrieval functions, data visualization functions, and simplified simulator functions.

The data retrieval function is the core function of the proposed system, which provides relevant data in response to a query. Using the data visualization functions, users can process retrieved data and draw charts or tables on the web browser. The resultant charts or tables can be downloaded and saved in a suitable format (Figures 4.4-5 and 4.4-6).

The third function—simplified simulator function, is a *light-version* of the energy supply/demand simulator based on *the Lao Energy Model* developed by IEEJ in this study. Users can manipulate various parameters to see the energy situation in the future.

(1) Data retrieval function

Figure 4.4-5 shows an example of a screenshot from the basic energy data retrieval system.

Users can easily find and choose the items they desire in the scroll boxes. In this example, the user chooses “Electricity” for the Energies category, “Imports” and “Exports” for the Production & Imports/Exports category, etc.

The resultant data can be displayed on the screen or downloaded in the relevant formats.

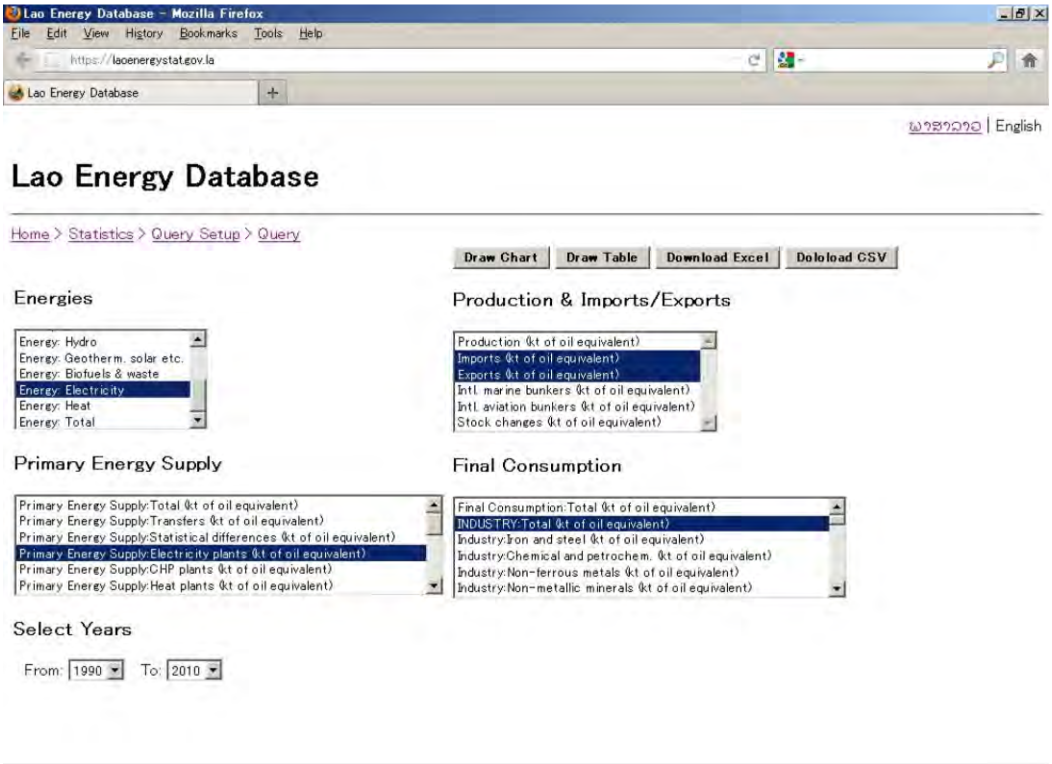


Figure 4.4-5 Statistical Data Retrieval

(2) Data visualization functions

As mentioned above, data can be retrieved in a format of the user's choice. For some data categories for which a graphical representation is preferred, an online chart drawing utility is provided (Figure 4.4-6).

In this example, the user draws an area chart of trends in energy consumption by sector for the years between 1990 and 2010.

As can be seen in the "Series B" scroll box, a user can retrieve not only energy data but also related data such as socioeconomic data, and demographic data. These data would be provided by the Lao Statistics Bureau (LSB) and be consistent with LaoInfo, the Lao Expenditure Consumption Surveys (LECS), etc. Thus, a close alliance between the Ministry of Energy and Mines (MEM) and the LSB is required to run and maintain the Lao Energy Database.

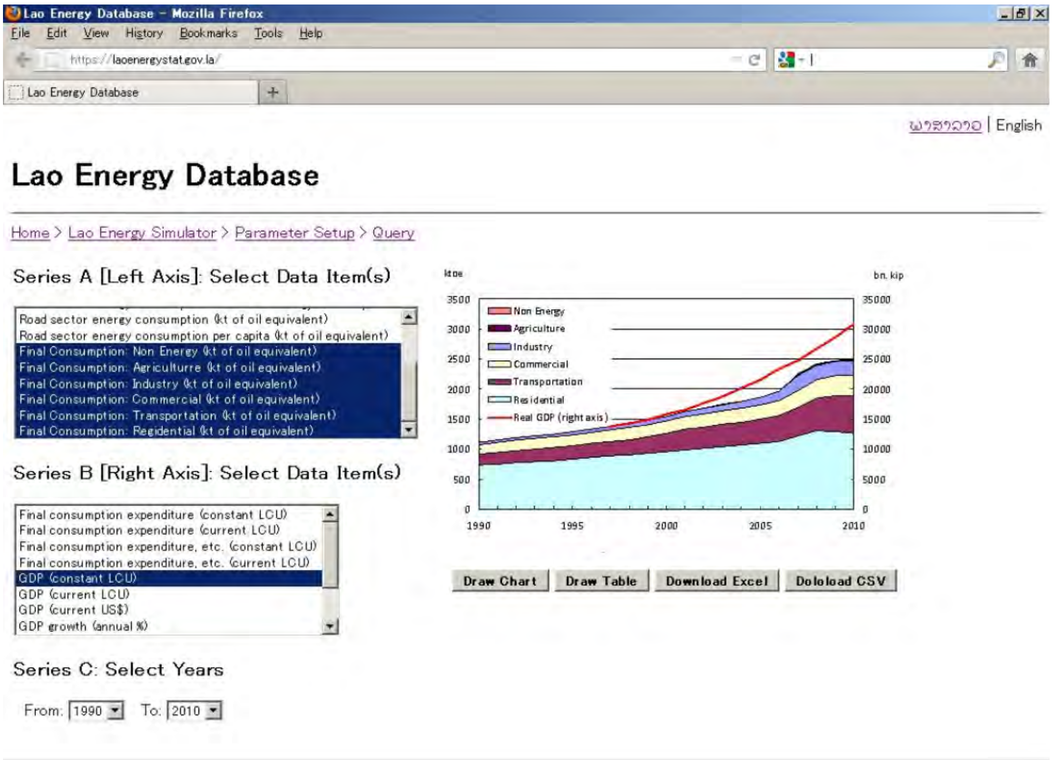


Figure 4.4-6 Data Visualization

(3) Simplified simulator functions

As discussed in Chapter 5, IEEJ has developed *the Lao Energy Model* in this study. The proposed database system also provides users with a simplified energy demand/supply simulator on-line.

4.4.4 Database Development Process

A database development process consists several sub-processes:

1. Definition of Requirements
2. Conceptual Design
3. Physical Design
4. Implementation

(1) Definition of Requirements

In "Definition of requirements" sub-process, users' requirements of the database are analyzed. These requirements correspond to the three major functions of the proposed system, namely: data retrieval functions, data visualization functions, and simplified simulator functions.

Data items, comprising 16 energy categories and 14 Supply & Demand categories are identified for the energy balance table. Thus, the resultant data matrix gives 224 data items

(Table 4.4-1). *Lao Energy Database's* will start with these 224 data items and gradually increase them. Taking the IEA database as a benchmark, its energy balance table contains ca. 60 energy categories and 80 Supply & Demand categories, or ca. 4,800 data items. This number is the final target of the Lao Energy Database.

Table 4.4-1 Data Items Identified in this Study

Energy		Supply & Demand	
Coal		**Total Primary Energy Supply**	
Petroleum Products			Domestic Production
	Gasoline		Import
	Jet Fuel		Export
	Diesel Oil	**Domestic Primary Energy Supply**	
	Heavy Oil		Power Generation (EdL)
	Other Petroleum Products		Others (transformation)
	LPG		Own Use & Losses
Biodiesel			Statistical Difference
Bioethanol			Total Final Energy Demand
Fuel Wood & Charcoal			Industry
	Fuel Wood		Agriculture & Forestry
	Charcoal		Residential
Hydro			Commercial
Photovoltaic			Transport
Wind Power			Non Energy
Others (Renewables)			
Electricity			

Source: JICA Study Team

(2) Conceptual/Physical Design & Implementation

The next sub-processes involve rather technical discussions, such as table structure of database (i.e. the way data are stored in "tables" and the way they are connected or "relations") in *the Conceptual Design*, and what database software we should use (DB2 of IBM? Oracle? MySQL or GNU software?) in t*he Physical Design*. Then, a prototype of the system is *Implemented*.

However, the resultant database is not the "final." It needs some ongoing fine-tuning. This is called a *Spiral Development Cycle or Plan-Do-Check-Act (PDCA) Cycle*.

Through these cycles, the launch of actual database services with the *Lao Energy Database* can be anticipated around 2020 (Figure 4.4-7).

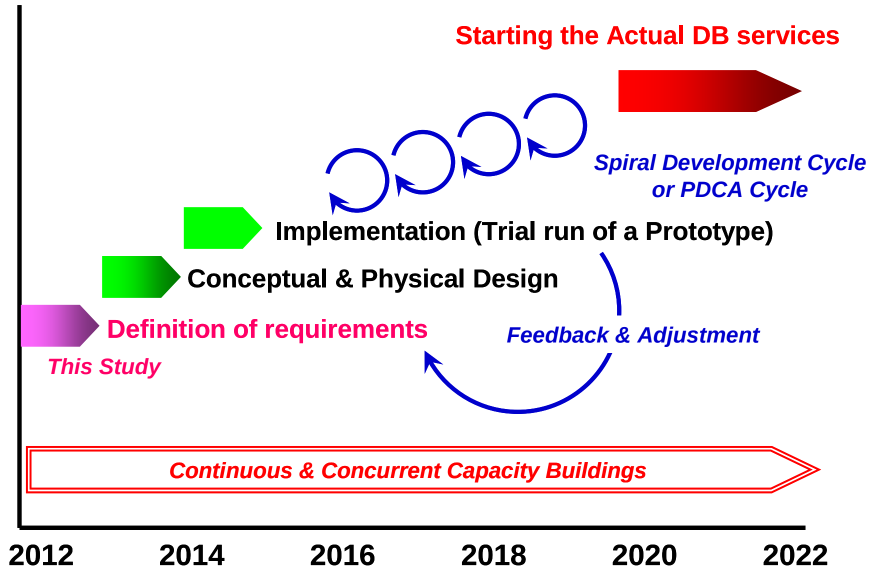


Figure 4.4-7 Database Development Process

4.4.5 Need for Capacity Building

The proposed system is an integrated structure, consisting of subsystems for data collection, data check, data storage, and data retrieval including data processing. Running the whole system properly requires interministerial/institutional cooperation.

As discussed elsewhere, capacity building for energy statistics and database (basic concepts of energy data, data collection and integrity check, scheduling, O&M, etc.) is of vital importance.

When establishing *the Lao Energy Database* to contribute to policy-making, not only in Lao PDR but also in GMS countries, human and institutional capacity building is indispensable.

4.5 Energy Demand Survey

4.5.1 Objective of Survey

To verify statistical data on energy consumption and supply, and future energy demand forecasting in this Study, part of the sampling survey was entrusted to a local consultant. The industry sector consumes 15% of final energy consumption. But, energy consumption by industrial sub-sectors is not specified. To verify energy consumption by industrial sub-sectors, a sampling survey of factories was conducted.

4.5.2 Target Industries

The target industries were the 59 industries shown in Table 5.5-1 and the total number of factories surveyed is 106: 78 in Vientiane Capital and 28 in Vientiane Province.

Table 4.5-1 List of Industries Surveyed

No.	Industry	Sample No.	No.	Industry	Sample No.
1	Animal food	2	31	Noodle	1
2	Beer	1	32	Champa	1
3	Bio fertilizer	1	33	Liquid concrete	2
4	Bread	2	34	Mattress and pillow	1
5	Bricks	4	35	Mechanic Service and steel boiling	1
6	Car assembling	1	36	Medical drug	1
7	Cartoon Pop-up book	1	37	Motorbyke spare parts	2
8	Cassava Powder	1	38	Noodle	1
9	Cement	1	39	Oxygen, Acetylen & Cac2	2
10	Cement bags	1	40	Pants for export	3
11	Cigarette & dry tobaco leafs	1	41	Paper and boxes	2
12	Cloths	7	42	Perfume	1
13	Concrete pole, pipe, bricks	2	43	Plastic	4
14	Concrete products	2	44	PVC, Chairs	1
15	Cooper and zinc products	1	45	Recycle paper	1
16	CPAC shingles	2	46	Salt	1
17	Detergent & Dishwashing liquid	1	47	Secondhand cars	1
18	Dimond	1	48	Shingle and roof material	2
19	Doors, windows	2	49	Shoes and leather	1
20	Drinking water	3	50	Soft drink	1
21	Drinking water in bottles	5	51	Spare parts of camera	1
22	Drugs	1	52	Steel bar	2
23	Fabric & dye	1	53	Tile brick, CPAC, tile	1
24	Furniture	2	54	Timbers	3
25	Garment for export	6	55	T-shirts for export	1
26	Ice	7	56	Vegetable oil, juice, plastic bottles	1
27	Iodized salt	1	57	Waste paper compress	1
28	Iron roof/shingle	1	58	White charcoal	2
29	Jewelry	1	59	White lime	1
30	KCL	1		Total	106

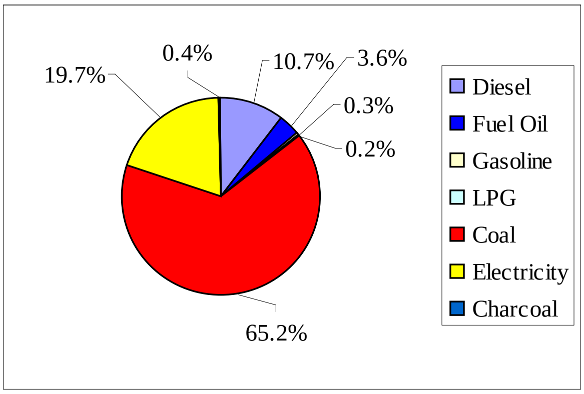
4.5.3 Results of Survey

Number of average workers of 106 factories was 125, of which, the maximum was 1,700 and minimum was 2. Total energy consumption of the 106 factories was 41.24 ktoe, and coal was the largest source of energy consumed at 26.87 ktoe, following by electricity, diesel, fuel oil, charcoal, gasoline, and LPG, as shown in Table 4.5-2 and Figure 4.5-1. Diesel and gasoline are mainly used by delivery vehicles. Fuel for vehicles is categorized in the transport sector. Therefore, the share of energy consumption in the industrial sector is shown as Figure 4.5-2.

Table 4.5-2 Energy Consumption of Surveyed Industries

Diesel	Fuel Oil	Gasoline	LPG	Coal	Electricity	Charcoal	Total
4.41	1.48	0.11	0.09	26.87	8.12	0.16	41.24
10.7%	3.6%	0.3%	0.2%	65.2%	19.7%	0.4%	100.0%

Source: Energy Demand Survey



Source: Energy Demand Survey

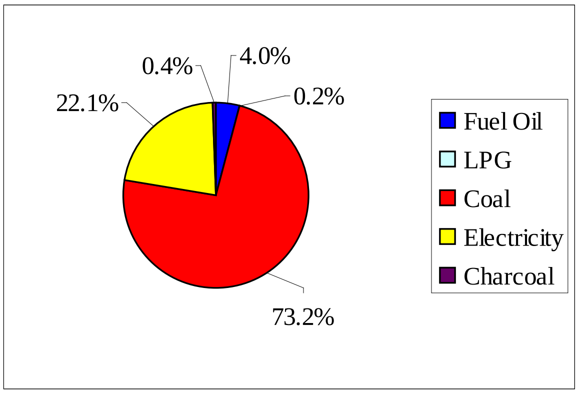
Figure 4.5-1 Share of Energy Consumption of Surveyed Industries

Table 4.5-3 Energy Consumption of Surveyed Industries Excluding Diesel and Gasoline

(ktoe)

Fuel Oil	LPG	Coal	Electricity	Charcoal	Total
1.48	0.09	26.87	8.12	0.16	36.72
4.0%	0.2%	73.2%	22.1%	0.4%	100.0%

Source: Energy Demand Survey



Source: Energy Demand Survey

Figure 4.5-2 Share of Energy Consumption of Surveyed Industries Excluding Diesel and Gasoline

Table 4.5-4 shows final energy consumption of the industrial sector of Lao PDR in 2010. The industrial sector of Lao PDR consumed 232.1 ktoe of energy in 2010. This volume is 6.3 times that of the energy demand survey in this study. According to information from the Ministry of Commerce and Industry, there are 3,559 factories in Lao PDR, as shown in Table 4.5-5. In our energy demand survey, we selected factories that consume a lot of energy. Therefore, energy consumption in this energy demand survey might be large, despite only 106 factories being covered.

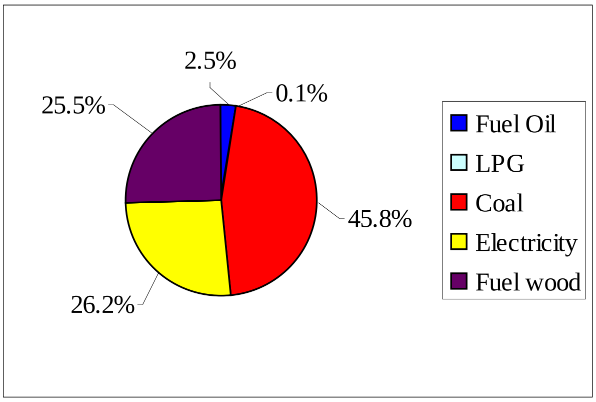
Regardless, an energy demand survey and/or reporting system of energy consumption is effective for improving the accuracy of energy statistics.

Table 4.5-4 Energy Consumption of Industry Sector (2010)

(ktoe)

Fuel Oil	LPG	Coal	Electricity	Fuel wood	Total
5.7	0.2	106.2	60.8	59.2	232.1
2.5%	0.1%	45.8%	26.2%	25.5%	100.0%

Source: MEM



Source: MEM

Figure 4.5-3 Share of Energy Consumption of Industry Sector (2010)

Table 4.5-5 Number of Factories (2011)

Factory Size			Total
Large	Middle	Small	
405	589	2,565	3,559

Source: Ministry of Commerce and Industry

4.5.4 Possibility of Energy Conservation

In Lao PDR, there is no energy conservation and efficiency policy at present. However, there is potential for energy conservation in the industrial sector as observed from the energy demand survey and the interview survey. Taking the cement industry as an example, unit energy consumption for one ton of cement product in Lao PDR is 40% higher than that of Japan, as shown in Table 4.5-6. In this way, energy statistics are useful for comparing energy consumption with other countries and for making energy conservation policy. The cement industry in Lao PDR is already evaluating energy consumption and preparing future targets. However, these data have not been disclosed. Data should be disclosed widely to interested users.

Table 4.5-6 Comparison of Unit Energy Consumption for the Cement Industry

Japan		Laos	
Coal	Electricity	Coal	Electricity
MJ/t-cement	kWh/t-cement	MJ/t-cement	kWh/t-cement
2,500	102	3,590	141

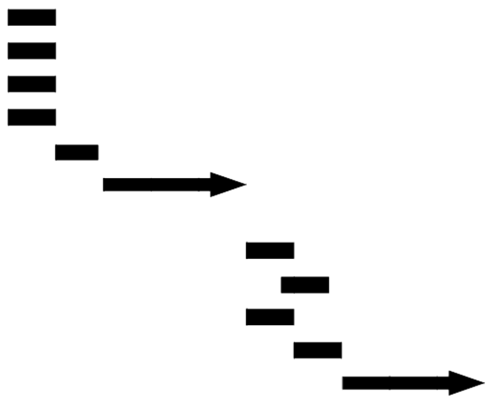
Source: Energy Demand Survey and Interview Survey

4.6 Implementation Schedule

Table 4.6-1 shows the implementation schedule for data collection. In the short term, the Ministry of Planning and Investment (MPI) revises the Statistics Law and adds energy statistics to Article 8. The MEM chooses designated factories based on the factory list of MIC, and prepares the format of the energy consumption periodic report. The MEM establishes an organization for handling and analyzing data under the MEM or outside party, and trains staff on energy statistics.

In the medium-term, a data collection system using online system and database system is built by outsourcing to increase efficiency. The MEM provides an ID and password to designated factories for accessing data collection system. The online system is linked to the database system to store data automatically.

Table 4.6-1 Implementation Schedule for Data Collection System



5 Energy Demand and Supply Forecasting

5.1 Functions and Objectives of IEEJ model

(1) Current situation

There are two major approaches to forecasting demand: bottom-up approach and top-down (econometric model) approach. These approaches are generally used according to the objectives because both have their own characteristics (strengths and weaknesses). Figure 5.1-1 shows the two approaches in the light of: 1) short term or medium to long term, 2) practical and business oriented or comprehensive strategy oriented, and 3) specified energy or whole energy. The IEEJ model developed through this study is based on an econometric approach for the long term (2011-2025), covering overall energy in Lao, while a medium-term prediction of electricity demand was compiled by EdL as a power development plan (PDP) for the coming 10 years, using the bottom-up approach. According to Figure 5.1-1, the demarcation between IEEJ model and EdL model seems to be relatively clear. However, more important is that the models are consistent with each other regarding economic conditions and estimation results.

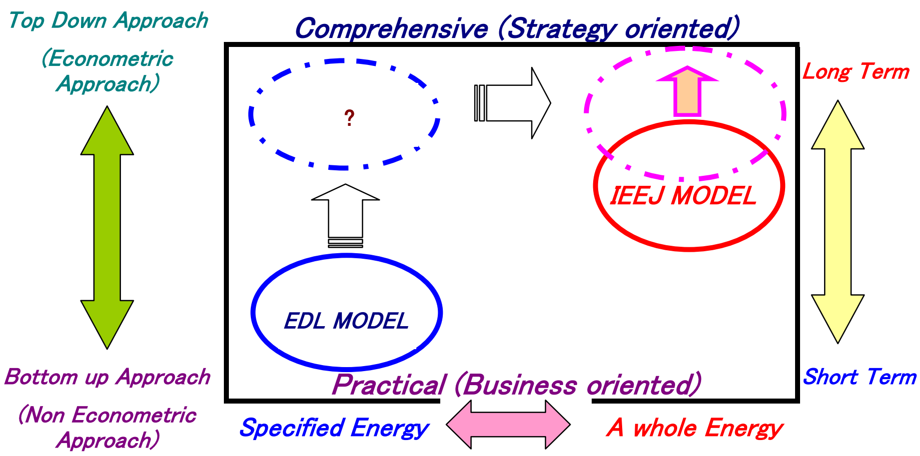


Figure 5.1-1 Demarcation between Bottom-up and Econometric Approaches

The primary purpose of developing and using an energy demand-forecasting model is to estimate future energy demand and supply more accurately. If the prediction term is short (less than five years), the bottom-up approach is preferred. On the other hand, an econometric approach enables us to explain the transition mechanism from economy to energy demand theoretically. In particular, it is useful for measuring the cost-effectiveness of an energy investment plan under various energy scenarios (policies).

(2) Basic Concept of IEEJ model

Judging from the current situation of Lao PDR, the first priority is to gather the necessary data and to estimate energy demand, either medium term or long term, in a way that is consistent with economic theories using a relatively basic and simple model. Accordingly, the framework of the IEEJ model is based on this concept. This model principally consists of two sections: macro-economy and energy demand and supply; however, an econometric approach is not used in the macro- economic section because economic data are not sufficiently available at present; this means that the economic indicators required for the model are set as exogenous variables, with the exception of a few indicators. In the energy demand and supply section, while final energy demand equations are formulated by the least-square methods—the core of the program in this model, variables for the supply side such as export/import and renewable energy are set as exogenous conditions in accordance with each scenario. In conclusion, the total energy supply can be obtained using both demand and supply values.

5.2 Outlook of IEEJ model

5.2.1 Structure of model

(1) Software

Among the various types of software available for econometric modeling, this study employed original software called "Simple E," which had been developed by the Institute of Energy Economics, Japan (IEEJ), taking into consideration the condition that those new to econometric modeling can understand the basic menus, i.e., estimation methods, model development, and simulation, and easily learn actual operating methods. The basic characteristics are as follows.

(a) Using the macro-function with Microsoft Excel, the software can function like general econometric software using the least-square method. Model development, simulation, and graphics can also be carried out, so users can perform econometric analyses as if they are making graphs and tables in Excel.

(b) This software has been used in many training workshops for econometric analysis skills in Asian countries.

(c) A user-friendly operation manual is available for beginners.

(d) This software can be used simply by launching Excel in Windows.

(e) Input and output data are provided in Excel spreadsheet format.

(f) Expertise can be easily transferred within the Lao Government and agencies involved.

(2) Structure of model

The basic structure of the model is divided into three as indicated in Figure 5.2-1

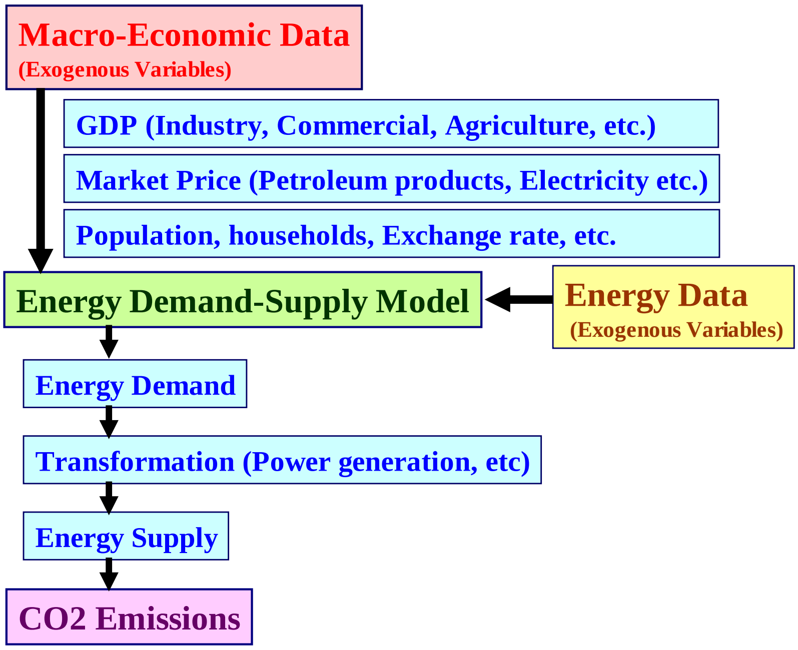


Figure 5.2-1 Structure of Econometric Model

The structural equations of the model consist of 27 estimation equations and 215 definition equations, totaling 242 equations. They are categorized into the following blocks.

(a) Macro-economy block

Macro-indicators such as GDP, crude oil price, exchange rate, prices, and population: exogenous variables

(b) Energy-related data block

Indicators for production and transportation activities, energy retail price etc.: estimation equations or exogenous variables (Three estimation equations)

(c) Energy demand and supply block

Final demand of energy: estimation and definition equations (19 estimation equations, 88 definition equations: total of 107 equations)

Others (production, export and import, transformation, loss, statistical errors etc.): estimation and definition equations (eight estimation equations, 127 definition equations: total of 135 equations)

When developing estimation equations in the energy demand block, accurate time-series data were not available because the distribution market is not well developed and the data sampling method is not good. Therefore, some data could not be chosen as explanatory variables because of inconsistency with the explanations of the actual economy, such as having the opposite sign for an estimated parameter. Details are discussed in the chapter on statistics and databases, but in general, data are not sufficiently available for estimations with the exception of electricity and transportation fuel (gasoline and light diesel oil).

Final Demand
Industry

CLIN=−109.11(−7.1)+.12696(7.96)*RGDPCO+13.123(1.06)*DUM.2008+35.008(2.59)*DUM.2009
LS: R.917; AR.892; DW1.13; F36.9
GAIN=LAG1.GAIN
JTIN=LAG1.JTIN
DSIN=LAG1.DSIN
HOIN=.1026(7.36)+.00053043(6.95)*RGDPIN−.0004131(−2.07)*CRNPRICE*EXR/CPINONFOOD
+5.2644(16.2)*((DUM.2007+DUM.2008))
LS: R.989; AR.984; DW2.71; F202.7
OPIN=LAG1.OPIN
LPIN=.30941(7.08)+.0000017269(.169)*RGDPIN+.11515(1.96)*DUM.2006−.058743(−.921)*DUM.2009
LS: R.349; AR.154; DW.56; F1.8
PTIN=GAIN+JTIN+DSIN+HOIN+OPIN+LPIN
BDIN=LAG1.BDIN
BEIN=LAG1.BEIN
FWIN=8.622(32.5)+.0030115(11.1)*RGDPIN+5.7433(4.56)*((DUM.2007+DUM.2008))
LS: R.946; AR.936; DW1.59; F96.7
CHIN=LAG1.CHIN
FCIN=FWIN+CHIN
ELIN=−6.9211(−.35)+.011687(9.37)*RGDPIN−5.4846(−1.01)*ELINNPRICE/CPINONFOOD
+16.341(3.95)*((DUM.2006+DUM.2007+DUM.2008))
LS: R.952; AR.931; DW2.25; F45.9
TLIN=CLIN+PTIN+BDIN+BEIN+FCIN+ELIN

Note: Values indicated within parentheses after coefficients of the estimation equations shows t-values.

Figure 5.2-2 Structural Equations of Model (final demand in industrial sector)

(3) Calculation flow in econometric model

The econometric model is categorized by the five working blocks shown in Figure 5.2-3.

(a) Collect and develop data for developing model, and prepare data structure (energy balance table).

(b) Prepare estimation equations for final demand using the least-square method.

(c) Develop model of overall demand and supply (prepare estimation and definition equations).

(d) Run simulations
- Set exogenous variables in standard scenario (precondition, BAU)
- Set scenarios (change some exogenous variables for each scenario)
- Prepare model files by scenario, run simulations, and save results

(e) Analyze simulation results
- Check energy balance table (check consistency of results)
- Prepare various figures and tables for analysis

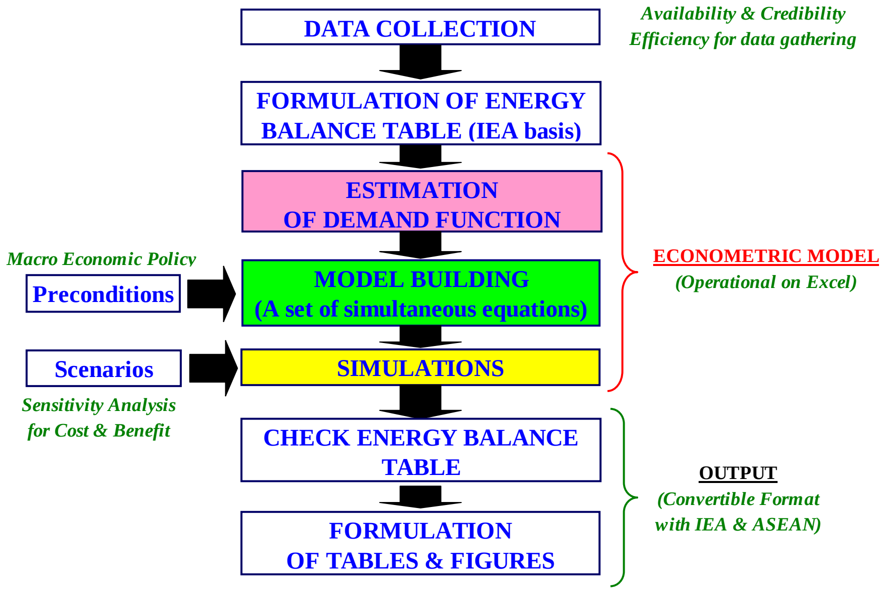


Figure 5.2-3 Operation and Calculation Flow in Econometric Model (Simple E)

The simulations are conducted based on the flow above, but at the initial stage, it is expected that accurate results will not be obtained. It is important to retain models developed in the past and simulation results because improved models can be developed based on fact-finding from various past-formulated estimations along with improvements to time data series. This enables users to clearly understand how estimation methods with data constraints can be improved, and implies what kind of statistics and data need to be gathered for projections and analyses needed in the future.

5.2.2 Energy balance tables

One convenient tool to understand current energy demand and supply in Lao PDR and overall image of the future projection is an energy balance table. An energy balance table describes the balance of the entire energy demand and supply of one country with a common scale, and is a convenient statistical table through which users can trace the process of each type of energy as primary energy or converted as secondary energy until final consumption. This is also a very effective statistical and analytical tool for making assessments and analyses: the energy flow of one country from production, export and import to final consumption; and, interactions and competition between sectors and energy sources. Energy balance tables are used extensively worldwide, and the International Energy Agency (IEA) releases tables as Energy Balances and Statistics every year.

As indicated in Figure 5.2-3, energy balance tables are developed automatically for actual performance (Table 5.2-1) and future estimation results (Table 5.2-2) in the IEEJ model. Table 5.2-1 is the energy balance table of Lao PDR in 2010 based on MEM data. Table 5.2-2 is the energy balance table for 2025 based on simulation results of the model. The 1st to 5th rows in this table indicate supply (production, export and import); the 6th to 8th rows indicate transformation (power generation etc.); and, 10th and lower rows indicate final consumption.

Table 5.2-1 Energy Balance Table (2010)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	**19**
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	**TL**
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	360.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,740.9	1,740.9	0.0	716.1	0.0	0.0	10.5		**2,828.3**
2	IM	Import	34.2	689.0	139.1	62.1	477.6	5.7	2.8	1.7	0.0	0.0	0.0	0.0	0.0					104.0	**827.3**
3	PR	**Total Primary Energy Supply**	**395.0**	**689.0**	**139.1**	**62.1**	**477.6**	**5.7**	**2.8**	**1.7**	**0.0**	**0.0**	**1,740.9**	**1,740.9**	**0.0**	**716.1**	**0.0**	**0.0**	**10.5**	**104.0**	**3,655.5**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−571.6	**−811.2**
5	PD	**Domestic Primary Energy Supply**	**155.4**	**689.0**	**139.1**	**62.1**	**477.6**	**5.7**	**2.8**	**1.7**	**0.0**	**0.0**	**1,740.9**	**1,740.9**	**0.0**	**716.1**	**0.0**	**0.0**	**10.5**	**−467.6**	**2,844.3**
6	PU	Power Generation	0.0	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−716.1	0.0	0.0	−10.5	726.6	**−0.0**
7	OT	Others (transformation)											−226.7	−354.9	128.2						**−226.7**
8	OU	Own Use & Losses																		−30.0	**−30.0**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**106.2**	**591.7**	**121.0**	**62.1**	**398.4**	**5.7**	**2.8**	**1.7**	**0.0**	**0.0**	**1,514.2**	**1,385.9**	**128.2**					**209.9**	**2,422.0**
11	IN	Industry	106.2	6.0	0.0	0.0	0.0	5.7	0.0	0.2	0.0	0.0	59.2	59.2	0.0					60.8	**232.2**
12	AF	Agriculture & Forestry	0.0	17.2	0.0	0.0	17.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					3.7	**20.9**
13	HS	Residential	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1,187.8	1,125.3	62.5					81.1	**1,269.4**
14	CM	Commercial	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	267.1	201.4	65.8					64.4	**332.4**
15	TN	Transport	0.0	564.3	121.0	62.1	381.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**564.3**
16	NE	Non Energy	0.0	2.8	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**2.8**

Table 5.2-2 Energy Balance Table (2025)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	**19**
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	**TL**
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	3,077.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	127.1	27.5	2,726.5	2,726.5	0.0	1,207.7	0.0	0.0	46.4		**7,212.2**
2	IM	Import	905.3	1,878.0	265.2	312.6	1,253.3	26.0	17.5	3.4	0.0	0.0	0.0	0.0	0.0					579.4	**3,362.8**
3	PR	**Total Primary Energy Supply**	**3,982.4**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**1,207.7**	**0.0**	**0.0**	**46.4**	**579.4**	**10,575.0**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−1,482.4	**−1,722.1**
5	PD	**Domestic Primary Energy Supply**	**3,742.8**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**1,207.7**	**0.0**	**0.0**	**46.4**	**−903.0**	**8,852.9**
6	PU	Power Generation	−2,425.4	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−1,207.7	0.0	0.0	−46.4	2,102.9	**−1,576.5**
7	OT	Others (transformation)											−493.2	−772.1	278.9						**−493.2**
8	OU	Own Use & Losses																		−253.3	**−253.3**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,268.2**	**1,780.7**	**247.1**	**312.6**	**1,174.2**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,233.3**	**1,954.4**	**278.9**					**927.5**	**6,364.3**
11	IN	Industry	1,268.2	26.4	0.0	0.0	0.0	26.0	0.0	0.4	0.0	0.0	174.1	174.1	0.0					508.5	**1,977.1**
12	AF	Agriculture & Forestry	0.0	29.9	0.0	0.0	29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					4.8	**34.8**
13	HS	Residential	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1,637.7	1,476.5	161.2					226.3	**1,865.1**
14	CM	Commercial	0.0	1.9	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	421.5	303.8	117.8					187.9	**611.3**
15	TN	Transport	0.0	1,704.0	247.1	312.6	1,144.2	0.0	0.0	0.0	127.1	27.5	0.0	0.0	0.0					0.0	**1,858.6**
16	NE	Non Energy	0.0	17.5	0.0	0.0	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**17.5**

5.3 Setting Standard Scenario and Evaluating Results Estimated by the Model

5.3.1 Assumptions (BAU)

As explained in 1.1, the macro-economic conditions were mainly based on the Seventh National Socio-economic Development Plan (2011-2015), referring in part to projections by ADB and IMF. The model for future projections is set according to calendar year because it employs time-series data of the ADB and IMF for most of the macro-economic indicators. The estimated values, therefore, differ slightly from those in the Seventh Five-year Plan, which is based on the Lao fiscal year (October to September). Basic concepts underlying the main assumptions are described below (Table 5.3-1).

Table 5.3-1 Assumptions (BAU)

			2000	2010	2015	2020	2025	2000-2010 AAGR	2010-2015 AAGR	2015-2020 AAGR	2020-2025 AAGR	2010-2025 AAGR
Population		millions	5.09	6.26	6.91	7.57	8.22	2.1%	2.0%	1.8%	1.7%	1.8%
Households		thousands	822	1,053	1,162	1,273	1,383	2.5%	2.0%	1.8%	1.7%	1.8%
REAL GDP		bil. Kips at 2002	15,815	30,899	45,300	63,833	86,517	6.9%	8.0%	7.1%	6.3%	7.1%
	Industry	bil. Kips at 2002	2,979	7,850	15,818	27,938	44,993	10.2%	15.0%	12.0%	10.0%	12.3%
	Commercial	bil. Kips at 2002	4,944	11,799	16,199	20,649	24,519	9.1%	6.5%	5.0%	3.5%	5.0%
	Agriculture	bil. Kips at 2002	7,032	9,237	10,728	12,138	13,401	2.8%	3.0%	2.5%	2.0%	2.5%
Price Indexes (nonfood)		1999=100	107	200	281	376	480	6.5%	7.0%	6.0%	5.0%	6.0%
WTI (Nominal)		US$/bbl	30	79	100	130	143	10.1%	4.7%	5.4%	1.9%	4.0%
Exchange Rate		Kips/US$	7,888	8,259	8,000	8,000	8,000	0.5%	-0.6%	0.0%	0.0%	-0.2%
Nominal GDP per Capita		thou. Kips per capita	2,539	8,677	16,160	27,818	44,319	13.1%	13.2%	11.5%	9.8%	11.5%
		US$ per capita	322	1,051	2,020	3,477	5,540	12.6%	14.0%	11.5%	9.8%	11.7%

(1) Population size and number of households

While the population census (conducted every five years) in 2005 estimates population growth rate at 2.1%, the model in this study assumes a gradual decline of growth in parallel with an increase in income level (same as projections by the ADB and IMF) and sets the average growth rate from 2011-2025 at 1.8%.

The number of persons per household generally decreases with urbanization, but in this model, the current family size is assumed to remain relatively unchanged until 2025, because this will largely depend on the performance of social policy (potential unemployment rate in rural areas) such as poverty alleviation measures being planned by the government.

(2) GDP

Due to the lack of a representative production index such as an industrial production index, each energy demand was estimated using real GDP in each sector (industry, agriculture and forestry, and commerce, etc.). For the future projection of real GDP in each sector, target values provided in the Seventh Five-year Plan were employed for 2011-2015, and the model assumed a decline in growth during and after 2016. This model consequently set the average annual growth rate of real GDP at 7.1% for 2011-2025, while setting 12.3% for the industry sector in the same period, assuming that mining and power generation sectors in particular will firmly support the high economic growth of Lao PDR.

(3) Prices and exchange rates

Economic indicators were converted into real values using the consumer price index (CPI) because a GDP deflator (including deflator by factor) is not officially released. As explained in 1.1, a steep drop in the exchange rate and high inflation induced by the Asian financial crisis had almost been restored by around 2005, and then stabilized. The basic policy of the government's budget expansion (expansion of budget deficit) will continue, taking into consideration the government's strategies for stabilizing social infrastructure, such as poverty alleviation measures and reducing rural villages with no electricity. Both domestic and foreign experts also point out strong pressures, such as expansion of trading deficit by increasing imports due to economic growth, to weaken the exchange rate and increase inflation. The assumptions in this study, however, set the inflation rate at around the current level of 7% and the exchange rate at 8,000-9,000 kip for USD1, due to the government's successful budget and financial policies.

(4) Crude oil price

This study assumed that crude oil prices would continue to rise gradually in the medium- to long-term, assuming the surge of crude oil prices in the international market due to the recent crisis regarding Iran to be temporary. While the nominal WTI price in 2025 is USD143 per barrel, this study assumed that the real price would remain stable at USD120-130, assuming about a 1-2% price increase rate in the United States.

(5) Conditions on energy supply side

(a) Petroleum products (including LPG) were assumed to continue to be imported from Thailand, Vietnam etc., with no domestic refinery for domestic crude oil (or imported crude oil). A small amount is actually exported, but this is set at zero for future exports.

(b) This study assumed that no natural gas is supplied including domestic production and imports.

(c) Coal production[30] was estimated with a regression equation, and export volume was assumed to be the same level as actual volume in 2010. Import volume was calculated by subtracting demand and exports from production.

(d) Electricity imports were estimated in proportion to demand using demand as an explanatory variable. Also, production volume[31] was estimated using trend as an explanatory variable. Exports of electricity are assumed to be the surplus obtained from domestic power generation and imports minus domestic demand.

(e) For renewable energy, it was assumed that small hydroelectric generation and bio-fuel (blended gasoline or blended diesel fuel with bio-fuel) would be introduced, but no other options were assumed due to economic inefficiency.

a) Small hydroelectric generation supplied 5% of electricity demand in 2010. From the viewpoint of environmental considerations for large hydroelectric development and

[30] In coal production, coal thermal generation use (HONGSA) was added separately to the estimation results.

[31] In total power generation volume, a portion of large-scale hydraulic power (NAM THEUN 2, NAM NGUM 2) was added separately to the estimation results.

economic efficiency, this study assumed 5% of electricity demand would be met by small hydroelectric generation until 2025.

b) This study assumed that bio-fuel would be introduced as a form of blended gasoline or blended diesel fuel in 2016 (with 1% of bio-fuel) and would be blended with up to 10% by 2025 (E10 and B10). With reference to the blending ratio actually used or planned in neighboring countries, the maximum blending ratio was set at 10% considering quality specification as transportation fuel.

5.3.2 Projection for energy retail prices

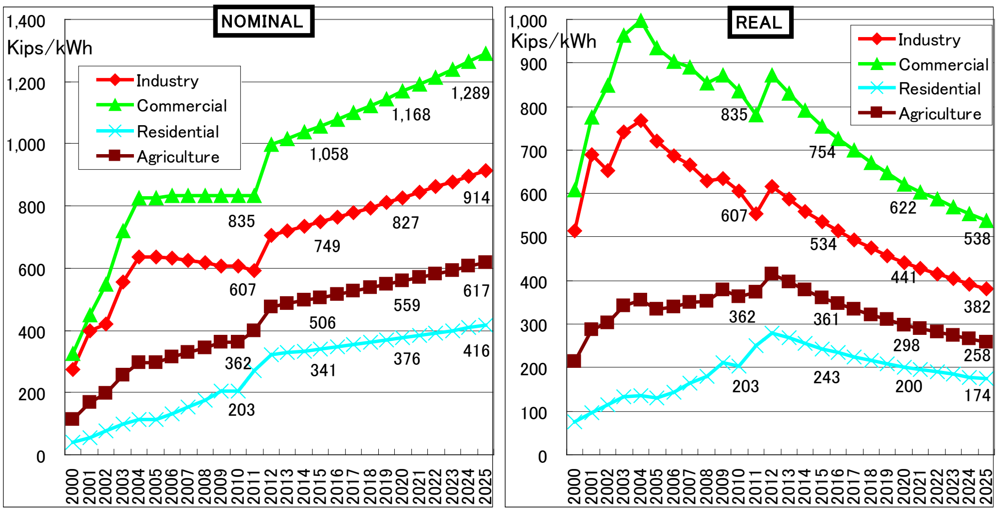
(1) Projection for electricity retail prices

Time-series data for energy retail prices that can be used for equations estimating energy demand are available for electricity prices, and prices of gasoline and light diesel oil. Although electricity prices are controlled by the government, in this study the electricity demand parameter was negative (-) and t-values are also fairly effective in many cases. The projection of price rise until 2025 was based on electricity price increases (until 2017) decided in March 2012, which was set for the BAU scenario. The actual impact, therefore, is to reduce prices as shown in Figure 5.3-1 because the annual average growth rate from 2011 to 2025 is lower than the domestic price increase rate (6%).

(2) Projection of retail prices of petroleum products

Petroleum products (gasoline, light diesel oil etc.) are all imported, the majority of which are supplied from petroleum refinery plants in Thailand and Vietnam. Because the international market prices of petroleum products for Asia are linked to Platt’s price, which is based on the spot market in Singapore, the price is eventually linked to the WTI crude oil via Dubai crude oil. For the brought-in price to each country, overhead costs including transportation (freight and ground transportation), tariffs, and retail margin are added to the FOB price. As shown in the graph to the left in Figure 5.3-2, the time-series data of the retail prices (nominal) in Lao PDR and the WTI crude oil price (nominal) show a very high correlation. The actual Lao domestic price, which is calculated from the WTI crude oil price (nominal) based on the assumption of a fixed exchange rate (equivalent to the current rate), will increase annually by less than 6% in terms of the inflation rate. Thus, the real value of the domestic price decreases significantly.

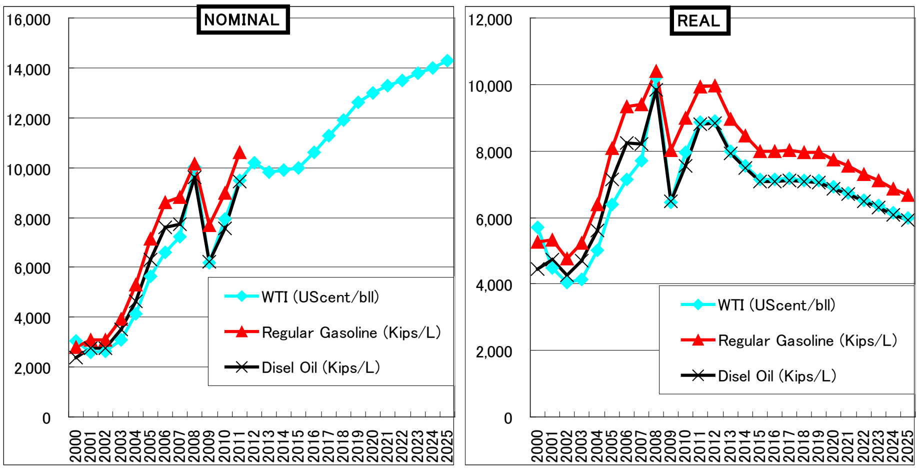
As is typically seen in time-series data of a country that experiences long-term high economic growth, negative (-) impacts of price rises are not clearly seen in the estimation equations of demand for gasoline and light diesel oil, while the estimation provides very strong positive (+) impacts from economic indicators such as GDP. This causes difficulties in obtaining parameters with statistical significance.



unit: Kips/kWh	2000	2010	2015	2020	2025	2000-2010 AAGR	2010-2015 AAGR	2015-2020 AAGR	2020-2025 AAGR	2010-2025 AAGR
Industry	274	607	749	827	914	8.3%	4.3%	2.0%	2.0%	2.8%
Commercial	325	835	1,058	1,168	1,289	9.9%	4.8%	2.0%	2.0%	2.9%
Residential	41	203	341	376	416	17.3%	10.9%	2.0%	2.0%	4.9%
Agriculture	114	362	506	559	617	12.2%	6.9%	2.0%	2.0%	3.6%
CPI	107	200	281	376	480	6.5%	7.0%	6.0%	5.0%	6.0%

Source: EdL annual report (actual figures)

Figure 5.3-1 Assumed Electricity Prices



Source: DOE (actual figures)

Figure 5.3-2 Assumed Petroleum Product Prices

5.3.3 Simulation results of energy demand in BAU scenario

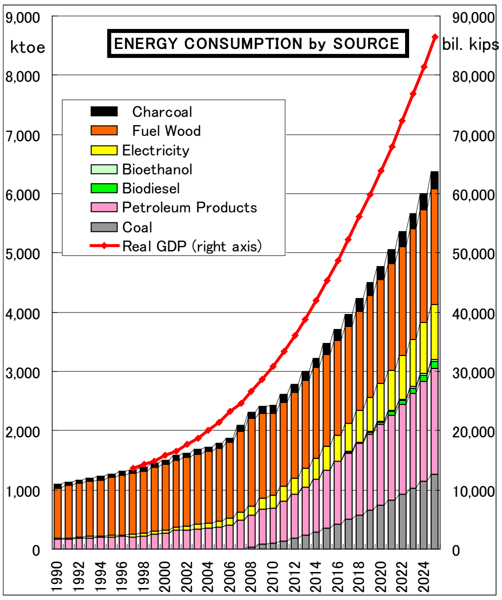
(1) Outlook of simulation results

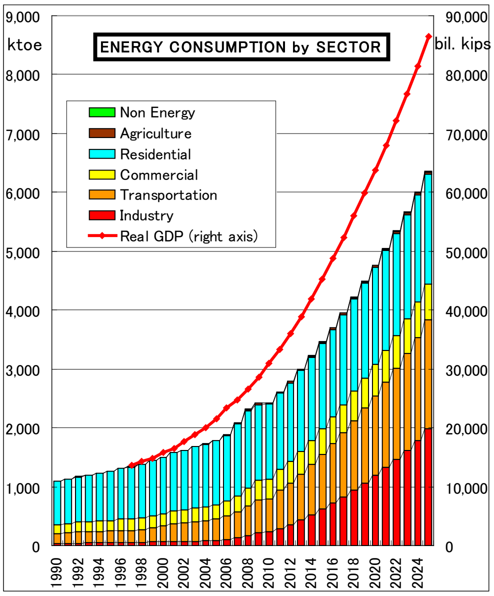
Total energy demand will increase at an annual average of 6.7% for real GDP growing at an annual average of 7.1% for the period 2010-2025; therefore, GDP elasticity to energy is 0.94. Looking at details by energy source, coal (annual average 18.0%) and electricity (annual average 10.4%) will increase significantly in the period 2010-2025, and coal (4.4% in 2010 to

19.9% in 2025) and electricity (8.7% in 2010 to 14.6% in 2025) will expand their shares in 2025, while these shares will still only be half that of fuel wood and charcoal (35.1%) and petroleum products (28.0%).

By sector, the industrial sector, which is assumed to have high real GDP growth, will rapidly increase demand (annual average 15.3%), expanding its share from 9.6% (2010) to 31.1% (2025), which will be higher than the transportation sector (29.2% in 2025) and household (residential) sector (29.3% in 2025). On the other hand, the increase rate of residential use will remain at 2.6% as an annual average in 2010-2025, because its growth in 2000-2010 is small compared to other sectors.

Figure 5.3-4 shows a further detailed analysis of electricity by sector. Growth in the industrial sector is also largest for electricity, which will have a 15.2% annual average increase during the period 2010-2025.





Energy Demand

unit: ktoe	2000	2010	2015	2020	2025
Coal	0	106	355	746	1,268
Petroleum Products	272	592	981	1,355	1,781
Biodiesel	0	0	0	46	127
Bioethanol	0	0	0	11	27
Electricity	55	210	393	633	927
Fuel Wood	1,103	1,386	1,561	1,752	1,954
Charcoal	71	128	174	226	279
Total	1,502	2,422	3,464	4,769	6,364

Energy Demand

unit: ktoe	2000	2010	2015	2020	2025
Industry	63	232	615	1,193	1,977
Transportation	266	564	939	1,354	1,859
Commercial	210	332	431	528	611
Residential	959	1,269	1,446	1,651	1,865
Agriculture	3	21	26	30	35
Non Energy	0	3	7	12	17
Total	1,502	2,422	3,464	4,769	6,364

Annual Average Growth Rate

	2000–2010 AAGR	2010–2015 AAGR	2015–2020 AAGR	2020–2025 AAGR	2010–2025 AAGR
Coal	77.4%	27.3%	16.0%	11.2%	18.0%
Petroleum Products	8.1%	10.6%	6.7%	5.6%	7.6%
Biodiesel	#DIV/0!	#DIV/0!	#DIV/0!	22.8%	#DIV/0!
Bioethanol	#DIV/0!	#DIV/0!	#DIV/0!	20.4%	#DIV/0!
Electricity	14.3%	13.4%	10.0%	7.9%	10.4%
Fuel Wood	2.3%	2.4%	2.3%	2.2%	2.3%
Charcoal	6.1%	6.3%	5.4%	4.3%	5.3%
Total	4.9%	7.4%	6.6%	5.9%	6.7%

Annual Average Growth Rate

	2000–2010 AAGR	2010–2015 AAGR	2015–2020 AAGR	2020–2025 AAGR	2010–2025 AAGR
Industry	13.9%	21.5%	14.2%	10.6%	15.3%
Transportation	7.8%	10.7%	7.6%	6.5%	8.3%
Commercial	4.7%	5.4%	4.1%	3.0%	4.1%
Residential	2.8%	2.6%	2.7%	2.5%	2.6%
Agriculture	19.9%	4.4%	3.2%	2.7%	3.5%
Non Energy	27.6%	19.9%	10.7%	8.3%	12.9%
Total	4.9%	7.4%	6.6%	5.9%	6.7%

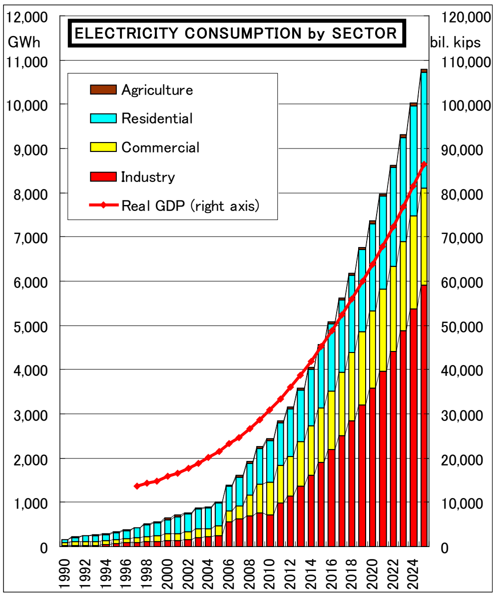
Share by Source

	2000	2010	2015	2020	2025
Coal	0.0%	4.4%	10.3%	15.6%	19.9%
Petroleum Products	18.1%	24.4%	28.3%	28.4%	28.0%
Biodiesel	0.0%	0.0%	0.0%	1.0%	2.0%
Bioethanol	0.0%	0.0%	0.0%	0.2%	0.4%
Electricity	3.7%	8.7%	11.4%	13.3%	14.6%
Fuel Wood	73.5%	57.2%	45.1%	36.7%	30.7%
Charcoal	4.7%	5.3%	5.0%	4.7%	4.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Share by Sector

	2000	2010	2015	2020	2025
Industry	4.2%	9.6%	17.8%	25.0%	31.1%
Transportation	17.7%	23.3%	27.1%	28.4%	29.2%
Commercial	14.0%	13.7%	12.5%	11.1%	9.6%
Residential	63.9%	52.4%	41.7%	34.6%	29.3%
Agriculture	0.2%	0.9%	0.7%	0.6%	0.5%
Non Energy	0.0%	0.1%	0.2%	0.2%	0.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 5.3-3 Energy Demand by Energy Source and Sector (BAU)



Electricity Demand

unit: GWh	2000	2010	2015	2020	2025
Industry	135	707	1,899	3,576	5,912
Commercial	147	749	1,225	1,747	2,185
Residential	325	943	1,402	1,985	2,631
Agriculture	33	43	47	52	56
Total	640	2,441	4,574	7,360	10,785

Annual Average Growth Rate

	2000-2010 AAGR	2010-2015 AAGR	2015-2020 AAGR	2020-2025 AAGR	2010-2025 AAGR
Industry	18.0%	21.8%	13.5%	10.6%	15.2%
Commercial	17.7%	10.4%	7.4%	4.6%	7.4%
Residential	11.2%	8.3%	7.2%	5.8%	7.1%
Agriculture	2.4%	2.2%	1.9%	1.5%	1.9%
Total	14.3%	13.4%	10.0%	7.9%	10.4%

Share by Sector

	2000	2010	2015	2020	2025
Industry	21.1%	29.0%	41.5%	48.6%	54.8%
Commercial	23.0%	30.7%	26.8%	23.7%	20.3%
Residential	50.7%	38.6%	30.6%	27.0%	24.4%
Agriculture	5.2%	1.7%	1.0%	0.7%	0.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

Figure 5.3-4 Electricity Demand by Sector (BAU)

(2) Comparisons with neighboring countries [32]

Energy demand projection (estimation result) for Lao PDR during the period 2011-2025 is shown above. The following results are for neighboring countries, which are at different stages of economic development. These results are discussed as one approach to examining the validity of the demand estimation (model fitness) by comparing energy demand and performance of Thailand and Vietnam, which are ahead of Lao PDR by about 30 years and 10 years, respectively.

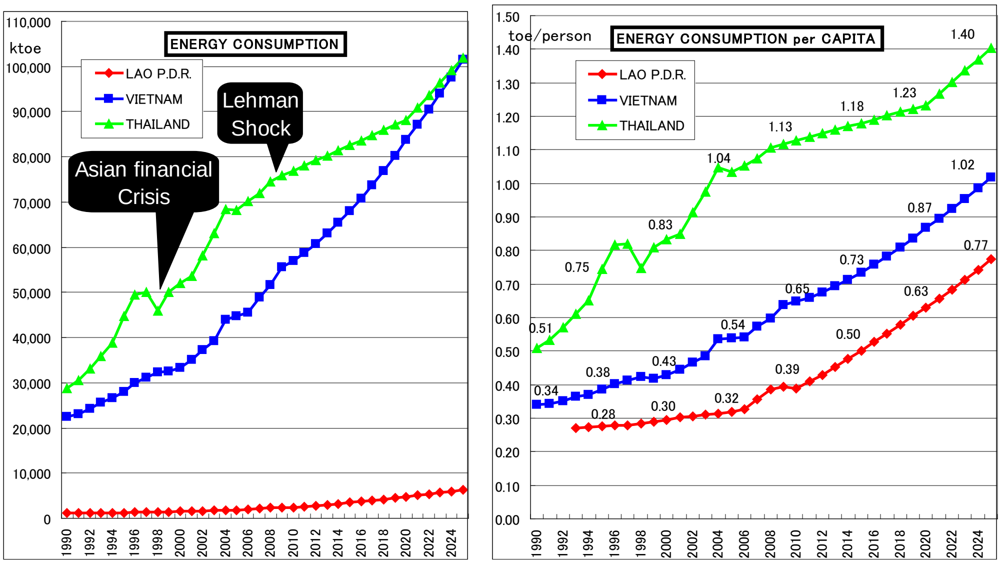


Figure 5.3-5 Comparison of Energy Demand of Neighboring Countries

32 Prospects for Thailand and Vietnam for 2011-2025 are based on "World Energy Outlook 2011" by IEEJ.

As Figure 5.3-5 indicates, there is no straightforward comparison of these countries by total energy demand because of population gaps, i.e., the populations of Vietnam and Thailand in 2010 were 88 million and 68 million, respectively, which is more than 10 times that of Lao PDR (6.3 million). When comparing energy demand per capita, therefore, the situation of Lao PDR in 2025 is equivalent to Vietnam in 2015 and Thailand in 1995. The electricity demand estimation also provides similar results as shown in Figure 5.3-6, i.e., the situation of Lao PDR in 2025 is equivalent to Vietnam in 2018 and Thailand in 1997.

Because energy demand is economy-induced demand, Lao PDR will probably follow a path of growing energy demand, which is similar to Thailand and Vietnam, assuming economic development of Lao PDR will catch up with these countries with a flying geese pattern of development. Figure 5.3-5 and Figure 5.3-6 show the trends of such demand.

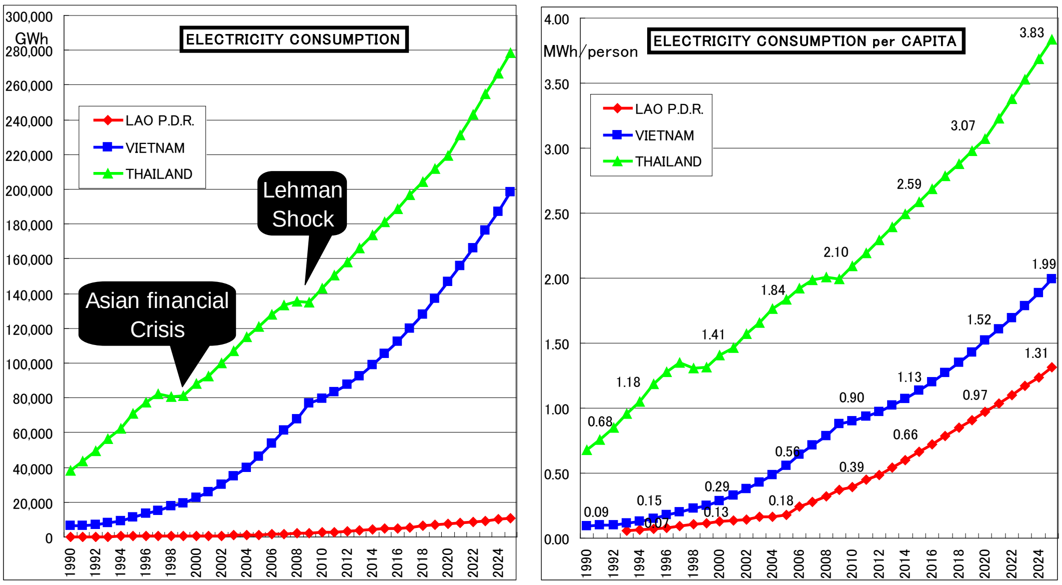


Figure 5.3-6 Comparison of Electricity Demand of Neighboring Countries

5.3.4 Sensitivity analysis

(1) Elasticity

Section 5.3.3 explains simulation results (energy and electricity demand) based on the BAU scenario. In this section, a sensitivity analysis of GDP (elasticity of energy and electricity demand) is performed, and fitness of the model is discussed.

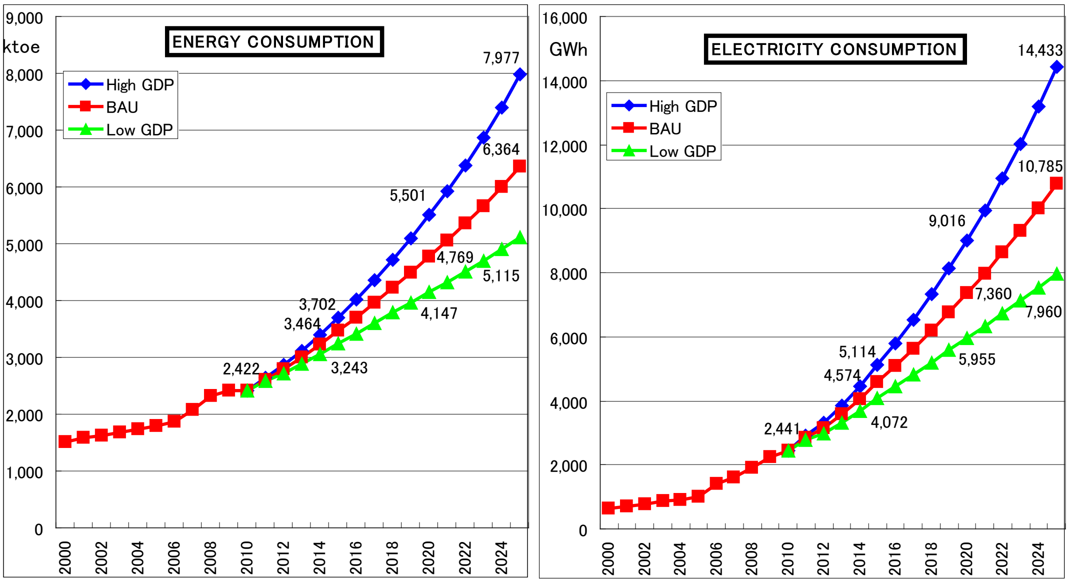
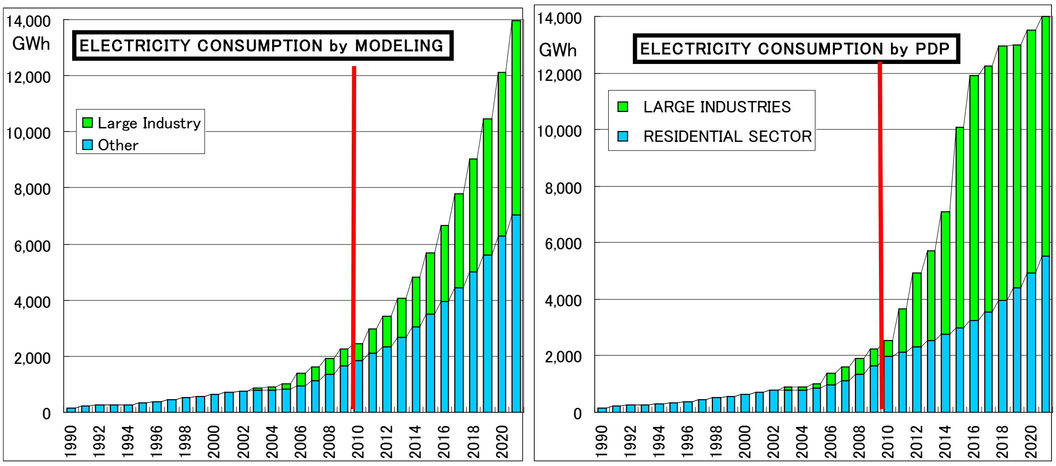


Figure 5.3-7 Change in Demand Compared to BAU for Case with Fluctuating GDP (+2%, -2%)

Figure 5.3-7 shows simulation results for scenarios with 2% higher or lower GDP growth rate compared to BAU (annual average growth rate at 7.1%). The elasticity of energy demand to GDP (2010-2025) is 0.94 and that of electricity demand to GDP is 1.47. When comparing energy demand in 2025, the estimated volumes differ by about 1.6 times in the two scenarios (7.98 million tons of oil equivalent for the +2% scenario and 5.11 million tons of oil equivalent for the -2% scenario). Similarly, the difference in the comparison of electricity demand is as much as about 1.8 times (1.44 billion kWh for the former scenario and 0.8 billion kWh for the latter).

(2) Comparison with demand estimated by PDP

Estimating GDP level of industrial sector with a model simulation, this study found that energy demand in 2020 estimated by PDP would require GDP growth of 18% in the industrial sector, which is 8% higher than BAU, and for the period 2011-2015, it would require 23%, which is 12% higher than BAU (Figure 5.3-8). This fact points to the need for macro-level consistency between the power development plan and the economic plan.



			2000	2010	2015	2020	2025	2000–2010	2010–2015	2015–2020	2020–2025	2010–2025
REAL GDP		bil. Kips at 2002	15,815	30,899	51,609	91,015	136,726	6.9%	10.8%	12.0%	8.5%	10.4%
	Industry	bil. Kips at 2002	2,979	7,850	22,127	55,120	95,202	10.2%	23.0%	20.0%	11.5%	18.1%
	Commerci	bil. Kips at 2002	4,944	11,799	16,199	20,649	24,519	9.1%	6.5%	5.0%	3.5%	5.0%
	Agriculture	bil. Kips at 2002	7,032	9,237	10,728	12,138	13,401	2.8%	3.0%	2.5%	2.0%	2.5%

(BAU)

REAL GDP		bil. Kips at 2002	15,815	30,899	45,300	63,833	86,517	6.9%	8.0%	7.1%	6.3%	7.1%
	Industry	bil. Kips at 2002	2,979	7,850	15,818	27,938	44,993	10.2%	15.0%	12.0%	10.0%	12.3%

Figure 5.3-8 GDP Estimation Using the Model in Response to PDP's Demand Projection

5.4 Setting each scenario and studying energy demand and supply balances

5.4.1 Comparison of each case for energy demand and supply balances

Demand in 2025 (BAU:1) calculated with the IEEJ econometric model described in the previous section (Section 3) is used as a common denominator[33], when four supply scenarios (J, A, B, and C) are set out in this Section. Then, demand and supply balances for individual cases in 2025 are formulated. In addition, demand in 2025 (BAU revised:2) is set at a +2% higher GDP growth rate compared to that in BAU, which is outlined in Section 5.3.4 (sensitivity analysis), which is also used as the common denominator for four supply scenarios (J, A, B, and C). In total, eight cases of demand and supply balances are formulated as shown in Table 5.4-1.The alphabet "A" of CASE A-1 indicates supply scenario "A" and the number "1" indicates demand estimation based on 7.1% annual average growth rate of GDP.

[33] The inconsistent economic conditions (or simulation periods) for energy demand estimations by PDP(EdL) or REDS(MEM) make it difficult to formulate consistent demand and supply balances for comparisons. For demand, an attempt was made to clarify the characteristics of demand and supply balances of each supply scenario based on the demand estimation by the IEEJ econometric model.

Table 5.4-1 Matrix for Case Study on Energy Demand and Supply

Supply / Demand		J	A	B	C
		Domestic Demand Driven Strategy	PDP Supply Planning	PDP + REDS Supply Planning	IEEJ Supply Planning
		(Nothing like export strategy)	(only Export Strategy for Power)	(Export Strategy for Power and RE strategy)	(Best mix for Export Strategy and D.Demand Driven Strategy)
1	BAU (AAGR of GDP 7.1%)	CASE J-1 (BASE)	CASE A-1	CASE B-1	CASE C-1
2	BAU revised (AAGR of GDP 9.1%)	CASE J-2	CASE A-2	CASE B-2	CASE C-2

Supply Conditions

		J	A	B	C
RE	Small Hydro	5% of Domestic Elec. Demand	⇒	based on REDS	10% of Domestic Elec. Demand
RE	Biofuel	E10 (Gasoline with 10% Bioethanol) / B10 (Diesel Oil with 10% Biodiesel)	⇒	based on REDS	E10 (Gasoline with 10% Bioethanol) / B10 (Diesel Oil with 10% Biodiesel)
RE	The others	None	⇒	based on REDS	None
Coal	Coal fired Power station	Only Hongsa	based on PDP (2 coal fired Plants)	⇒	⇒
Hydro	Hydro power generation	D.Demand Driven Strategy	based on PDP	⇒	IEEJ projection (Review of PDP)

Note: Demand estimation of all cases is based on IEEJ model (Econometric approach)

Supply scenario J employs the domestic demand-driven strategy. Domestic demand is met through the production of energy resources within a country, and if production is in surplus or there is a shortfall, the difference is adjusted through exports or imports. The same approach is adopted for electricity and fossil fuel such as oil and coal. Renewable energies are set at minimum levels taking economic conditions and workability into account, with the exception of the introduction of bio fuel to transportation fuel to a certain extent.

On the other hand, scenario A, which is similar to the current Lao PDR, is based on the presupposition that an export-oriented strategy (PDP) is adopted for electricity, rendering domestic demand to be merely a derivative. The renewable energies of scenario A are set at the same levels as supply scenario J. Supply scenario B also follows supply scenario A with regard to electricity. A difference is found only in the addition of a scenario for determining how much renewable energy is introduced in accordance with REDS, which increases the ratio of electricity supply with renewable energies (small hydroelectric generation, sunlight, and wind power) to domestic demand for power.

In supply scenario C, generation capacity (export) with fewer feasible projects such as hydraulic power stations along the Mekong mainstream is removed from power generation plans (PDP) set out by supply scenario A[34]. This is the middle case between supply scenario J and supply scenario A. Meanwhile, electricity with renewable energy (small hydroelectric generation)[35], although there remain some problems on the economic front, is promoted to the extent regarded as permissible in the light of environmental protection or constraints on excessive dependence on large-scale hydroelectric generation.

(2) Energy demand for 2025

[34] Based on the assessment in Chapter 3, Section 1.
[35] Based on the assessment in Chapter 3, Section 3.

Prior to comparing demand and supply balances, the structural characteristics of demand for 2025 (compared to 2010) indicated by two demand estimations (BAU and BAU revised for 2025) are clarified. The simulation results (demand estimations) based on the IEEJ model are summarized in energy balance tables, Table 5.6-1 (actual results of 2010), Table 5.6-2 (BAU, 2025), and Table 5.6-3 (BAU revised, 2025). Based on these energy balance tables, Figure 5.4-1 shows final demand by sector (energy used by end users). According to Figure 5.4-1, final demand in 2025 jumps roughly 2.6 times to 6,364 Mtoe from 2,422 Mtoe in 2010 by BAU; besides, significant changes are observed in the makeup ratio of sectors. The residential sector, which constituted 52.4% of the share in 2010, plummets by a large margin in 2025 (from 52.4% to 29.3%) due to a sharp increase in the industrial sector (from 9.6% to 31.1%) and steady increase in the transportation sector (from 23.3% to 29.2%). The industrial, transportation, and residential sectors in the makeup ratio are close to striking a balance with one another.

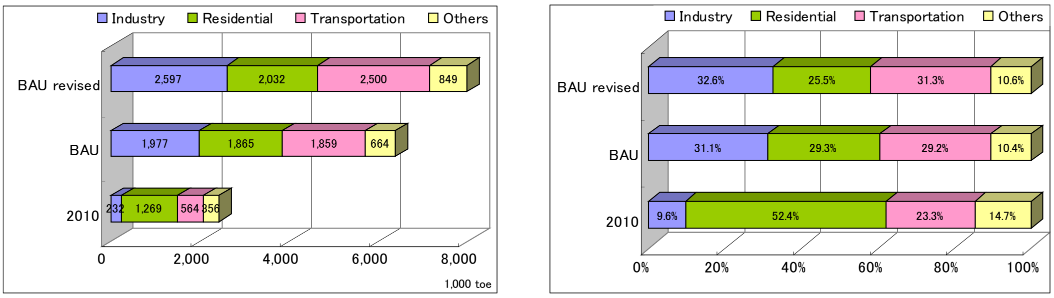


Figure 5.4-1 Energy Demand by Sector in 2025

With respect to the case of BAU revised, for which the GDP growth rate is set at 2% higher than that of BAU, final demand for 2025 is 7,977 Mtoe, which is even higher than that of BAU, increasing the share of industrial and transportation sectors.

Figure 5.4-2, on the other hand, illustrates changes by energy source. High economic growth spurs increases of all energies in their absolute quantity, from traditional biomass (fuel wood, charcoal, etc.), electricity, coal, and petroleum (including LPG) to bio-fuel (blended gasoline and diesel fuel), resulting in a remarkable change in the makeup ratio.

The ratio of electricity, which stood at 8.7% in 2010, increases to 14.6% in 2025 (BAU) as the use of electric appliances spreads among households, and industrial development, especially of large-scale factories, creates strong demand for electricity. Moreover, as transportation activity increases, petroleum products, mainly gasoline and diesel fuel, expand remarkably from 24.4% in 2010 to 28.0% in 2025 (BAU) (to 30.4% if bio-fuel of 2.4% is added). Similarly, coal (excluding that for thermal power generation) increases to 19.9% from 4.4%, indicating that demand for coal rises as heating energy mainly in the cement industry in parallel with the growth of the industrial sector. In contrast, the makeup ratio of traditional biomass, which has been consumed largely by households, in addition to the agricultural and industrial sectors, plummets from 62.5% in 2010 to 35.1% in 2025 (BAU).

The increase in traditional biomass as an absolute quantity (from 1514 Mtoe to 2233 Mtoe) can be explained by the fact that most people in local areas are prevented from shifting from biomass to LPG (for cooking, etc.) by infrastructure constraints, although energy consumption has been steadily on the rise as living standards improve[36]. Roughly the same tendency is observed for BAU revised having a 2% higher GDP growth rate.

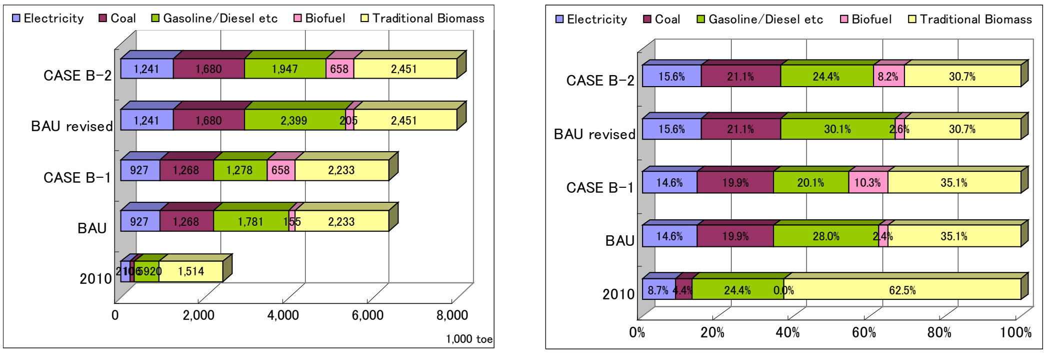


Figure 5.4-2 Energy Demand by Energy Source in 2025[37]

5.4.2 Comparison of energy demand and supply balances for 2025

(1) Analysis procedure and study method

The simulation results for individual cases are given in energy balance tables (based on IEA) attached at the end of this Chapter (Table 5.7-1 through Table 5.7-9). Figures attached at the end of this Chapter visualize the actual flow of energy sources based on these energy balance tables (Figure 5.7-1 to Figure 5.7-8). Based on the numbers in these figures and tables, the analysis in this Section is made by dividing all kinds of energy into electricity and others. This is because, as mentioned, the demand and supply balance of electricity is controlled by an export-driven approach, whereas that of fossil fuel such as petroleum products and coal is controlled by a domestic demand-driven approach. Analyzing energy demand and supply for these two types of energy, therefore, better serves to build an energy strategy for Lao PDR.

(2) Study on demand and supply balance for electricity

Figure 5.4-3 shows the electricity demand and supply balances for individual cases. Domestic demand for electricity, which was 2,441 GWh in 2010, soars 4.4 times to 10,785 GWh in 2025 for cases J-1 through C-1 (demand by BAU). Meanwhile, for CASE J-1, which adopts the demand and supply balance controlled by a domestic demand-driven approach, power generation jumps 2.9 times to 24,453 GWh, while exports increase 2.6 times to 17,238 GWh.

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[36] The tendency, which is typically associated with the initial phase of economic growth, had been observed in Indonesia, Thailand, etc.

[37] Case B-1 is based on the same demand estimation as that of BAU. The sum of petroleum products and bio fuel is the same for BAU and CASE 1; only the volume converted from gasoline and diesel fuel into bio fuel is different. The same holds true for CASE B-2 and BAU revised.

However, because the demand and supply balance of electricity is in reality controlled by the export-driven approach, CASE A-1 and CASE B-1 are closer to actual supply conditions: they are mainly based on PDP[38]. Assuming that domestic demand (final demand) is set at 100, the ratio of power generation and exports to domestic demand for each case changes dramatically from 323 and 272 in 2010 to 717 and 670 in 2025 for CASE A-1, and 753 and 666 in 2025 for CASE B-1, the exception being CASE J-1(197 and 160 in 2025).

Expansion of domestic demand and development of a strong export strategy drive these major changes. The increase in generation capacity in the future depends on the capacity expansion of IPP for exports. Because it is difficult to dynamically convert exports into domestic consumption when meeting surging domestic demand[39], an unnecessarily high export ratio to domestic demand would be undesirable from the standpoint of flexible supply. The existing IPP facilities, which are to be returned to Lao PDR from around 2023, would be beneficial for responding flexibly to domestic supply. As far as the period 2011-2025 is concerned, its effect would not be as high as might be expected at this time.

The demand and supply balance has been discussed using the assumptions for demand and supply estimations of BAU. Actually, estimated demand in PDP is higher than that of BAU, mainly due to the over-estimation of large-scale industries. As described in 5.3.4, the annual average growth rate (AAGR) of GDP needs to be 10% or more for 15 straight years (this is not precise) to meet estimated demand in PDP. Assuming that the demand estimation in PDP roughly corresponds to that of “BAU revised” for 9.1% (AAGR of GDP), PDP is assumed to be the common denominator of demand for CASE J-2, CASE A-2, CASE B-2, and CASE C-2. Except for 149 (generation) and 113 (export) in 2025 for CASE J-2, a slight relief is observed in CASE A-2 with 537 and 490 in 2025, and in CASE B-2 with 562 and 487 in 2025. CASE C-1 and CASE C-2 represent scenarios expanding the generation capacity of small hydroelectric generation, which is renewable energy (for domestic demand), instead of removing construction of power stations along the Mekong mainstream from PDP– and they are unlikely to be implemented. The ratio to domestic demand declines sharply to 516 and 464 in 2025 for CASE C-1 and to 388 and 336 in 2025 for CASE C-2.

If domestic demand based on 2% higher growth, that is to say 9.1%, occurs, the imbalance between exports and domestic demand will almost be resolved. But, as depicted in Section 5.3.4, it is doubtful whether such a high GDP growth rate is sustainable in this country.

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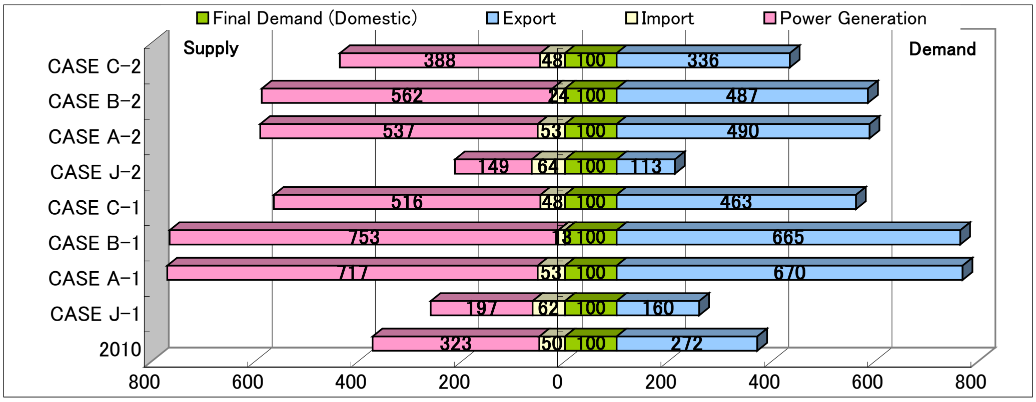
[38] For the above study, the supply condition in 2025 is assumed to remain the same as the final calendar year of PDP (2025).

[39] Although approximately 10% (case by case) of generated electricity is to be allotted for domestic consumption according to the contract (PPA) between the IPP and MEM, it is difficult to ensure flexibility because of the Take-or-Pay clause.



GWh

		2010	CASE J−1	CASE A−1	CASE B−1	CASE C−1	CASE J−2	CASE A−2	CASE B−2	CASE C−2
Gross Demand	Final Demand (Domestic)	2,441	10,785	10,785	10,785	10,785	14,433	14,433	14,433	14,433
	System Loss and others	571	3,168	10,200	10,669	7,523	3,189	10,220	10,669	7,563
	Export	6,646	17,238	72,219	71,750	49,970	16,277	70,696	70,246	48,426
	S−total	9,659	31,190	93,204	93,204	68,278	33,899	95,348	95,348	70,422
Gross Supply	Power Generation	8,449	24,453	87,537	91,847	63,150	24,635	87,719	91,847	63,515
	Import	1,210	6,738	5,667	1,357	5,128	9,264	7,629	3,501	6,907
	S−total	9,659	31,190	93,204	93,204	68,278	33,899	95,348	95,348	70,422
FD ratio to Power Generation		28.9%	44.1%	12.3%	11.7%	17.1%	58.6%	16.5%	15.7%	22.7%

Note: In the figure above final demand in each case is set at 100 (index) and, for example, the index of power generation is defined as (power generation minus system loss and others) divided by domestic demand.

Figure 5.4-3 Comparison of Each Case for Electricity Demand and Supply in 2025

Table 5.4-2 shows changes in the makeup of power sources. Hydraulic power drops from 98.6% of 2010 to 82.6% in CASE A-1 and 78.7% in CASE B-1, except for CASE J-1, which stands at 57.4% with a domestic demand-driven approach. The drop in hydraulic power is caused by the operation of coal-fired power generation. On the whole, the changes are preferable as they indicate that energy sources are becoming more diversified. The key to further lowering the ratio of hydraulic power is to increase the capacity of coal-fired power generation. As described in Chapter 3, Section 2, securing coal is of vital importance to increase the capacity of coal-fired power generation. Details are not available because a detailed investigation for coal has not been implemented.

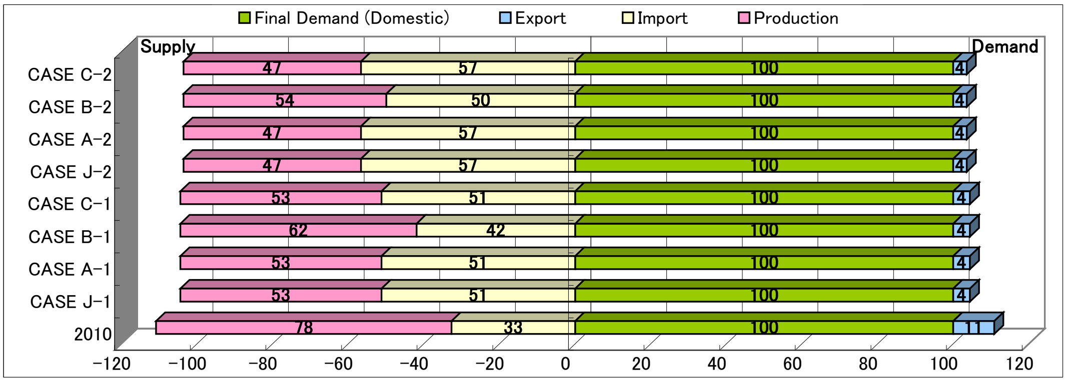
On the other hand, the usage ratio of renewable energy to total power generation is only about 5.0% in CASE B-1, even when all target values given in the renewable energy development scheme (REDS) are counted in. The ratio of renewable energy to domestic demand in 2025 remains unchanged from 5.0% in 2010 for CASE J-1 and CASE A-1, because in these cases renewable energy is not introduced. But, the ratio for CASE B-1 changes to 45.0% in 2025, because all types of renewable electricity described in REDS are to be introduced. In reality, when fluctuations in supplies of renewable electricity and economic conditions are taken into account, CASE C-1 (the ratio is 9.9%), for which small hydraulic power generation is introduced to the extent that is regarded as permissible, is considered to be preferable economically and practically.

Table 5.4-2 Comparison of Each Case for Power Supply in 2025

		2010	CASE J-1	CASE A-1	CASE B-1	CASE C-1	CASE J-2	CASE A-2	CASE B-2	CASE C-2
Conventional	Hydro	8,327	14,043	72,316	72,316	47,390	14,043	72,316	72,316	47,390
	Coal fired	0	9,871	14,682	14,682	14,682	9,871	14,682	14,682	14,682
	S-total	8,327	23,913	86,998	86,998	62,072	23,913	86,998	86,998	62,072
REDS	Small hydro	122	539	539	2,977	1,066	722	722	2,977	1,432
	Solar	0	0	0	244	0	0	0	244	0
	Wind	0	0	0	547	0	0	0	547	0
	Biomass	0	0	0	814	0	0	0	814	0
	Others	0	0	0	267	0	0	0	267	0
	S-total	122	539	539	4,849	1,066	722	722	4,849	1,432
Total Power Generation		8,449	24,453	87,537	91,847	63,138	24,635	87,719	91,847	63,504
Hydro ratio to Total Power Generation		98.6%	57.4%	82.6%	78.7%	75.1%	57.0%	82.4%	78.7%	74.6%
Coal fired ratio to Total Power Generation		0.0%	40.4%	16.8%	16.0%	23.3%	40.1%	16.7%	16.0%	23.1%
REDS ratio to Total Power Generation		1.4%	2.2%	0.6%	5.3%	1.7%	2.9%	0.8%	5.3%	2.3%
REDS ratio to Final Demand		5.0%	5.0%	5.0%	45.0%	9.9%	5.0%	5.0%	33.6%	9.9%

(3) Study on demand and supply balance of energies other than electricity

Figure 5.4-4 shows the demand and supply balance of energy other than electricity. Traditional biomass and coal are being produced in the country. Coal (except that for power generation) is supplied through the development of small to medium-sized coal mines in response to increasing domestic demand as the economy grows. When production is not sufficient, the gap between demand and supply is adjusted by imports. Because the increase in demand for petroleum products (including LPG) leads to increased imports, the ratio of imports to domestic demand inevitably rises. The ratio of imports to domestic demand, which stood at 32.7% in 2010, expands to 51.2% in CASE J-1, 51.2% in CASE A-1, 41.9% in CASE B-1, and 51.2% in CASE C-1 in 2025. As one option for reducing the dependency on imports, bio-fuel needs to be used for transportation fuels in place of gasoline and diesel fuels. However, a sharp decline in the use of petroleum products is not expected because the blending ratio of bio-fuel to transportation fuel (gasoline, diesel fuel) is set at approximately 10% at most, due to the specifications of blended fuels for automobiles. Although the ratio would become 41.9% on average for CASE B-1 if the target values of REDS were used, the number should be regarded as unrealistic when quality and economic constraints are taken into consideration. Although it would in the distant future, introduction of electric vehicles using abundant electric power might be included in the study as means of transportation in urban areas. Petroleum products meet increasing demand for transportation in a rapidly growing economy.



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	Name of Case	2010	CASE J−1	CASE A−1	CASE B−1	CASE C−1	CASE J−2	CASE A−2	CASE B−2	CASE C−2
Gross Demand	Final Demand (Domestic)	2,212	5,437	5,437	5,437	5,437	6,736	6,736	6,736	6,736
	System Loss and others	373	640	640	640	640	786	786	786	786
	Input to Power Generation	0	2,425	3,608	3,608	3,608	2,425	3,608	3,608	3,608
	Export	240	240	240	240	240	240	240	240	240
	S-total	2,825	8,741	9,924	9,924	9,924	10,187	11,369	11,369	11,369
Gross Supply	Production	2,102	5,958	7,140	7,643	7,140	6,373	7,555	8,007	7,555
	Import	723	2,783	2,783	2,280	2,783	3,814	3,814	3,361	3,814
	S-total	2,825	8,741	9,924	9,924	9,924	10,187	11,369	11,369	11,369
Import ratio to Final Demand		32.7%	51.2%	51.2%	41.9%	51.2%	56.6%	56.6%	49.9%	56.6%

Note: In the above figure the final demand of each case is set at 100 (index) and, for example, the index of production is defined as (coal production minus input to power generation minus system loss and others[40]) divided by domestic demand.

Figure 5.4-4 Comparison of Each Case for Demand and Supply in 2025 (Excluding Electricity)

Table 5.4-3 Comparison of Each Case for Final Energy Demand in 2025

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	Name of Case	2010	CASE J−1	CASE A−1	CASE B−1	CASE C−1	CASE J−2	CASE A−2	CASE B−2	CASE C−2
By Energy Source	Coal	106	1,268	1,268	1,268	1,268	1,680	1,680	1,680	1,680
	Gasoline/Diesel etc	592	1,781	1,781	1,278	1,781	2,399	2,399	1,947	2,399
	Biofuel	0	155	155	658	155	205	205	658	205
	Traditional Biomass	1,514	2,233	2,233	2,233	2,233	2,451	2,451	2,451	2,451
	S-total	2,212	5,437	5,437	5,437	5,437	6,736	6,736	6,736	6,736
By Sector	Industry	171	1,469	1,469	1,469	1,469	1,929	1,929	1,929	1,929
	Residential	1,188	1,639	1,639	1,639	1,639	1,722	1,722	1,722	1,722
	Transportation	564	1,859	1,859	1,859	1,859	2,500	2,500	2,500	2,500
	Others	288	471	471	471	471	585	585	585	585
	S-total	2,212	5,437	5,437	5,437	5,437	6,736	6,736	6,736	6,736

	Name of Case	2010	CASE J−1	CASE A−1	CASE B−1	CASE C−1	CASE J−2	CASE A−2	CASE B−2	CASE C−2
By Energy Source	Coal	4.8%	23.3%	23.3%	23.3%	23.3%	24.9%	24.9%	24.9%	24.9%
	Gasoline/Diesel etc	26.8%	32.8%	32.8%	23.5%	32.8%	35.6%	35.6%	28.9%	35.6%
	Biofuel	0.0%	2.8%	2.8%	12.1%	2.8%	3.0%	3.0%	9.8%	3.0%
	Traditional Biomass	68.5%	41.1%	41.1%	41.1%	41.1%	36.4%	36.4%	36.4%	36.4%
	S-total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
By Sector	Industry	7.7%	27.0%	27.0%	27.0%	27.0%	28.6%	28.6%	28.6%	28.6%
	Residential	53.7%	30.1%	30.1%	30.1%	30.1%	25.6%	25.6%	25.6%	25.6%
	Transportation	25.5%	34.2%	34.2%	34.2%	34.2%	37.1%	37.1%	37.1%	37.1%
	Others	13.0%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%	8.7%
	S-total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

40 System losses and others include not only transmission losses and own use by power stations, but also statistical errors and discrepancies. Transmission losses are calculated on the assumption of an annual improvement rate.

5.5 Conclusion and future agenda

5.5.1 Projection of demand and supply balance for 2025

CASE C-1 would be a desirable option for the demand and supply balance in 2025, based on the assumption of the demand estimation of BAU, which sets GDP growth at 7.1%. The major characteristics of the supply scenario in this case are given below.

(a) In the demand for electricity, the imbalance between domestic demand and exports is kept within a certain range. On the basis of cautious and accurate demand forecasting, measures are taken to head off excessive power generation installations.

(b) To secure supplies, attempts are made to increase the capacity of coal-fired power generation and promote small hydraulic power generation, which is a renewable energy. In particular, the effective use of small hydraulic power generation is favored from the viewpoint of preventing environmental destruction.

(c) With regard to renewable power generation other than small hydraulic power generation, measures are taken cautiously from the viewpoint of economy.

(d) Because the expansion of coal use hinges on potential underground reserves of coal, investigations of coal mines are promoted.

(e) Concerning increasing demand for petroleum products, bio fuel[41] is introduced to the extent that economy and quality are well maintained in the light of lowering dependency on imports (saving foreign currency).

It is considered that CASE C-1 strikes a good balance from the viewpoints of securing supply, economy, and environmental protection in comparison with CASE A-1 or CASE B-1, which correspond to the current power development plan (PDP) and renewable energy development scheme (REDS).

5.5.2 Issue of energy supply strategy

Unlike Japan, Europe, or the United States, exports of electricity from Lao PDR, together with exports of nonferrous metals, play a strategic role in earning foreign currency for the country. Therefore, this study differs essentially from examining energy supply against energy demand derived from growing economic activity in a country. In other words, it is fair to say that Lao PDR is a country that embraces an export-driven strategy and not a domestic demand-driven strategy. However, the country depends 100% on overseas sources when it comes to oil, therefore it adopts a domestic demand-driven strategy for fossil fuels when excluding electricity. Hence, Lao PDR should be regarded as a country that adopts a combined export-driven and domestic demand-driven strategy. Actually, as Lao PDR is currently in the initial phase of high growth, the aspect of a domestic demand-driven strategy is often not given

[41] Introducing bio-fuel into gasoline and diesel fuel depends on whether financial resources created by the introduction—additional tax on petroleum products and amount of foreign currencies for saving minus subsidies for bio-fuel—could be fully maintained. It is well known not to be commercially viable for bio-fuel projects without government subsidies; Brazil's ethanol is the exception in the world.

much attention while exports of electricity take center stage in most discussions.

The export strategy is the linchpin of the economic plan of Lao PDR. However, it is not clear what effect the export strategy might have on the macro-economy of the country, and what ramifications it would have for the overall demand and supply balance of energy, and as a result, how the export strategy should be positioned in relation to the energy supply strategy. Hence, a problem arises in that overall consistency has not been sufficiently addressed. If the country keeps on a path of rapid economic growth, this problem could gradually loom as a major contentious issue in the future.

5.5.3 Need to formulate energy master plan

A national energy plan is formulated from two perspectives: a general bird's-eye plan and itemized in-depth plans. In general, it is effective to draw up a plan with a three-tiered pyramid structure. In the first phase, the macro-economic framework provided by the five-year economic plan is set as a common premise. In the second phase, a comprehensive energy demand and supply plan covering all energy is formulated based on the first phase. Then, in the third phase, itemized power development plans (PDP) and renewable energy development strategy (REDS) are prepared in close relation to the second phase.

It is imperative for the comprehensive demand and supply plan for all energy to be implemented by a cross-sectional organization involving all bodies concerned with the Ministry of Energy and Mines (MEM), which oversees all energy policies at the core. This energy plan is generally called the "Energy Master Plan."

The core for drafting this demand and supply plan is a demand and supply forecasting model based on an econometric approach. In principle, the models that have been developed through this study are designed to be used for such purposes (albeit that they are analogous to a plot model). To use the models effectively and make best use of their original functions, it is of great importance to set up a full-fledged organizational system focusing on work for an energy master plan.

5.6 Technology transfer and capacity building for demand forecasting

With respect to the IEEJ model developed in this study, technical expertise on its operation and expansion has been transferred through OJT.

5.6.1 Item

(1) Transferring of IEEJ model

(2) Preparation of manuals

- Guide to Energy Demand Forecasting Model (May 24, 2012)
- A set of variables (Exogenous and Endogenous) and a set of time series data used in IEEJ model

5.6.2 Schedule for technology transfer

(1) Tasks involved in transferring IEEJ model and Simple E (Software)
(2) Explanation of how to use Simple E (Software) and exercises
(Demand estimation, modeling, and simulation)
(3) Explanation of the IEEJ model and exercise
(Structure, using variables, and energy balance tables)

Table 5.6-1 Schedule of OJT for Energy Demand Forecasting

DATE			TIME		CONTENT		
MAY	20	SUN					
	21	MON					
	22	TUE					
	23	WED	AM				
	24	THU	AM	8:00-12:00		WS2	
	25	FRI					
	26	SAT					
	27	SUN					
	28	MON	PM	13:30-15:30	1	Explanation(1)	Simple E
						Exercise(1)	Operations of IEEJ Model (tentative)
	29	TUE	AM	9:00-12:00	2	Explanation(2)	Simple E (Q&A)
						Exercise(2)	Operations of IEEJ Model (tentative)
	30	WED					
	31	THU					
JLY	22	SUN					
	23	MON					
	24	TUE	AM	9:00-12:00	4	Explanation(4)	IEEJ Model (Completion)
						Exercise(4)	Operations of IEEJ Model
	25	WED	AM	9:00-11:00	5	Preparatory	
	26	THU	AM	8:00-12:00		WS3	
	27	FRI					
	28	SAT					
	29	SUN					

5.6.3 Maintaining IEEJ model

An econometric model needs to be updated at least once every two years when time series data are revised and demand functions are re-estimated if necessary. If a new economic policy or new regulations are introduced, the structure of the model is to be reviewed. Accordingly, various follow-up training is needed for maintaining the operability of demand forecasting model.

5.7 Simulation Results: Figures and Tables

(1) Figures

Figure 5.7-1 Energy Demand and Supply Balance in 2025 (CASE J-1)
Figure 5.7-2 Energy Demand and Supply Balance in 2025 (CASE J-2)
Figure 5.7-3 Energy Demand and Supply Balance in 2025 (CASE A-1)
Figure 5.7-4 Energy Demand and Supply Balance in 2025 (CASE A-2)

(2) Tables

(3) Note

Step 1: The above tables show energy balance (the IEA standard) transformed from simulation results.

Step 2: The above figures are visualizations of energy balance tables in the form of energy flows.

Unit 1,000toe

Upper	2010
Lower	2025

Coal Input

Upper	0
Lower	2,425

Electric Power Supply

		Generation ①	Import ②	Export ③	①+②−③	Own Use, Losses, Statistical Error	Domestic Demand
Hydro	Upper	716		572	*145*		
	Lower	1,208		718	*489*		
Coal Fired	Upper	0		0	*0*		
	Lower	849		764	*85*		
Small Hydro	Upper	11	Local Production for Local Consumption		*11*		
	Lower	46			*46*		
Photovoltaic	Upper	0			*0*		
	Lower	0			*0*		
Wind	Upper	0			*0*		
	Lower	0			*0*		
Biomass & Biogas	Upper	0			*0*		
	Lower	0			*0*		
Others (Renewables)	Upper	0			*0*		
	Lower	0			*0*		
Import	Upper		104		*104*		
	Lower		579		*579*		
Total	Upper	727	104	572	*259*	-49	210
	Lower	2,103	579	1,482	*1,200*	-272	927

Final Demand by Energy Source

		Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	Upper	61	106			6	59		232
	Lower	508	1,268			26	174		1,977
Agriculture & Forestry	Upper	4			17				21
	Lower	5			30				35
Residential	Upper	81				1	1,188		1,269
	Lower	226				1	1,638		1,865
Commercial	Upper	64				1	267		332
	Lower	188				2	422		611
Transport	Upper	0		121	381	62		0	564
	Lower	0		247	1,144	313		155	1,859
Non Energy	Upper	0				3			3
	Lower	0				17			17
Total	Upper	210	106	121	398	72	1,514	0	2,422
	Lower	927	1,268	247	1,174	359	2,233	155	6,364

Coal through Biodiesel & Bioethanol total:

Upper	2,212
Lower	5,437

Other Supply

		Domestic Production ①	Import ②	Export ③	①+②−③	Statistical Error	Domestic Demand
Coal	Upper	361	34	240	*155*	-49	106
	Lower	3,077	905	240	*3,743*	-49	1,268
Gasoline	Upper		139		*139*	-18	121
	Lower		265		*265*	-18	247
Diesel Oil	Upper		478		*478*	-79	398
	Lower		1,253		*1,253*	-79	1,174
Other Petroleum Products	Upper		72		*72*	0	72
	Lower		359		*359*	0	359
Charcoal & Fuel Wood	Upper	1,514	Local Production for Local Consumption		*1,514*		1,514
	Lower	2,233			*2,233*		2,233
Biodiesel Bioethanol	Upper	0			*0*		0
	Lower	155			*155*		155
Total	Upper	1,875	723	240	*2,359*	-147	2,212
	Lower	5,465	2,783	240	*8,009*	-147	5,437

Note: Ethanol is blended with 10% of Gasoline (E10) and BDF is blended with 10% of Diesel fuel (B10)

Figure 5.7-1 Energy Demand and Supply Balance in 2025 (CASE J-1)

Unit	1,000toe
Upper	2010
Lower	2025

Coal Input

Upper	0
Lower	2,425

Electric Power Supply

		① Generation	② Import	③ Export	①+②−③
Hydro		716		572	145
		1,208		636	572
Coal Fired		0		0	0
		849		764	85
Small Hydro		11	Local Production for Local Consumption		11
		62			62
Photovoltaic		0			0
		0			0
Wind		0			0
		0			0
Biomass & Biogas		0			0
		0			0
Others (Renewables)		0			0
		0			0
Import			104		104
			797		797
Total		727	104	572	259
		2,119	797	1,400	1,515

Own Use, Losses, Statistical Error	Domestic Demand
−49	210
−274	1,241

Final Demand by Energy Source

	Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	61	106			6	59		232
	667	1,680			34	215		2,597
Agriculture & Forestry	4			17				21
	6			43				49
Residential	81				1	1,188		1,269
	310				1	1,721		2,032
Commercial	64				1	267		332
	258				2	515		775
Transport	0		121	381	62		0	564
	0		321	1,526	447		205	2,500
Non Energy	0				3			3
	0				25			25
Total	210	106	121	398	72	1,514	0	2,422
	1,241	1,680	321	1,569	509	2,451	205	7,977

2,212
6,736

Other Supply

	① Domestic Production	② Import	③ Export	①+②−③	Statistical Error	Domestic Demand
Coal	361	34	240	155	−49	106
	3,077	1,318	240	4,155	−49	1,680
Gasoline		139		139	−18	121
		339		339	−18	321
Diesel Oil		478		478	−79	398
		1,648		1,648	−79	1,569
Other Petroleum Products		72		72	0	72
		509		509	0	509
Charcoal & Fuel Wood	1,514	Local Production for Local Consumption		1,514		1,514
	2,451			2,451		2,451
Biodiesel Bioethanol	0			0		0
	205			205		205
Total	1,875	723	240	2,359	−147	2,212
	5,734	3,814	240	9,308	−147	6,736

Figure 5.7-2 Energy Demand and Supply Balance in 2025 (CASE J-2)

Unit	1,000toe
Upper	2010
Lower	2025

Coal Input

Coal Input
0
3,608

Electric Power Supply

	Generation ①	Import ②	Export ③	①+②-③	Own Use, Losses, Statistical Error	Domestic Demand
Hydro	716		572	*145*		
	6,219		5,189	*1,030*		
Coal Fired	0		0	*0*		
	1,263		1,022	*241*		
Small Hydro	11	Local Production for Local Consumption		*11*		
	46			*46*		
Photovoltaic	0			*0*		
	0			*0*		
Wind	0			*0*		
	0			*0*		
Biomass & Biogas	0			*0*		
	0			*0*		
Others (Renewables)	0			*0*		
	0			*0*		
Import		104		*104*		
		487		*487*		
Total	727	104	572	*259*	-49	210
	7,528	487	6,211	*1,805*	-877	927

Final Demand by Energy Source

	Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	61	106			6	59		232
	508	1,268			26	174		1,977
Agriculture & Forestry	4			17				21
	5			30				35
Residential	81				1	1,188		1,269
	226				1	1,638		1,865
Commercial	64				1	267		332
	188				2	422		611
Transport	0		121	381	62		0	564
	0		247	1,144	313		155	1,859
Non Energy	0				3			3
	0				17			17
Total	210	106	121	398	72	1,514	0	2,422
	927	1,268	247	1,174	359	2,233	155	6,364

2,212
5,437

Other Supply

	Domestic Production ①	Import ②	Export ③	①+②-③	Statistical Error	Domestic Demand
Coal	361	34	240	*155*	-49	106
	4,259	905	240	*4,925*	-49	1,268
Gasoline		139		*139*	-18	121
		265		*265*	-18	247
Diesel Oil		478		*478*	-79	398
		1,253		*1,253*	-79	1,174
Other Petroleum Products		72		*72*	0	72
		359		*359*	0	359
Charcoal & Fuel Wood	1,514	Local Production for Local Consumption		*1,514*		1,514
	2,233			*2,233*		2,233
Biodiesel Bioethanol	0			*0*		0
	155			*155*		155
Total	1,875	723	240	*2,359*	-147	2,212
	6,647	2,783	240	*9,191*	-147	5,437

Figure 5.7-3 Energy Demand and Supply Balance in 2025 (CASE A-1)

Unit: 1,000toe

Upper	2010
Lower	2025

Electric Power Supply

Coal Input: 0 (2010) / 3,608 (2025)

		Generation ①	Import ②	Export ③	①+②−③	Own Use, Losses, Statistical Error	Domestic Demand
Hydro	2010	716		572	*145*		
	2025	6,219		5,058	*1,161*		
Coal Fired	2010	0		0	*0*		
	2025	1,263		1,022	*241*		
Small Hydro	2010	11	Local Production for Local Consumption		*11*		
	2025	62			*62*		
Photovoltaic	2010	0			*0*		
	2025	0			*0*		
Wind	2010	0			*0*		
	2025	0			*0*		
Biomass & Biogas	2010	0			*0*		
	2025	0			*0*		
Others (Renewables)	2010	0			*0*		
	2025	0			*0*		
Import	2010		104		*104*		
	2025		656		*656*		
Total	2010	727	104	572	*259*	−49	210
	2025	7,544	656	6,080	*2,120*	−879	1,241

Final Demand by Energy Source

		Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	2010	61	106			6	59		232
	2025	667	1,680			34	215		2,597
Agriculture & Forestry	2010	4			17				21
	2025	6			43				49
Residential	2010	81				1	1,188		1,269
	2025	310				1	1,721		2,032
Commercial	2010	64				1	267		332
	2025	258				2	515		775
Transport	2010	0		121	381	62		0	564
	2025	0		321	1,526	447		205	2,500
Non Energy	2010	0				3			3
	2025	0				25			25
Total	2010	210	106	121	398	72	1,514	0	2,422
	2025	1,241	1,680	321	1,569	509	2,451	205	7,977

Coal to Biodiesel & Bioethanol combined: 2,212 (2010) / 6,736 (2025)

Other Supply

		Domestic Production ①	Import ②	Export ③	①+②−③	Statistical Error	Domestic Demand
Coal	2010	361	34	240	*155*	−49	106
	2025	4,259	1,318	240	*5,337*	−49	1,680
Gasoline	2010		139		*139*	−18	121
	2025		339		*339*	−18	321
Diesel Oil	2010		478		*478*	−79	398
	2025		1,648		*1,648*	−79	1,569
Other Petroleum Products	2010		72		*72*	0	72
	2025		509		*509*	0	509
Charcoal & Fuel Wood	2010	1,514	Local Production for Local Consumption		*1,514*		1,514
	2025	2,451			*2,451*		2,451
Biodiesel Bioethanol	2010	0			*0*		0
	2025	205			*205*		205
Total	2010	1,875	723	240	*2,359*	−147	2,212
	2025	6,916	3,814	240	*10,490*	−147	6,736

Figure 5.7-4 Energy Demand and Supply Structure in 2025 (CASE A-2)

Unit	1,000toe
Upper	2010
Lower	2025

Electric Power Supply

	Generation ①	Import ②	Export ③	①+②−③	Own Use, Losses, Statistical Error	Domestic Demand
Hydro	716		572	145		
	6,219		5,149	1,070		
Coal Fired	0		0	0		
	1,263		1,022	241		
Small Hydro	11	Local Production for Local Consumption		11		
	256			256		
Photovoltaic	0			0		
	21			21		
Wind	0			0		
	47			47		
Biomass & Biogas	0			0		
	70			70		
Others (Renewables)	0			0		
	23			23		
Import		104		104		
		117		117		
Total	727	104	572	259	−49	210
	7,899	117	6,170	1,845	−918	927

Coal Input
0
3,608

Final Demand by Energy Source

	Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	61	106			6	59		232
	508	1,268			26	174		1,977
Agriculture & Forestry	4			17				21
	5			30				35
Residential	81				1	1,188		1,269
	226				1	1,638		1,865
Commercial	64				1	267		332
	188				2	422		611
Transport	0		121	381	62		0	564
	0		0	888	313		658	1,859
Non Energy	0				3			3
	0				17			17
Total	210	106	121	398	72	1,514	0	2,422
	927	1,268	0	918	359	2,233	658	6,364

2,212
5,437

Other Supply

	Domestic Production ①	Import ②	Export ③	①+②−③	Statistical Error	Domestic Demand
Coal	361	34	240	155	−49	106
	4,259	905	240	4,925	−49	1,268
Gasoline		139		139	−18	121
		18		18	−18	0
Diesel Oil		478		478	−79	398
		997		997	−79	918
Other Petroleum Products		72		72	0	72
		359		359	0	359
Charcoal & Fuel Wood	1,514	Local Production for Local Consumption		1,514		1,514
	2,233			2,233		2,233
Biodiesel Bioethanol	0			0		0
	658			658		658
Total	1,875	723	240	2,359	−147	2,212
	7,150	2,280	240	9,191	−147	5,437

Figure 5.7-5 Energy Demand and Supply Balance in 2025 (CASE B-1)

Unit	1,000toe
Upper	2010
Lower	2025

Electric Power Supply

	Generation ①	Import ②	Export ③	①+②−③	Own Use, Losses, Statistical Error	Domestic Demand
Hydro	716		572	145		
	6,219		5,019	1,200		
Coal Fired	0		0	0		
	1,263		1,022	241		
Small Hydro	11	Local Production for Local Consumption		11		
	256			256		
Photovoltaic	0			0		
	21			21		
Wind	0			0		
	47			47		
Biomass & Biogas	0			0		
	70			70		
Others (Renewables)	0			0		
	23			23		
Import		104		104		
		301		301		
Total	727	104	572	259	−49	210
	7,899	301	6,041	2,159	−918	1,241

Coal Input
0
3,608

Final Demand by Energy Source

	Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	61	106			6	59		232
	667	1,680			34	215		2,597
Agriculture & Forestry	4			17				21
	6			43				49
Residential	81				1	1,188		1,269
	310				1	1,721		2,032
Commercial	64				1	267		332
	258				2	515		775
Transport	0		121	381	62		0	564
	0		83	1,312	447		658	2,500
Non Energy	0				3			3
	0				25			25
Total	210	106	121	398	72	1,514	0	2,422
	1,241	1,680	83	1,355	509	2,451	658	7,977

2,212
6,736

Other Supply

	Domestic Production ①	Import ②	Export ③	①+②−③	Statistical Error	Domestic Demand
Coal	361	34	240	155	−49	106
	4,259	1,318	240	5,337	−49	1,680
Gasoline		139		139	−18	121
		101		101	−18	83
Diesel Oil		478		478	−79	398
		1,434		1,434	−79	1,355
Other Petroleum Products		72		72	0	72
		509		509	0	509
Charcoal & Fuel Wood	1,514	Local Production for Local Consumption		1,514		1,514
	2,451			2,451		2,451
Biodiesel Bioethanol	0			0		0
	658			658		658
Total	1,875	723	240	2,359	−147	2,212
	7,368	3,361	240	10,490	−147	6,736

Figure 5.7-6 Energy Demand and Supply Balance in 2025 (CASE B-2)

Unit	1,000toe
Upper	2010
Lower	2025

Electric Power Supply

	Generation ①	Import ②	Export ③	①+②−③	Own Use, Losses, Statistical Error	Domestic Demand
Hydro	716		572	145		
	4,076		3,276	800		
Coal Fired	0		0	0		
	1,263		1,022	241		
Small Hydro	11	Local Production for Local Consumption		11		
	93			93		
Photovoltaic	0			0		
	0			0		
Wind	0			0		
	0			0		
Biomass & Biogas	0			0		
	0			0		
Others (Renewables)	0			0		
	0			0		
Import		104		104		
		441		441		
Total	727	104	572	259	−49	210
	5,431	441	4,297	1,574	−647	927

Coal Input
0
3,608

Final Demand by Energy Source

	Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	61	106			6	59		232
	508	1,268			26	174		1,977
Agriculture & Forestry	4			17				21
	5			30				35
Residential	81				1	1,188		1,269
	226				1	1,638		1,865
Commercial	64				1	267		332
	188				2	422		611
Transport	0		121	381	62		0	564
	0		247	1,144	313		155	1,859
Non Energy	0				3			3
	0				17			17
Total	210	106	121	398	72	1,514	0	2,422
	927	1,268	247	1,174	359	2,233	155	6,364

2,212
5,437

Other Supply

	Domestic Production ①	Import ②	Export ③	①+②−③	Statistical Error	Domestic Demand
Coal	361	34	240	155	−49	106
	4,259	905	240	4,925	−49	1,268
Gasoline		139		139	−18	121
		265		265	−18	247
Diesel Oil		478		478	−79	398
		1,253		1,253	−79	1,174
Other Petroleum Products		72		72	0	72
		359		359	0	359
Charcoal & Fuel Wood	1,514	Local Production for Local Consumption		1,514		1,514
	2,233			2,233		2,233
Biodiesel Bioethanol	0			0		0
	155			155		155
Total	1,875	723	240	2,359	−147	2,212
	6,647	2,783	240	9,191	−147	5,437

Figure 5.7-7 Energy Demand and Supply Balance in 2025 (CASE C-1)

Unit	1,000toe
Upper	2010
Lower	2025

Electric Power Supply

		Generation ①	Import ②	Export ③	①+②−③
Hydro	Upper	716		572	145
	Lower	4,076		3,143	933
Coal Fired	Upper	0		0	0
	Lower	1,263		1,022	241
Small Hydro	Upper	11	Local Production for Local Consumption		11
	Lower	124			124
Photovoltaic	Upper	0			0
	Lower	0			0
Wind	Upper	0			0
	Lower	0			0
Biomass & Biogas	Upper	0			0
	Lower	0			0
Others (Renewables)	Upper	0			0
	Lower	0			0
Import	Upper		104		104
	Lower		594		594
Total	Upper	727	104	572	259
	Lower	5,462	594	4,165	1,892

Coal Input	
Upper	0
Lower	3,608

	Own Use, Losses, Statistical Error	Domestic Demand
Upper	−49	210
Lower	−650	1,241

Final Demand by Energy Source

		Electricity	Coal	Gasoline	Diesel Oil	Other Petroleum Products	Charcoal & Fuel Wood	Biodiesel & Bioethanol	Total
Industry	Upper	61	106			6	59		232
	Lower	667	1,680			34	215		2,597
Agriculture & Forestry	Upper	4			17				21
	Lower	6			43				49
Residential	Upper	81				1	1,188		1,269
	Lower	310				1	1,721		2,032
Commercial	Upper	64				1	267		332
	Lower	258				2	515		775
Transport	Upper	0		121	381	62		0	564
	Lower	0		321	1,526	447		205	2,500
Non Energy	Upper	0				3			3
	Lower	0				25			25
Total	Upper	210	106	121	398	72	1,514	0	2,422
	Lower	1,241	1,680	321	1,569	509	2,451	205	7,977

	Total (Coal to Biodiesel & Bioethanol)
Upper	2,212
Lower	6,736

Other Supply

		Domestic Production ①	Import ②	Export ③	①+②−③	Statistical Error	Domestic Demand
Coal	Upper	361	34	240	155	−49	106
	Lower	4,259	1,318	240	5,337	−49	1,680
Gasoline	Upper		139		139	−18	121
	Lower		339		339	−18	321
Diesel Oil	Upper		478		478	−79	398
	Lower		1,648		1,648	−79	1,569
Other Petroleum Products	Upper		72		72	0	72
	Lower		509		509	0	509
Charcoal & Fuel Wood	Upper	1,514	Local Production for Local Consumption		1,514		1,514
	Lower	2,451			2,451		2,451
Biodiesel Bioethanol	Upper	0			0		0
	Lower	205			205		205
Total	Upper	1,875	723	240	2,359	−147	2,212
	Lower	6,916	3,814	240	10,490	−147	6,736

Figure 5.7-8 Energy Demand and Supply Balance in 2025 (CASE C-2)

Table 5.7-1 Energy Balance Table (2010)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	TL
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	360.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,740.9	1,740.9	0.0	716.1	0.0	0.0	10.5		**2,828.3**
2	IM	Import	34.2	689.0	139.1	62.1	477.6	5.7	2.8	1.7	0.0	0.0	0.0	0.0	0.0					104.0	**827.3**
3	PR	**Total Primary Energy Supply**	**395.0**	**689.0**	**139.1**	**62.1**	**477.6**	**5.7**	**2.8**	**1.7**	**0.0**	**0.0**	**1,740.9**	**1,740.9**	**0.0**	**716.1**	**0.0**	**0.0**	**10.5**	**104.0**	**3,655.5**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−571.6	**−811.2**
5	PD	**Domestic Primary Energy Supply**	**155.4**	**689.0**	**139.1**	**62.1**	**477.6**	**5.7**	**2.8**	**1.7**	**0.0**	**0.0**	**1,740.9**	**1,740.9**	**0.0**	**716.1**	**0.0**	**0.0**	**10.5**	**−467.6**	**2,844.3**
6	PU	Power Generation (EDL)	0.0	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−716.1	0.0	0.0	−10.5	726.6	**−0.0**
7	OT	Others (transformation)											−226.7	−354.9	128.2						**−226.7**
8	OU	Own Use & Losses																		−30.0	**−30.0**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**106.2**	**591.7**	**121.0**	**62.1**	**398.4**	**5.7**	**2.8**	**1.7**	**0.0**	**0.0**	**1,514.2**	**1,385.9**	**128.2**					**209.9**	**2,422.0**
11	IN	Industry	106.2	6.0	0.0	0.0	0.0	5.7	0.0	0.2	0.0	0.0	59.2	59.2	0.0					60.8	**232.2**
12	AF	Agriculture & Forestry	0.0	17.2	0.0	0.0	17.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					3.7	**20.9**
13	HS	Residential	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	1,187.8	1,125.3	62.5					81.1	**1,269.4**
14	CM	Commercial	0.0	0.9	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	267.1	201.4	65.8					64.4	**332.4**
15	TN	Transport	0.0	564.3	121.0	62.1	381.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**564.3**
16	NE	Non Energy	0.0	2.8	0.0	0.0	0.0	0.0	2.8	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**2.8**

Table 5.7-2 Energy Balance Table in 2025 (CASE J-1)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	**TL**
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	3,077.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	127.1	27.5	2,726.5	2,726.5	0.0	1,207.7	0.0	0.0	46.4		**7,212.2**
2	IM	Import	905.3	1,878.0	265.2	312.6	1,253.3	26.0	17.5	3.4	0.0	0.0	0.0	0.0	0.0					579.4	**3,362.8**
3	PR	**Total Primary Energy Supply**	**3,982.4**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**1,207.7**	**0.0**	**0.0**	**46.4**	**579.4**	**10,575.0**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−1,482.4	**−1,722.1**
5	PD	**Domestic Primary Energy Supply**	**3,742.8**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**1,207.7**	**0.0**	**0.0**	**46.4**	**−903.0**	**8,852.9**
6	PU	Power Generation (EDL)	−2,425.4	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−1,207.7	0.0	0.0	−46.4	2,102.9	**−1,576.5**
7	OT	Others (transformation)											−493.2	−772.1	278.9						**−493.2**
8	OU	Own Use & Losses																		−253.3	**−253.3**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,268.2**	**1,780.7**	**247.1**	**312.6**	**1,174.2**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,233.3**	**1,954.4**	**278.9**					**927.5**	**6,364.3**
11	IN	Industry	1,268.2	26.4	0.0	0.0	0.0	26.0	0.0	0.4	0.0	0.0	174.1	174.1	0.0					508.5	**1,977.1**
12	AF	Agriculture & Forestry	0.0	29.9	0.0	0.0	29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					4.8	**34.8**
13	HS	Residential	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1,637.7	1,476.5	161.2					226.3	**1,865.1**
14	CM	Commercial	0.0	1.9	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	421.5	303.8	117.8					187.9	**611.3**
15	TN	Transport	0.0	1,704.0	247.1	312.6	1,144.2	0.0	0.0	0.0	127.1	27.5	0.0	0.0	0.0					0.0	**1,858.6**
16	NE	Non Energy	0.0	17.5	0.0	0.0	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**17.5**

Table 5.7-3 Energy Balance Table in 2025 (CASE J-2)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	TL
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	Total
1	DP	Domestic Production	3,077.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	169.5	35.7	3,090.5	3,090.5	0.0	1,207.7	0.0	0.0	62.1		**7,642.5**
2	IM	Import	1,317.6	2,496.2	339.5	447.3	1,647.8	33.2	24.6	3.8	0.0	0.0	0.0	0.0	0.0					796.7	**4,610.4**
3	PR	**Total Primary Energy Supply**	**4,394.6**	**2,496.2**	**339.5**	**447.3**	**1,647.8**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**3,090.5**	**3,090.5**	**0.0**	**1,207.7**	**0.0**	**0.0**	**62.1**	**796.7**	**12,252.9**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−1,399.8	**−1,639.4**
5	PD	**Domestic Primary Energy Supply**	**4,155.0**	**2,496.2**	**339.5**	**447.3**	**1,647.8**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**3,090.5**	**3,090.5**	**0.0**	**1,207.7**	**0.0**	**0.0**	**62.1**	**−603.2**	**10,613.5**
6	PU	Power Generation (EDL)	−2,425.4	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−1,207.7	0.0	0.0	−62.1	2,118.6	**−1,576.5**
7	OT	Others (transformation)											−639.3	−1,000.8	361.5						**−639.3**
8	OU	Own Use & Losses																		−255.1	**−255.1**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,680.4**	**2,398.9**	**321.4**	**447.3**	**1,568.6**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**2,451.2**	**2,089.7**	**361.5**					**1,241.2**	**7,976.9**
11	IN	Industry	1,680.4	33.6	0.0	0.0	0.0	33.2	0.0	0.4	0.0	0.0	215.1	215.1	0.0					667.5	**2,596.6**
12	AF	Agriculture & Forestry	0.0	42.7	0.0	0.0	42.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					6.1	**48.8**
13	HS	Residential	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1,721.1	1,511.1	210.0					309.7	**2,031.9**
14	CM	Commercial	0.0	2.2	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	515.0	363.5	151.6					257.9	**775.2**
15	TN	Transport	0.0	2,294.6	321.4	447.3	1,525.9	0.0	0.0	0.0	169.5	35.7	0.0	0.0	0.0					0.0	**2,499.9**
16	NE	Non Energy	0.0	24.6	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**24.6**

Table 5.7-4 Energy Balance Table in 2025 (CASE A-1)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	TL
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	4,259.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	127.1	27.5	2,726.5	2,726.5	0.0	6,219.2	0.0	0.0	46.4		**13,405.9**
2	IM	Import	905.3	1,878.0	265.2	312.6	1,253.3	26.0	17.5	3.4	0.0	0.0	0.0	0.0	0.0					487.3	**3,270.7**
3	PR	**Total Primary Energy Supply**	**5,164.6**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**6,219.2**	**0.0**	**0.0**	**46.4**	**487.3**	**16,676.6**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−6,210.8	**−6,450.5**
5	PD	**Domestic Primary Energy Supply**	**4,925.0**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**6,219.2**	**0.0**	**0.0**	**46.4**	**−5,723.5**	**10,226.1**
6	PU	Power Generation (EDL)	−3,607.6	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−6,219.2	0.0	0.0	−46.4	7,528.2	**−2,344.9**
7	OT	Others (transformation)											−493.2	−772.1	278.9						**−493.2**
8	OU	Own Use & Losses																		−858.0	**−858.0**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,268.2**	**1,780.7**	**247.1**	**312.6**	**1,174.2**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,233.3**	**1,954.4**	**278.9**					**927.5**	**6,364.3**
11	IN	Industry	1,268.2	26.4	0.0	0.0	0.0	26.0	0.0	0.4	0.0	0.0	174.1	174.1	0.0					508.5	**1,977.1**
12	AF	Agriculture & Forestry	0.0	29.9	0.0	0.0	29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					4.8	**34.8**
13	HS	Residential	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1,637.7	1,476.5	161.2					226.3	**1,865.1**
14	CM	Commercial	0.0	1.9	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	421.5	303.8	117.8					187.9	**611.3**
15	TN	Transport	0.0	1,704.0	247.1	312.6	1,144.2	0.0	0.0	0.0	127.1	27.5	0.0	0.0	0.0					0.0	**1,858.6**
16	NE	Non Energy	0.0	17.5	0.0	0.0	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**17.5**

Table 5.7-5 Energy Balance Table in 2025 (CASE A-2)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT							BD	BE	FC			HD	PV	WP	OT	EL	TL
					GA	JT	DS	HO	OP	LP				FW	CH						
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	4,259.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	169.5	35.7	3,090.5	3,090.5	0.0	6,219.2	0.0	0.0	62.1		**13,836.2**
2	IM	Import	1,317.6	2,496.2	339.5	447.3	1,647.8	33.2	24.6	3.8	0.0	0.0	0.0	0.0	0.0					656.1	**4,469.8**
3	PR	**Total Primary Energy Supply**	**5,576.8**	**2,496.2**	**339.5**	**447.3**	**1,647.8**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**3,090.5**	**3,090.5**	**0.0**	**6,219.2**	**0.0**	**0.0**	**62.1**	**656.1**	**18,306.0**
4	EX	Export	-239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					-6,079.8	**-6,319.4**
5	PD	**Domestic Primary Energy Supply**	**5,337.2**	**2,496.2**	**339.5**	**447.3**	**1,647.8**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**3,090.5**	**3,090.5**	**0.0**	**6,219.2**	**0.0**	**0.0**	**62.1**	**-5,423.8**	**11,986.5**
6	PU	Power Generation (EDL)	-3,607.6	-0.0	0.0	0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-6,219.2	0.0	0.0	-62.1	7,543.9	**-2,344.9**
7	OT	Others (transformation)											-639.3	-1,000.8	361.5						**-639.3**
8	OU	Own Use & Losses																		-859.7	**-859.7**
9	SD	Statistical Difference	-49.3	-97.3	-18.1	0.0	-79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					-19.2	**-165.7**
10	FD	**Total Final Energy Demand**	**1,680.4**	**2,398.9**	**321.4**	**447.3**	**1,568.6**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**2,451.2**	**2,089.7**	**361.5**					**1,241.2**	**7,976.9**
11	IN	Industry	1,680.4	33.6	0.0	0.0	0.0	33.2	0.0	0.4	0.0	0.0	215.1	215.1	0.0					667.5	**2,596.6**
12	AF	Agriculture & Forestry	0.0	42.7	0.0	0.0	42.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					6.1	**48.8**
13	HS	Residential	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1,721.1	1,511.1	210.0					309.7	**2,031.9**
14	CM	Commercial	0.0	2.2	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	515.0	363.5	151.6					257.9	**775.2**
15	TN	Transport	0.0	2,294.6	321.4	447.3	1,525.9	0.0	0.0	0.0	169.5	35.7	0.0	0.0	0.0					0.0	**2,499.9**
16	NE	Non Energy	0.0	24.6	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**24.6**

Table 5.7-6 Energy Balance Table in 2025 (CASE B-1)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	TL
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	4,259.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	383.0	274.6	2,726.5	2,726.5	0.0	6,219.2	21.0	47.0	349.0		**14,279.5**
2	IM	Import	905.3	1,375.0	18.1	312.6	997.5	26.0	17.5	3.4	0.0	0.0	0.0	0.0	0.0					116.7	**2,397.1**
3	PR	**Total Primary Energy Supply**	**5,164.6**	**1,375.0**	**18.1**	**312.6**	**997.5**	**26.0**	**17.5**	**3.4**	**383.0**	**274.6**	**2,726.5**	**2,726.5**	**0.0**	**6,219.2**	**21.0**	**47.0**	**349.0**	**116.7**	**16,676.6**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−6,170.5	**−6,410.1**
5	PD	**Domestic Primary Energy Supply**	**4,925.0**	**1,375.0**	**18.1**	**312.6**	**997.5**	**26.0**	**17.5**	**3.4**	**383.0**	**274.6**	**2,726.5**	**2,726.5**	**0.0**	**6,219.2**	**21.0**	**47.0**	**349.0**	**−6,053.8**	**10,266.5**
6	PU	Power Generation (EDL)	−3,607.6	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−6,219.2	−21.0	−47.0	−349.0	7,898.8	**−2,344.9**
7	OT	Others (transformation)											−493.2	−772.1	278.9						**−493.2**
8	OU	Own Use & Losses																		−898.4	**−898.4**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,268.2**	**1,277.8**	**0.0**	**312.6**	**918.3**	**26.0**	**17.5**	**3.4**	**383.0**	**274.6**	**2,233.3**	**1,954.4**	**278.9**					**927.5**	**6,364.3**
11	IN	Industry	1,268.2	26.4	0.0	0.0	0.0	26.0	0.0	0.4	0.0	0.0	174.1	174.1	0.0					508.5	**1,977.1**
12	AF	Agriculture & Forestry	0.0	29.9	0.0	0.0	29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					4.8	**34.8**
13	HS	Residential	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1,637.7	1,476.5	161.2					226.3	**1,865.1**
14	CM	Commercial	0.0	1.9	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	421.5	303.8	117.8					187.9	**611.3**
15	TN	Transport	0.0	1,201.0	0.0	312.6	888.4	0.0	0.0	0.0	383.0	274.6	0.0	0.0	0.0					0.0	**1,858.6**
16	NE	Non Energy	0.0	17.5	0.0	0.0	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**17.5**

Table 5.7-7 Energy Balance Table in 2025 (CASE B-2)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	**TL**
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	4,259.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	383.0	274.6	3,090.5	3,090.5	0.0	6,219.2	21.0	47.0	349.0		**14,643.4**
2	IM	Import	1,317.6	2,043.8	100.6	447.3	1,434.3	33.2	24.6	3.8	0.0	0.0	0.0	0.0	0.0					301.1	**3,662.5**
3	PR	**Total Primary Energy Supply**	**5,576.8**	**2,043.8**	**100.6**	**447.3**	**1,434.3**	**33.2**	**24.6**	**3.8**	**383.0**	**274.6**	**3,090.5**	**3,090.5**	**0.0**	**6,219.2**	**21.0**	**47.0**	**349.0**	**301.1**	**18,306.0**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−6,041.2	**−6,280.8**
5	PD	**Domestic Primary Energy Supply**	**5,337.2**	**2,043.8**	**100.6**	**447.3**	**1,434.3**	**33.2**	**24.6**	**3.8**	**383.0**	**274.6**	**3,090.5**	**3,090.5**	**0.0**	**6,219.2**	**21.0**	**47.0**	**349.0**	**−5,740.0**	**12,025.2**
6	PU	Power Generation (EDL)	−3,607.6	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−6,219.2	−21.0	−47.0	−349.0	7,898.8	**−2,344.9**
7	OT	Others (transformation)											−639.3	−1,000.8	361.5						**−639.3**
8	OU	Own Use & Losses																		−898.4	**−898.4**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,680.4**	**1,946.6**	**82.5**	**447.3**	**1,355.2**	**33.2**	**24.6**	**3.8**	**383.0**	**274.6**	**2,451.2**	**2,089.7**	**361.5**					**1,241.2**	**7,976.9**
11	IN	Industry	1,680.4	33.6	0.0	0.0	0.0	33.2	0.0	0.4	0.0	0.0	215.1	215.1	0.0					667.5	**2,596.6**
12	AF	Agriculture & Forestry	0.0	42.7	0.0	0.0	42.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					6.1	**48.8**
13	HS	Residential	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1,721.1	1,511.1	210.0					309.7	**2,031.9**
14	CM	Commercial	0.0	2.2	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	515.0	363.5	151.6					257.9	**775.2**
15	TN	Transport	0.0	1,842.3	82.5	447.3	1,312.5	0.0	0.0	0.0	383.0	274.6	0.0	0.0	0.0					0.0	**2,499.9**
16	NE	Non Energy	0.0	24.6	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**24.6**

Table 5.7-8 Energy Balance Table in 2025 (CASE C-1)

(1,000 toe)

			1 CL Coal	2 PT Petroleum Products	3 GA Gasoline	4 JT Jet Fuel	5 DS Diesel Oil	6 HO Heavy Oil	7 OP Other Petroleum Products	8 LP LPG	9 BD Biodiesel	10 BE Bioethanol	11 FC FuelWood & Charcoal	12 FW FuelWood	13 CH Charcoal	14 HD Hydro	15 PV Photovoltaic	16 WP Wind Power	17 OT Others (Renewables)	18 EL Electricity	21 TL Total
1	DP	Domestic Production	4,259.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	127.1	27.5	2,726.5	2,726.5	0.0	4,075.5	0.0	0.0	92.7		**11,308.6**
2	IM	Import	905.3	1,878.0	265.2	312.6	1,253.3	26.0	17.5	3.4	0.0	0.0	0.0	0.0	0.0					441.0	**3,224.3**
3	PR	**Total Primary Energy Supply**	**5,164.6**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**4,075.5**	**0.0**	**0.0**	**92.7**	**441.0**	**14,532.9**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−4,297.4	**−4,537.1**
5	PD	**Domestic Primary Energy Supply**	**4,925.0**	**1,878.0**	**265.2**	**312.6**	**1,253.3**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,726.5**	**2,726.5**	**0.0**	**4,075.5**	**0.0**	**0.0**	**92.7**	**−3,856.5**	**9,995.9**
6	PU	Power Generation (EDL)	−3,607.6	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−4,075.5	0.0	0.0	−92.7	5,430.9	**−2,344.9**
7	OT	Others (transformation)											−493.2	−772.1	278.9						**−493.2**
8	OU	Own Use & Losses																		−627.8	**−627.8**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,268.2**	**1,780.7**	**247.1**	**312.6**	**1,174.2**	**26.0**	**17.5**	**3.4**	**127.1**	**27.5**	**2,233.3**	**1,954.4**	**278.9**					**927.5**	**6,364.3**
11	IN	Industry	1,268.2	26.4	0.0	0.0	0.0	26.0	0.0	0.4	0.0	0.0	174.1	174.1	0.0					508.5	**1,977.1**
12	AF	Agriculture & Forestry	0.0	29.9	0.0	0.0	29.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					4.8	**34.8**
13	HS	Residential	0.0	1.1	0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1,637.7	1,476.5	161.2					226.3	**1,865.1**
14	CM	Commercial	0.0	1.9	0.0	0.0	0.0	0.0	0.0	1.9	0.0	0.0	421.5	303.8	117.8					187.9	**611.3**
15	TN	Transport	0.0	1,704.0	247.1	312.6	1,144.2	0.0	0.0	0.0	127.1	27.5	0.0	0.0	0.0					0.0	**1,858.6**
16	NE	Non Energy	0.0	17.5	0.0	0.0	0.0	0.0	17.5	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**17.5**

Table 5.7-9 Energy Balance Table in 2025 (CASE C-2)

(1,000 toe)

			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	21
			CL	PT	GA	JT	DS	HO	OP	LP	BD	BE	FC	FW	CH	HD	PV	WP	OT	EL	TL
			Coal	Petroleum Products	Gasoline	Jet Fuel	Diesel Oil	Heavy Oil	Other Petroleum Products	LPG	Biodiesel	Bioethanol	FuelWood & Charcoal	FuelWood	Charcoal	Hydro	Photovoltaic	Wind Power	Others (Renewables)	Electricity	**Total**
1	DP	Domestic Production	4,259.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	169.5	35.7	3,090.5	3,090.5	0.0	4,075.5	0.0	0.0	124.1		**11,754.6**
2	IM	Import	1,317.6	2,496.2	339.5	447.3	1,647.8	33.2	24.6	3.8	0.0	0.0	0.0	0.0	0.0					594.0	**4,407.7**
3	PR	**Total Primary Energy Supply**	**5,576.8**	**2,496.2**	**339.5**	**447.3**	**1,647.8**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**3,090.5**	**3,090.5**	**0.0**	**4,075.5**	**0.0**	**0.0**	**124.1**	**594.0**	**16,162.3**
4	EX	Export	−239.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−4,164.7	**−4,404.3**
5	PD	**Domestic Primary Energy Supply**	**5,337.2**	**2,496.2**	**339.5**	**447.3**	**1,647.8**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**3,090.5**	**3,090.5**	**0.0**	**4,075.5**	**0.0**	**0.0**	**124.1**	**−3,570.7**	**11,758.1**
6	PU	Power Generation (EDL)	−3,607.6	−0.0	0.0	0.0	−0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	−4,075.5	0.0	0.0	−124.1	5,462.3	**−2,344.9**
7	OT	Others (transformation)											−639.3	−1,000.8	361.5						**−639.3**
8	OU	Own Use & Losses																		−631.3	**−631.3**
9	SD	Statistical Difference	−49.3	−97.3	−18.1	0.0	−79.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					−19.2	**−165.7**
10	FD	**Total Final Energy Demand**	**1,680.4**	**2,398.9**	**321.4**	**447.3**	**1,568.6**	**33.2**	**24.6**	**3.8**	**169.5**	**35.7**	**2,451.2**	**2,089.7**	**361.5**					**1,241.2**	**7,976.9**
11	IN	Industry	1,680.4	33.6	0.0	0.0	0.0	33.2	0.0	0.4	0.0	0.0	215.1	215.1	0.0					667.5	**2,596.6**
12	AF	Agriculture & Forestry	0.0	42.7	0.0	0.0	42.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0					6.1	**48.8**
13	HS	Residential	0.0	1.2	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	1,721.1	1,511.1	210.0					309.7	**2,031.9**
14	CM	Commercial	0.0	2.2	0.0	0.0	0.0	0.0	0.0	2.2	0.0	0.0	515.0	363.5	151.6					257.9	**775.2**
15	TN	Transport	0.0	2,294.6	321.4	447.3	1,525.9	0.0	0.0	0.0	169.5	35.7	0.0	0.0	0.0					0.0	**2,499.9**
16	NE	Non Energy	0.0	24.6	0.0	0.0	0.0	0.0	24.6	0.0	0.0	0.0	0.0	0.0	0.0					0.0	**24.6**

6 Investment Plan

6.1 Energy Investment Plan

6.1.1 Energy Supply Scenario and Investment Plan

The way forward has been clarified for structuring the energy supply scenario. Therefore, further review and deeper discussions on the energy supply scenario will be conducted for each energy source. To review the energy supply scenario, the JICA Study Team members pay attention to the policy and plans announced by Lao PDR. Issues to match energy supply based on the policy and plans of Lao PDR will be identified and reviewed later to structure an energy supply scenario for each energy source. An investment plan will be completed in accordance with the final energy supply scenario.

Through discussions among stakeholders of the study, the following four items will be considered as possible investment concepts in Lao PDR. Each concept is to be evaluated to identify the economic viability of investments.

(a) Mining activities for domestic fossil fuels (coal etc.)

(b) Infrastructure development activities (road, railway, pipeline business) for importation and domestic distribution of fossil fuels

(c) Thermal power station development activities (domestic and neighboring countries)

(d) Renewable energy (including biomass) development activities

As the study advanced, it was mutually understood that (b) Infrastructure development activities (road, railway, pipeline) intended for importation and domestic distribution of fossil fuels was not identified as a practical idea to be studied in the investment plan. Considering the results of discussions, the following investment plans are to be reviewed in the following study.

(a) Mining activities for domestic coal and coal thermal power development activities

(b) Renewable energy development (1 MW Solar/ Wind)

(c) Small-scale hydropower (less than 15 MW)

(d) Bio fuels (annual output 50,000-ton level)

To review coal thermal power projects and renewable energy projects, case studies are to be conducted considering fundamental conditions. Prioritization of project ideas follows economic evaluation.

15 MW is selected as the maximum capacity of a hydropower project with investment mainly from the private sector. This is because anything above medium scale, including 15 MW, is promoted by EdL as a public utility business.

6.1.2 Energy Investment and Government Assistance

One good example of (a) Mining activities for domestic coal and coal thermal power development activities is the Hongsa Mine-Mouth Power Project (Hongsa Power), which is under construction. In a follow-up study, identifying and confirming potential coal mines, a similar project idea to Hongsa Mine-Mouth Power Project may be reviewed and evaluated. At this stage, therefore, objectives of the investment plan other than (a) Mining activities of domestic coal and coal thermal power development activities, i.e., renewable energy investment, will be reviewed.

The installed capacity of five small-scale hydropower stations amounts to 14 MW in total in Lao PDR. Referring to the potential of 2,000 MW of small-scale hydropower to be developed further, no detailed data have been identified.

According to Lao PDR, the grid-connected system of Sola PV and Wind power are expected to be investment opportunities with greater potential. However, there are not likely to be commercial loans for those projects at present, because sales to end users will not be sufficient to cover the initial investment cost of renewable energy, which is normally more than conventional investments, operation and maintenance costs, and a reasonable margin. Therefore, private loans from commercial banks may not be available.

For those cases, the government usually promotes investments that provide effective assistance. For the initial investment cost, the following are typical government solutions, i.e., subsidy, soft loans, accelerated depreciation, and tax reductions for capital expenditures. Because of the high costs, renewable energy is usually considered to be one of the least viable technologies for investment. As an effective way to promote more investment for renewable energy, a feed-in tariff is promoted as a typical solution to plug the gap between invested cost and available return.

6.1.3 Lao Rural Electrification Investment and Assistance (Rural Electrification Fund)

Since 2001, the World Bank has carried out the Implementation Support for the Rural Electrification Program (REP). REP Phase I[42](REP I) is scheduled to be completed in April 2012 followed by REP Phase II[43](REP II), which will be conducted until 2014. REP is being implemented both through solar photovoltaic systems, i.e., solar home systems (SHS), and grid extension to develop rural energy access. To achieve a higher electrification rate in rural communities, a capacity of 20~40 Wp SHS is sold through a sales scheme[44] to rural households with monthly installments. Because size and capacity are relatively small, the unit price is not too high. However, the average price of US$500 is not cheap for rural households in remote areas in Lao to purchase in a lump sum in cash. The World Bank, therefore, has designed and introduced a longer-term payment scheme of 10 years.

Ownership of SHS is transferred to the household after completion of installments. However, SHS is installed with a battery and controller to charge energy in battery to use electricity at

[42] Installed numbers are 16,000 households

[43] The budget is US$5 million in total, US$3 million from IDB grants and US$2 million from Ausaid. Planned number of installations is 15,000 households.

[44] Hire and Purchase scheme

night, which requires operation and maintenance works. REP I introduced ESCO for operation and maintenance of SHS. Services from ESCO to repair and replace batteries and controllers are paid by users as fee-for-services.

Ten years is the maximum time limit of installments under the hire-and-purchase scheme. The monthly charge per unit is US$ 2-3, which consists of the following costs:

(a) 50% of initial cost

(b) Salary, expenses, and incentive required for ESCO business

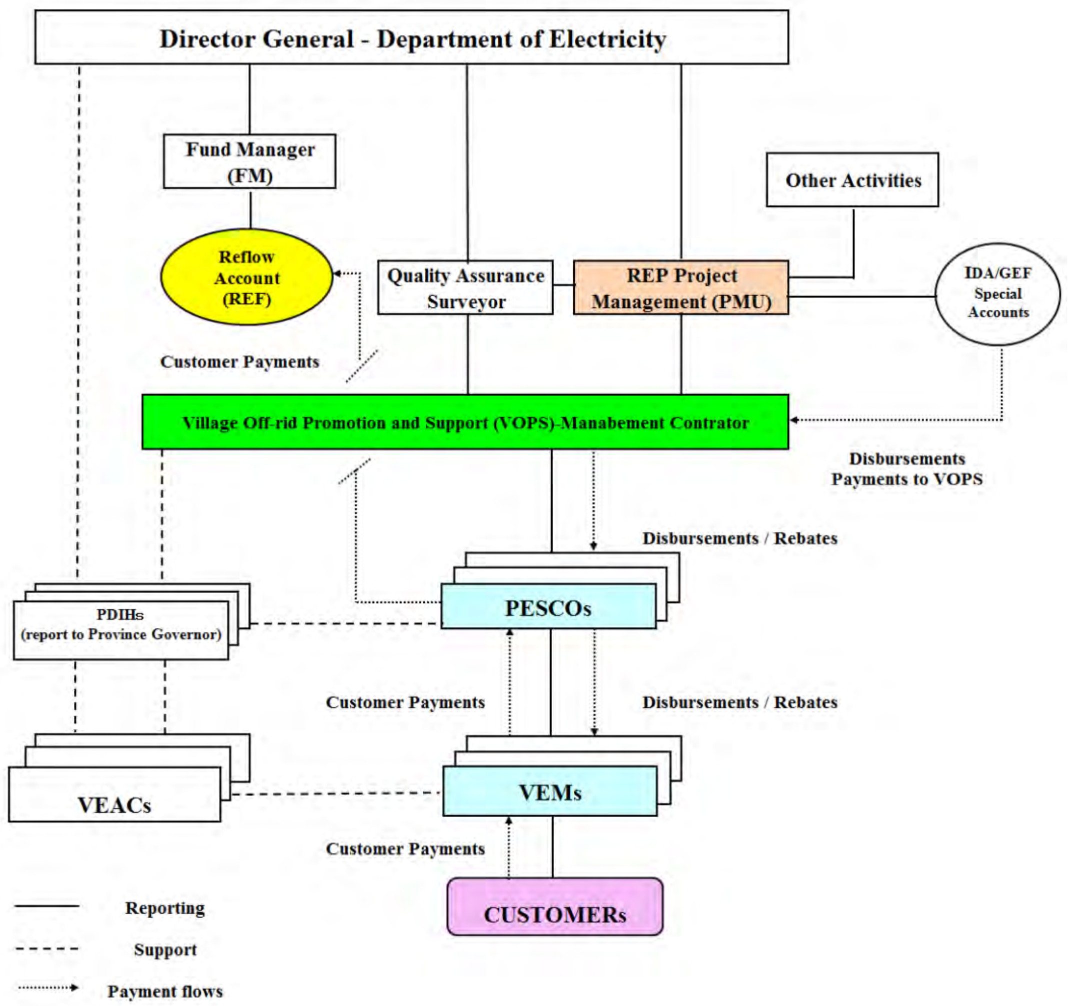
(c) Salary, expenses, and incentive for operators selected in communities

Monthly fees are collected and transferred from communities to Vientiane, MEM. Balances of the collected cash deducted by each village manager and ESCO for costs and incentives are pooled in the Rural Electrification Fund (REF), which is a revolving fund under the management of MEM for promoting further rural electrification. Figure 6.1–1 shows the structure of REF together with cash flow and work flow for both REP I & II. The main organization handling REF is VOPS[45], which is appointed by PMU[46] through an open tender organized by MEM. A French consultant, Innovative Energy Development, was selected in REP I. For REP II, Envir Tech Consultant Co. Ltd./Green Energy Company Limited, a joint venture between Thailand and Lao PDR was appointed in February 2012.

Solar home systems are installed under a grant from the World Bank and other donors. We may consider grant money for REP I & II as a capital investment from international donors to promote rural electrification. Manpower costs and expenses including incentives for village managers and ESCOs are similar to running costs for maintaining solar home systems. Initial investment cost, therefore, is recovered from the balance of installments after deducting operation and maintenance costs, together with incentives for village managers and ESCOs. Although the initial cost will not be repaid in full because of the insufficient components of the monthly charge as described above, e.g., only 50% of the initial cost is included, as we identified, the fund is reserved within REF as a revolving fund to promote further rural electrification, which may enable REP I & II to be considered reasonable investments for rural electrification.

[45] Village Off-grid Promotion and Support

[46] Project Management Unit



Source: JICA Project Study: "Financial Mechanism for Renewable Energy Promotion"

Figure 6.1-1 Rural Electrification Fund

6.1.4 Lao Rural Electrification Investment and Assistance (Power to the Poor：P2P)

REP implemented by the World Bank is a project consisting of solar home systems as reviewed in 7.3.3 and grid extension to promote rural electrification. As is often the case with remote villages without access to electricity, the local economies are very weak. Poor households are generally identified as using kerosene lamps and radio cassettes with dry cells. Some households are wealthy enough to purchase car batteries, which enable them to watch TV and use other electrical appliances.

Because the grid network has been rapidly extended in Lao PDR, the numbers of households with access to the EdL grid are increasing in remote areas. However, not all households are connected to the grid because of high connection fees, even including those living near EdL poles. Grid extension, a typical infrastructure investment, cannot be necessarily connect subscribers among poor rural households, which is considered to be one of the barriers to recovering a sufficient return on investment.

According to a report[47] by the World Bank, in September 2008, a support program was established and implemented to enhance connections to the grid. The program was named Power to the Poor (P2P). The program aims to assist poorer households living in villages to connect to the extended grid. If poorer households, the majority being in remote villages, can access the EdL grid, infrastructure investment is expected to have a greater return on investment by collecting connection fees and electricity subscription fees.

Source: World Bank

Figure 6.1-2 Power to the Poor (P2P)

The connection fee is US$100, which consists of the following:

(a) House wiring

(b) Cable connecting poles and houses

(c) Meter and meter box

Many households earn less than US$500 a year in villages without electricity. Therefore, it is not so easy for them to pay US$100 in a lump sum. Considering credit for those households as being indispensable, it is an issue that local commercial banks do not provide such small

[47] http://blogs.worldbank.org/eastasiapacific/node/2948

loans. The World Bank established microcredits for energy supplies to poor households accessing the grid. In EdL, a revolving fund was established with a grant from the World Bank. Late in 2008, a pilot project was implemented to promote connection of the poorer households to the grid among 20 villages in Chanpasak Province. A special subsidy to cancel the meter fee of US$20 reduced the connection fee from US$100 to US$80. Microfinance was executed from a revolving fund to provide three-year loans free of loan interest. A total of 537 households in Chanpasak Province benefited from the following microcredit:

(a) Loan amount (Connection fee): US$80…..Cancel US$20 of meter fees

(b) Repayment period: 3 years

(c) Interest: Interest-free

The microfinance scheme was established as follows:

(a) To maintain energy expenses at the same level before and after connection: Before connection to the grid US$3 (The following expenses)

- Kerosene
- Car battery and charging fee

(b) Repayment: US$2

(c) Power bill: US$1

With implementation of Power to the Poor, the electrification ratio of the 20 villages was immediately increased from 78% to 95%. The remaining 5% are households that built new houses away from EdL poles and required higher costs to connect. They cannot afford to pay back the loan even if a microcredit is available.

Those who benefitted from P2P were 12,500 households as of May 2011. Within three years, 38,000 households are expected to be connected to the grid.

P2P, as a support program provided by a pilot project of the World Bank, aims to enhance the profitability of infrastructure investment. Even a return of 100% is not likely, so to promote more investment using soft loans and grants, P2P is an indispensable measure.

6.2 Case Study for Energy Investment Plan

Referring to 6.1.1 Energy Supply Scenario and Investment Plan, a study was carried out to update and collect further data and information. Considering the collected data and information, the objectives of the investment plan are summarized and reviewed in a case study.

Mining domestic coal, which is proposed as an objective of the study in this section, is not reviewed here due to inadequate information and data. However, coal mining as a whole is to be presented and included under fuel costs, i.e., part of the operational costs of the coal thermal power business.

A biogas project is selected as a possible investment opportunity. MEM will start the biogas pilot scheme as part of the World Bank’s projects at pig farms in the suburbs of Vientiane.

The following are the objectives of the case study on the Investment Plan:

(a) Coal Thermal Power

(b) Small-scale Hydropower
(c) Mega Solar
(d) Wind Power
(e) Biogas Power

The case study aims to review possible and probable opportunities for future projects in Lao PDR. All of the cases are limited to On-grid projects. The following table shows the parameters of the investment plan. Referring to practical experience, each figure is reviewed and discussed within the JICA Study Team to make a reasonable estimate without identifying sites and areas of potential study.

Table 6.2-1 Parameters of Investment Plan

Category	Reference of Investment Plan	Unit Cost of Initial Cost US$/kW, US$MM/MW	Plant Factor	Operating Cost Ratio (%) vs Initial Cost ※1	Capacity	Initial Cost
Convntional Energy	Coal Thermal Power Plant	US$2,000/kW	75%	5%	600MW	US$1,200,000,000
Renewable Energy	Small Hydro Power Plant	US$2,500/kW	75%	1%	10MW	US$25,000,000
	Mega Solar Power Plant	US$2,500-3,000/kW	20%	1%	1MW	US$2,500,000
	Wind Power Plant	US$1,500/kW	20%	2%	1MW	US$1,500,000
	Small Wind Power Plant	US$5,000/kW	60%	2%	4kW	US$20,000
	Biogas Power Plant	US$3,200/kW	70%	5%	20kW (500m3 ※2)	US$64,000

※1 Operation & Maintenance including Replacement
※2 Biogas Production Unit Size

Source: JICA Study Team

The assumptions of the energy study are based on limited data, i.e., observations and discussions, including reviews of documents. Therefore, the output from this case study should be verified, reviewed, and revised if necessary at the implementation stage of a feasibility study.

6.2.1 Summary of Case Study

As shown in Table 6.2-1, six projects are proposed for the case study as On Grid projects. Each project plans to sell all power generated to EdL. Evaluation and analysis come under the following conditions:

(a) Selling price of Electricity: US ¢ 7.0（Sale to EdL）
(b) Initial cost: Given as US$/kW (See Table 6.2-1)
(c) Operation and Maintenance costs: Rate (%) of initial investment cost
(d) Discount rate: 10%
(e) Evaluation duration: 15 years
(f) Fund arrangement: 100% Loan from commercial banks
(g) Loan rate: 12% (Repayment of principal mid-year)

(h) Corporation tax rate: 10%

(i) CO_2 reduction: Certified Emission Reduction not considered

(j) Inflation: Not considered

(k) Loan, Payment of initial cost and repayment of loan are allocated at the beginning of the year before commissioning.

The following information is a summary of the simulation for each investment plan for six projects. The Baseline[48] is based on Table 6.2-1. Among the figures provided in the table, two parameters, i.e., Cost and Tariff, are the focus of the simulation in the case study.

1) Baseline

(a) Base Tariff: US ¢ 7.0/kWh

(b) Base Cost: as indicated in Table 6.2-1.

2) Breakeven Cost at Base Tariff

(a) Fix the Tariff as the base, i.e. US ¢ 7.0/kWh.

(b) Simulate the Net Present Value (NPV) as breakeven.

(c) Obtain Cost level to compare with baseline.

3) Breakeven Tariff at Base Cost (Without Subsidy)

(a) Set Base Cost as shown in Table 6.2-1.

(b) Simulate NPV as breakeven.

(c) Identify Tariff level to compare with baseline

As baseline cases do not show any economic viability, we try to identify solutions for the viable level of Cost and/or Tariff as follows:

1. Coal Thermal Power Plant

Baseline

Initial Investment Cost	US$1,200,000,000
Construction Cost per kW	**US$2,000/kW**
Electricity tariff	**US ¢ 7.0/kWh**
Electricity Production	3,942,000,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**▲US$149,886,587**

[48] NPV, IRR, and Payback period are shown in the APPENDIX.

a) Base Tariff (US ¢ 7.0/kWh)

Initial Investment Cost	US$1,200,000,000 → US$1,111,800,000 (92.7%)
Construction Cost per kW	**US$2,000/kW → US$1,853 (92.7%)**
Subsidy	**US$88.2/kW (7.3%)**
Electricity tariff	**US ¢ 7.0/kWh**
Electricity Production	3,942,000,0000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

b) Base Cost (Without Subsidy)

Initial Investment Cost	US$1,200,000,000
Construction Cost per kW	**US$2,000/kW**
Electricity tariff	**US ¢ 7.0/kWh → US ¢ 7.556/kWh (107.9%)**
Tariff Up	**US ¢ 0.556/kWh (7.9%up)**
Electricity Production	3,942,000,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

2. Small Hydro Power Plant

Baseline

Initial Investment Cost	US$25,000,000
Construction Cost per kW	**US$2,500/kW**
Electricity tariff	**US ¢ 7.0/kWh**
Electricity Production	65,700,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**▲US$4,161,360**

a) Base Tariff (US ¢ 7.0/kWh)

Initial Investment Cost	US$25,000,000 → 22,090,000 (88.4%)
Construction Cost per kW	**US$2,500/kW → 2,209 (88.4%)**
Subsidy	**US$291.0/kW (11.6%)**
Electricity tariff	**US ¢ 7.00/kWh**
Electricity Production	65,700,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

b) Base Cost (Without Subsidy)

Initial Investment Cost	US$25,000,000
Construction Cost per kW	**US$2,500/kW**

Electricity tariff	**US ¢ 7.00/kWh → US ¢ 7.922/kWh (113.2%)**
Tariff Up	**US ¢ 0.922/kWh (13.2%up)**
Electricity Production	65,700,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

3. Mega Solar Power Plant

Baseline

Initial Investment Cost	US$2,500,000
Construction Cost per kW	**US$2,500/kW**
Electricity tariff	**US ¢ 7.0/kWh**
Electricity Production	1,752,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**▲US$2,888,982**

a) Base Tariff (US US ¢ 7.0/kWh)

Initial Investment Cost	US$2,500,000 → US$589,000 (23.6%)
Construction Cost per kW	**US$2,500/kW → US$589 (23.6%)**
Subsidy	**US$1,911/kW (76.4%)**
Electricity tariff	**US ¢ 7.00/kWh**
Electricity Production	1,752,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

b) Base Cost (Without Subsidy)

Initial Investment Cost	US$2,500,000
Construction Cost per kW	**US$2,500/kW**
Electricity tariff	**US ¢ 7.00/kWh→US ¢ 29.708/kWh (424.4%)**
Tariff Up	**US ¢ 22.708/kWh (324.4%up)**
Electricity Production	1,752,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

4. Wind Power Plant

Baseline

Initial Investment Cost	US$1,500,000
Construction Cost per kW	**US$1,500/kW**
Electricity tariff	**US ¢ 7.0/kWh**

Electricity Production	1,752,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**▲US$1,474,356**

a) Base Tariff (US ¢ 7.0/kWh)

Initial Investment Cost	US$1,500,000 → 562,050 (37.5%)
Construction Cost per kW	**US$1,500/kW → 562.05 (37.5%)**
Subsidy	**US$937.95/kW (62.5%)**
Electricity tariff	**US ¢ 7.00/kWh**
Electricity Production	1,752,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

b) Base Cost (Without Subsidy)

Initial Investment Cost	US$1,500,000
Construction Cost per kW	US$1,500/kW
Electricity tariff	**US ¢ 7.00/kWh→US ¢ 18.681/kWh (266.8%)**
Tariff up	**US ¢ 11.681/kWh (166.8%up)**
Electricity Production	1,752,000kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

5. Small Wind Power Plant

Baseline

Initial Investment Cost	US$20,000
Construction Cost per kW	**US$5,000/kW**
Electricity tariff	**US ¢ 7.0/kWh**
Electricity Production	21,024kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**▲US$20,902**

a) Base Tariff (US US ¢ 7.0/kWh)

Initial Investment Cost	US$20,000 → US$6,744 (33.7%)
Construction Cost per kW	**US$5,000/kW → US$1,686 (33.7%)**
Subsidy	**US$3,314/kW (66.3%)**
Electricity tariff	**US ¢ 7.00/kWh**
Electricity Production	21,024kWh/year
Period	15 Years
Discount rate	10%

NPV (15 years)	**Zero (Breakeven)**

b) <u>Base Cost (Without Subsidy)</u>

Initial Investment Cost	US$20,000
Construction Cost per kW	**US$5,000/kW**
Electricity tariff	**US ¢ 7.00/kWh→US ¢ 20.756/kWh (296.5%)**
Tariff Up	**US ¢ 13.756/kWh (196.5%up)**
Electricity Production	21,024kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

6. Biogas Power Plant

<u>Baseline</u>

Initial Investment Cost	US$64,000,000
Construction Cost per kW	**US$3,200/kW**
Electricity tariff	**US ¢ 7.0/kWh**
Electricity Production	122,640kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**▲US$35,832**

a) <u>Base Tariff (US ¢ 7.0/kWh)</u>

Initial Investment Cost	US$64,000 → 43,540 (68.0%)
Construction Cost per kW	**US$3,200/kW → 2,177 (68.0%)**
Subsidy	**US$1,023/kW (32.0%)**
Electricity tariff	**US ¢ 7.00/kWh**
Electricity Production	122,640kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

b) <u>Base Cost (Without Subsidy)</u>

Initial Investment Cost	US$64,000
Construction Cost per kW	**US$3,200/kW**
Electricity tariff	**US ¢ 7.00/kWh → US ¢ 11.14/kWh (159.1%)**
Tariff UP	**US ¢ 4.14/kWh (59.1%up)**
Electricity Production	122,640kWh/year
Period	15 Years
Discount rate	10%
NPV (15 years)	**Zero (Breakeven)**

Each value above is summarized in the following table to show Baseline, Cost for Breakeven, and Tariff for Breakeven.

Table 6.2-2 Sensitivity Analysis for Cost and Tariff for Breakeven NPV

Projects \ Tariff & Cost	Baseline	Base Tariff		Base Cost	
	US ¢ 7.00/kWh	US ¢ 7.00/kWh			
	No Subsidy	Cost (NPV=0)	vs. Base	Tariff (NPV=0)	vs. Base
1 Coal Thermal Power Plant	US$ 2,000 / kW	US$ 1,853.00 / kW	92.7%	US ¢ 7.556 / kWh	107.9%
2 Small Hydro Power Plant	US$ 2,500 / kW	US$ 2,209.00 / kW	88.4%	US ¢ 7.922 / kWh	113.2%
3 Mega Solar Power Plant	US$ 2,500 / kW	US$ 589.00 / kW	23.6%	US ¢ 29.708 / kWh	424.4%
4 Wind Power Plant	US$ 1,500 / kW	US$ 562.05 / kW	37.5%	US ¢ 18.681 / kWh	266.9%
5 Small Wind Power Plant	US$ 5,000 / kW	US$ 1,686.00 / kW	33.7%	US ¢ 20.756 / kWh	296.5%
6 Biogas Power Plant	US$ 3,200 / kW	US$ 2,177.00 / kW	68.0%	US ¢ 11.140 / kWh	159.1%
			*1		*2

*1 : How much is the earning power by projects ?
*2 : How much increase the Tariff to viability ?

Source: JICA Study Team

(1) Coal Thermal Power Plant

Baseline shows NPV as negative US$149,886,587. To set Tariff as the base case, i.e., US ¢ 7.00/kWh, the feasible cost for the breakeven of NPV is obtained as US$1,853/kW. This is 92,7% of the Base Cost, i.e., US$2,000/kW. On the other hand, to set Cost as the base case, i.e., US$2,000/kW, the feasible sale price for the breakeven of NPV is obtained as US ¢ 7.556/kWh. This is 107.9% of the Base Tariff, i.e., US ¢ 7.00/kWh.

The economic performance of a coal thermal power plant is only viable in the following cases:

(a) Reduce Initial Cost at least 7.3% (US$147)

(b) Increase Sales Price at least 7.9% (US ¢ **0**.556/kWh)

(a) Shows the need for a governmental subsidy to cover the initial cost or technical and/or financial improvements by the invertors themselves. (b) Means the need to increase the selling price to EdL.

(2) Small-scale Hydropower Plant

Baseline shows NPV as negative US$4,161,360. To set the Tariff as the base case, i.e., US ¢ 7.00/kWh, a feasible cost for the breakeven of NPV obtained is US$2,209/kW. This is 88.4% of the Base Cost, i.e., US$2,500/kW. On the other hand, to set Cost as the base case, i.e., US$2,500/kW, the feasible sale price for the breakeven of NPV is obtained as US ¢ 7.922/kWh. This is 113.2% of the Base Tariff, i.e., US ¢ 7.00/kWh.

The economic performance of a Small-scale Hydropower Plant is only viable in the following cases:

(a) Reduce Initial Cost at least 11.6% (US$291)

(b) Increase Sales Price at least 13.2% (US ¢ 0.922/kWh)

(a) Shows the need for governmental subsidy to cover the initial cost or technical and/or financial improvements by investors themselves. (b) Means the need to increase the selling price to EdL.

(3) Mega Solar Power Plant

Baseline shows NPV as negative US$2,888,982. To set the Tariff as the base case, i.e., US ¢ 7.00/kWh, the feasible cost for the breakeven of NPV is obtained as US$589/kW. This is 76.4% of the Base Cost, i.e., US$2,500/kW. On the other hand, to set the Cost as the base case, i.e., US$2,500/kW, the feasible sale price for the breakeven of NPV is obtained as US ¢ 29.708/kWh. This is 424.4% of the Base Tariff, i.e., US ¢ 7.00/kWh.

The economic performance of a Mega Solar Power Plant is only viable in the following cases:

(a) Reduce Initial Cost at least 76.4% (US$1,911)

(b) Increase Sales Price at least 324.4% (US ¢ 22.708/kWh)

(a) Shows the need for governmental subsidy to cover the initial cost or technical and/or financial improvements by investors themselves. (b) Means the need to increase the selling price to EdL.

(4) Wind Power Plant

Baseline shows NPV as negative US$1,474,356. To set the Tariff as the base case, i.e., US ¢ 7.00/kWh, the feasible cost for the breakeven of NPV is obtained as US$562.05/kW. This is 62.5% of the Base Cost, i.e., US$1,500/kW. On the other hand, to set the Cost as the base case, i.e., US$1,500/kW, the feasible sale price for the breakeven of NPV is obtained as US ¢ 18.681/kWh. This is 266.8% of the Base Tariff, i.e., US ¢ 7.00/kWh.

The economic performance of Wind Power Plant is only viable in the following cases:

(a) Reduce the Initial Cost at least 62.5% (US$937.95)

(b) Increase the Sale Price at least 166.8% (US ¢ 11.681/kWh)

(a) Shows the need for governmental subsidy to cover the initial cost or technical and/or financial improvements by investors themselves. (b) Means the need to increase the selling price to EdL.

(5) Small Wind Power Plant

Baseline shows NPV as negative US$20,902. To set the Tariff as the base case, i.e., US ¢ 7.00/kWh, the feasible cost for the breakeven of NPV is obtained as US$1,686/kW. This is 66.3% of the Base Cost, i.e., US$5,000/kW. On the other hand, to set the Cost as the base case, i.e., US$5,000/kW, the feasible sale price for the breakeven of NPV is obtained as US ¢ 20.756/kWh. This is 296.5% of the Base Tariff, i.e., US ¢ 7.00/kWh.

The economic performance of Small Wind Power Plant is only viable in the following cases:

(a) Reduce Initial Cost at least 66.3% (US$3,314)

(b) Increase Sale Price at least 196.5% (US ¢ 13.756/kWh)

(a) Shows the need for governmental subsidy to cover the initial cost or technical and/or financial improvements by investors themselves. (b) Means the need to increase the selling price to EdL.

(6) Biogas Power Plant

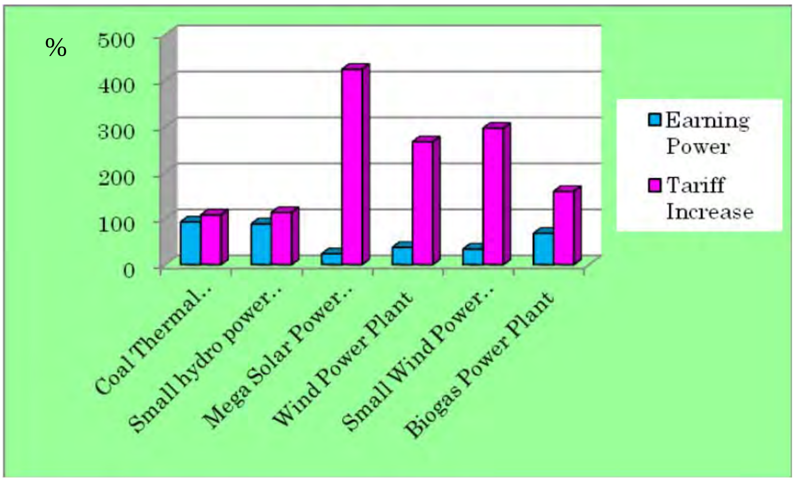
Baseline shows NPV as negative US$35,832. To set the Tariff as the base case, i.e., US ¢ 7.00/kWh, the feasible cost for the breakeven of NPV is obtained as US$2,177/kW. This is 68.0% of the Base Cost, i.e., US$3,200/kW. On the other hand, to set the Cost as the base case, i.e., US$3,200/kW, the feasible sale price for the breakeven of NPV is obtained as US ¢ 11.14/kWh. This is 159.1% of the Base Tariff, i.e., US ¢ 7.00/kWh.

The economic performance of Biogas Power Plant is only viable in the following cases:

(a) Reduce Initial Cost at least 32.0% (US$1,023)

(b) Increase Sale Price at least 59.1% (US ¢ 4.14/kWh)

(a) Shows the need for governmental subsidy to cover the initial cost or technical and/or financial improvements by investors themselves. (b) Means the need to increase the selling price to EdL.



Source: JICA Study Team

Figure 6.2-1 Viable Cost and Tariff

(7) Bio fuels

Besides the case study for On Grid projects, the case study of Bio fuels, i.e., Bio-Diesel from Jatropha, is reviewed and summarized below.:

(a) Baseline

- Initial Investment Cost: US$9,360,000
- Construction Cost per kL: US$3,600
- Bio-Diesel Sales Price: US¢90/L
- Bio-Diesel Production: 2,600 kL
- NPV: ▲US$7,224,040

(b) Base Sale Price (US¢90/L)

- Initial Investment Cost: US$9,360,000→US$6,533,800(69.8%)
- Construction Cost per kL: US$3,600→ US$2,513 (69.8%)
- Subsidy: US$1,087 /kL (30.2%)
- NPV: Zero (Breakeven)

(c) Base Cost (Without Subsidy)

- Initial Investment Cost: US$9,360,000
- Construction Cost per kL: US$3,600
- Bio-Diesel Sales Price: US¢90/L→US¢129 /L(142.2%)
- NPV: Zero (Breakeven)

If the price is set as the base Sales Price of US¢90/L together with the base Construction Cost: US$3,600/kL, NPV is negative ▲US$7,224,040.

To make NPV Zero, i.e., breakeven, with the base Sales Price of US¢90/L, the Construction Cost of US$3,600/ kL needs to be reduced by 69.8% to US$2,513/kL.

On the other hand, based on the base Construction Cost as US$3,600/kL, the Sales Price is subsidized by 42%, i.e., US¢129 /L (+US¢39/L) for NPV of breakeven.

6.3 Conclusion and Way Forward

The outcomes of the case studies present some ideas and trends based on the following tentative analysis.

(a) No project ideas are identified that are economically viable.

(b) In particular, Mega Solar and Wind Power are far from being feasible businesses.

(c) Coal Thermal Power Plant and Small-scale Hydropower Plant together with Bio fuels, may have some potential business opportunities depending on business and economic conditions.

As one possible and potential project, Small-scale Hydropower Plant is simulated further focusing on Bank Loan Rate, Soft Loan from Japanese government, i.e., Yen Loan, and increase in the sales price of electricity as follows:

(a) Loan rate to be lowered to enhance economic viability

- 12% -> 10% -> 7%

(b) Japanese Soft Loan, Yen Loan

- Repayment: 40 years with grace period of 10 years
- Interest Rate: 0.55%

(c) Increase of Sales price of Electricity

- Base price: US¢7/kWh to increase 4.47%/year

As detailed in the Appendix, the Bank Loan should be less than 7% for a feasible investment. Regarding the Yen Loan, if Japanese Products are installed, the feasibility of the investment may not be attractive even with the favorable financial conditions longer term repayment with lower interest rate as stated above. This is because of the higher prices of

Japanese products, i.e., Initial cost is US$10,625/kW (@Yen80/US$: Yen 850,000/kW) compared to US$2,500/kW for the price of local products. The following table shows the results of further simulations:

Table 6.3-1 Simulations of Small-scale Hydropower Plant for Economic Viability

Financial Conditions & Products / Price			Payback Less than 7 years
Bank Loan Rate		12%	8.0 years
		10%	7.6 years
		7%	7.1 years
Yen Loan	Products	Japanese	35.2 years
		Local	6.3 years
Electricity Price		4.47%/year up	4.3 years

Source: JICA Study Team

If local equipment and facilities are installed with a Yen Loan, the financial merits will be maximized with a 40-year repayment together with a lower rate, i.e., 0.55%. If the sales price of electricity is adjusted upward 4.47%/year, Pay Back is 4.3 years, the shortest available even with a loan rate of 12%.

As reviewed with a 10 MW Small-scale Hydropower Plant installing Japanese products, the Yen Loan program might not be feasible because of high prices. Therefore, Grant Aid should be considered as the only possible option for a Small-scale Hydropower Plant if Japanese products are to be installed.

At the implementation stage, further supporting data with detailed designs including site survey and study of potential follow feasibility studies.

One typical solution to promote new technologies is the special financial scheme provided by the government, e.g., Feed-in Tariff, or Subsidy for initial investment. Feed-in Tariff in Japan starts in July 2012. The tariff is US ¢ 50/kWh, which is almost 143% compared to a household, US ¢ 35/kWh. Subscribers share the additional cost.

In this analysis, special consideration is paid to avoiding the economic influences on nations caused by renewable energy promotion. That is why priority is given to maintaining the Base Tariff, i.e., US ¢ 7.00/kWh, when searching for possible financial solution, i.e., subsidy for investors to clear initial cost barriers. Secondly, the impact of the tariff is analyzed without a subsidy scheme to promote investment in the models. Even a subsidy scheme for the initial investment may also have some economic influence on people if a tax is the funding source for such a subsidy.

Comprehensive discussions must be developed among stakeholders in the country before taking decisions on a financial scheme to promote renewable energy investment.

7 Conclusion

7.1 2025 Supply Scenario

Section 4 of Chapter 5 (Estimated Energy Supply and Demand) describes in detail the ideal balance of energy supply and demand in 2025. The key points are summarized as follows.

(1) Demand conditions (refer to Sections 2, 3, and 4 of Chapter 5)
BAU (GDP growth rate 7.1%)

(2) Supply scenario (refer to Table 5.4-1, Section 4 of Chapter 5)
It was found that CASE C-1, which is well balanced in terms of stable supply, economy, and environmental measures, is preferred over CASE A-1 and CASE B-1, which correspond to the current Power Development Plan (PDP) and Renewable Energy Development Plan (REDS). The characteristics of CASE C-1 are as follows.

1) Limits imbalances between domestic demand and exports to a certain degree. To do so, it might be necessary to ensure appropriate power generation capacity and consider strengthening the power generation capacity by EdL-Gen, based on an accurate estimate of demand (domestic demand and export).
(Refer to Figure 5.4-3, Section 4, Chapter 5 and Table 3.1-19, Section 1, Chapter 3)
2) Expand coal-fired power capacity and promote small-scale hydroelectricity (renewable energy) to diversify and decentralize (enhance stable supply) power sources. Conduct research and explorations as expansion of coal use depends on recoverable reserves of coal.
(Refer to Table 5.4-2, Section 4, Chapter 5)
3) In response to the increase in demand for oil products, try to introduce biofuels from the viewpoint of reducing dependence on imports to the extent that economic efficiency and quality can be maintained.
(Refer to Table 5.4-3, Section 4, Chapter 5)
4) Although it is preferable to use renewable energy for the environment and the efficient use of domestic resources, renewable electricity except for small-scale hydroelectricity should be used carefully from the viewpoint of economic efficiency.
(Refer to Table 6.2-5, Section 2, Chapter 6)

The vector of the above comments is slightly different from that of current energy policy (particularly electricity policy). As stated in Section 3 of Chapter 2, the current energy policy prioritizes economic efficiency (financial regulation) among the 3E (stable supply of electricity, economic efficiency, and environment). It also aims to ensure stable supplies of electricity mainly through mutual dependence (mutual supply of electricity) in the region, which is rational and persuasive. However, assuming that domestic electricity demand will increase rapidly and external demand (exports) will rely on an unstable global economy in the future, the need should not be understated to enhance the independence and flexibility of emergency responses in Lao PDR alone, and it is considered important to take adequate note of the following three points.

(a) Strengthening the power generation capacity by EdL-Gen (not relying 100% on IPP)

In the future, rather than relying solely on exports (new establishment) on IPP, it is important to have a system under which switching between exports and domestic supply is possible by strengthening the power generation capacity of EdL-Gen. This is because the contract style of supplying around 10 percent of power generation out of export IPP, which is one measure, is considered to involve a high risk that IIP projects might not be achieved for some reasons in terms of energy security.

(b) Optimization of proportion of electricity exports and domestic supplies

There is no problem as long as external demand (exports) is in a good state. However, taking into account the recent destabilization of the global economy, if external demand drops rapidly, alternatives to growing domestic demand will not be sufficient. As a result, it is assumed that the country will have enormous excess capacity. In general, therefore, it is desirable that the proportions of exports and domestic supplies are in an appropriate range.

(c) Diversification and decentralization of power sources

As long as power plants are under the sovereignty of the Lao government (national government), they all belong to the Lao government in the mid- to long-term whether they are for export, domestic use, or specific consumers. Therefore, from the viewpoint of the efficient use of domestic resources, diversification and decentralization of power sources including hydropower, renewable energy, and coal-fired thermal power enhance the flexibility of energy policy.

Besides the above, when taking into account deepening mutual trust and inter-dependence within the region, the role of Lao PDR in supplementing future energy needs and acting as a battery at the GMS level is important. At the same time, it is considered a top priority to ensure a minimum level of energy independence.

7.2 Expected roles of DEPP

In the not so distant future, the Department of Energy Policy and Planning (DEPP) of MEM will play a central role in energy planning and policy-making, including formulation of the "Energy Master Plan." The expected roles and functions of DEPP are as follows.

7.2.1 Electricity

(1) Centralization of electricity policies by National PDP

Article 10 of the Electricity Law stipulates that MEM is responsible for the management and direction of the "Power Development Plan" (PDP) nationwide. To achieve the most appropriate development of domestic energy resources as an energy policy of Lao PDR, MEM establishes an electric power development system that covers both exports and domestic supplies, and formulates a power system improvement plan and National PDP for the entire

Lao PDR.

(2) Strengthening MEM's evaluation and supervision functions

The existing PDP developed by EdL only covers power plants and transmission lines for domestic demand and part of electric power development and power system improvement in the country. Power sources for exports are discussed project by project by MEM and developers as IPP. Electricity in Lao PDR is characterized by the large-scale development of power sources for export and a power system as a part of the GMS grid plan. It is, therefore, necessary to strengthen the evaluation and supervisory functions of MEM for EdL's power development plan and to formulate the most appropriate PDP that is consistent with the national plan. MEM will consider enhancing human resources development and organizational functions to strengthen its evaluation and supervision functions.

7.2.2 Oil products (including LPG) and biofuels

(1) Centralization of logistics management of oil products

Centralize the management of oil product imports and domestic distribution within MEM, and establish an organization for it within MEM. Integrate functions that have been performed by Lao Fuel & Gas Association and Lao State Fuel Company, and unify management of biofuels in the distribution system of oil products because they are used with gasoline and light oil.

(2) Development of oil-related statistics

Make it mandatory for oil sellers (including import companies) to regularly submit shipment statistics (import, stock, shipment) on oil products. In principle, the statistics are for surveying the number of authorized oil sellers. An Oil Statistics Law, with legal force, should be established for the submission of statistics and applying penalties, etc. These measures are necessary not only for the general purposes of developing statistical data, but also for managing mixed quantities and quality checks of biofuels that are expected to be implemented in the future, and managing quantity when products are stockpiled.

(3) Knowing import prices and monitoring retail prices

Find the prices of oil products imported by individual importers in cooperation with customs. Monitor retail prices in cooperation with the central bank and MPI. These measures are necessary not only for the general purpose of developing statistical data but also for preventing tax evasion when biofuels are mixed in the future and for making appropriate inventory valuations when stockpiling and shipping oil products.

7.2.3 Coal

Coal is under the jurisdiction of Department of Mines, not DEPP. However, coal-related matters are stated here because cooperation with DEPP is important.

(1) Unifying management of domestic supply/demand balance

1) Strengthening the organization of the coal section in the Department of Mines. First, develop coal supply/demand statistics (production, export, import, consumption) and unify management of coal supply and demand. Make it mandatory for domestic coal mines and major consumers to report production, imports, and consumption on a regular basis.

2) Coal-mining companies given concessions should be required by MEM to regularly submit reports on the state and results of exploration and organize data on reserves and properties.

(2) Promotion of coal survey

The Department of Mines should implement nationwide and on a full-scale (not only surface but deep underground) coal exploration in cooperation with the Department of Geology (currently under the umbrella of Ministry of Natural Resource and Environment).

(3) Human resources development

Establish an organization to promote coal exploration and coal development skills in the Department of Mines. Introduce overseas exploration and development technologies.

7.2.4 Energy statistics, database, and demand and supply forecasting

When formulating an energy plan, it is important to secure accurate data on energy demand, analyze data, and estimate energy demand and supply based on demand. To achieve this, DEPP needs to take the following measures.

1) Build a consensus by establishing a liaison council for government ministries and agencies with the aim of sharing and standardizing various data among ministries and agencies.

2) Develop a prototype database and have related people become aware of its value and effectiveness. Develop a road map for creating a comprehensive database.
   (Chapter 4, Section 4)

3) Analyze data and establish a system that estimates energy demand and supply.
   (Chapter 4, Section 5)

This survey (Chapter 4) shows a road map for conceptual design and future implementation toward the development of a prototype database. Technical transfer (Chapter 5, Section 6: Capacity Development Support) of IEEJ models that were developed in this survey was conducted for energy demand and supply forecasting.

The following are points to note concerning development of various statistics and database.

(1) Development of energy producer statistics

1) Establish new Oil Statistics Law and Coal Statistics Law, and as a rule, develop statistics of

producers (importers) including production, imports, and shipments (consumption) for all businesses (producers and importers).

2) Develop energy producer statistics (electricity, oil, and coal) together with existing electricity statistics (MEM, EdL).

3) Add the above-mentioned energy producer statistics for oil, coal, and electricity in Article 8 of the Statistics Act, stating that MEM is responsible for management. Establish a system by which statistical data can be promptly summarized.

(2) Development of energy consumer statistics

1) In cooperation with the Ministry of Industry and Commerce, also describe energy consumption in the survey of all factories (on production plan, production volume, prices, etc.) conducted annually by the Ministry of Industry and Commerce to track consumption volumes.

2) Make estimates based on sample surveys and interviews, and track energy consumption in the household sector and commercial buildings.

(3) Improvement of Energy Saving Act

The ultimate goal is considered to be to establish a law that corresponds to the Energy Conservation Law in Japan and mandate regular reporting of energy consumption status by factories and buildings of a certain scale. Focus on the aforementioned development of (1) and (2) for now, because progress is still at an early stage.

(4) Workflow for developing a database system

In the survey, a work analysis of data analysis was completed. Following this survey, it is necessary to decide detailed specifications, etc., by exchanging opinions on a detailed design between MEM (which will be the user and manager of the energy database system) and JICA. At the same time, capacity building for data collection and processing enables full-scale and smooth operation of the energy database system.

(5) Development of energy database prototype

The government will develop an energy database prototype and start internal test operations within around two years. During trial operations, conduct system development based on the so-called spiral model cycle, which identifies problems by operating the system in line with the series of processes from data collection (first operated with questionnaire method), data verification, data accumulation, and processing, and reflects problems in the design.

7.3 Recommendations for possible future cooperation

Two categories can be considered for possible future cooperation based on the results of this survey. 1) as stated in 7.3, when strengthening the roles and functions of DEPP and MEM, one issue is effective implementation of individual technical support (including T/A and capacity building support), and 2), another issue is what should be dealt with comprehensively in the "Energy Master Plan".

7.3.1 Technical Assistance (Including capacity-building support)

(1) Improvement of demand and supply forecasting skills

The IEEJ model developed in this survey needs model maintenance at least every two years. It requires development and updates of time series data, re-estimation of demand functions, and improvement of statistic methods to increase estimation accuracy, as well as replacement of the demand function in the model and improvement of skills for simulation tests. Therefore, it is always required to build the capacity of the people who carry out modeling and simulations. Technical transfers were conducted to C/P through short-term on-the-job training (OJT). After this study, it is necessary to conduct short-term training at least every two or three years.

(2) Geological survey and exploration of coal and capacity-building support

Exploration for nonferrous metals is progressing, while that for coal resources has not due to financial constraints and a lack of engineers who have acquired related skills. As mentioned in 7.3, it is considered necessary to conduct exploration for coal resources efficiently by fully using geological surveys that have already been conducted with cooperation from foreign donors. In particular, it is desirable that experts and engineers sent for exploration provide Lao engineers with capacity-building support (OJT).

(3) Development of database and technical support

As mentioned earlier, it is necessary to collect statistics and data and build a database, and these have a high priority for formulating energy plans and policies. However, a database is generally built after completing the system for collecting statistics and data. It is true that building a database can be slow in many cases because of gaps in cooperation and awareness among related ministries and agencies and between central and local governments. Therefore, as mentioned in 7.3, it is considered possible to first build a prototype focusing on a certain field, strengthen recognition of the need for sharing among related organizations based on it, raise awareness of the need for building a comprehensive database, and make cooperative systems perform smoother. This is why it is considered more effective to provide technical support on database building as an independent project as quickly as possible.

7.3.2 Need for Energy Master Plan

Policies and roadmap for electricity (which accounts for the majority of energy of Lao PDR) have been clarified at a practical level. However, they appear not to be coordinated as a whole to position electricity planning in general energy, and to achieve consistency at the macro-economy level within a five-year plan (socioeconomic development plan). Until now, the national wealth of Lao PDR has increased where growth is possible. However, as economic growth accelerates it will become difficult to obtain sufficient results unless there is consistent national planning and effective investments. It is considered that the time has come to make a national energy plan (Energy Master Plan). How individual problems (unique problems Lao PDR is facing), which have not been previously recognized, are to be positioned in the Energy Master Plan will be the focus as described below.

(1) Dual structure of energy strategy

As stated in Section 5 of Chapter 5, electricity, as a product like mineral resources used to acquire foreign currencies, is not exported as the result of adjusting the demand and supply gap against domestic demand derived from domestic economic activity in Lao PDR. Electricity generation itself is a major economic activity, and does not always depend on the level of domestic economic activity[49]. This is an export-driven strategy[50]. On the other hand, petroleum demand is decided as the result of adjusting demand and supply balance—in Lao PDR that means supply is 100% imported. The country is in the same position as Japan, the USA, and the EU from the viewpoint of how supply meets demand derived from domestic economic activity. This is a domestic demand-driven strategy.

Lao PDR has dual energy strategies: one is to export electricity and the second is to import oil. Lao PDR is currently at the early stage of high economic growth. The latter, therefore, is not recognized sufficiently and discussions focus on the former export-driven strategy based on electricity. There is no basic supply/demand plan (systematic and reliable strategic data) for oil and coal, and it is also unclear where management and responsibility of the government concerning exports/imports and production lie. Therefore, an energy strategy should still be a priority.

(2) Governance of MEM concerning electricity policy

The “Power Development Plan” (PDP) formulated by EdL is limited to estimating domestic demand and a corresponding plan for power plants and transmission lines. It does not cover IPP for export, which composes a large proportion of power sources in Lao PDR. Lao PDR has two types of power plan—EdL for domestic supply and MEM for export (IPP), and there is no National PDP for Lao PDR as a whole including IPP.

(3) Financial problems and economic efficiency

The absolute income of EdL’s domestic electricity sales is small and is limited by a small

[49] Domestic demand is derived from domestic economic activity, but as exports are overwhelmingly larger than domestic demand, exports are not the result of adjusting to supply domestic demand.

[50] In Europe, many countries deal with electricity as an export and import. But, these exports are in principle based on adjusting individual demand and supply gaps, and they are not only for the purpose of exporting electricity.

population. Strengthening and expanding the transmission and distribution network, and developing electric power for export or for domestic large-scale consumers requires a large amount of funds, and it is difficult for the government (or EdL) to procure these on its own. Lao PDR, therefore, chose to focus on using foreign capital through IPP for electric power development, and EdL focuses on investing on the transmission network. To achieve economic efficiency for power generation projects, it is natural to mainly use large hydroelectric generation. However, although there might be other options in terms of securing energy supplies, there have not been sufficient discussions on options.

7.3.3 Terms to be issued in Master Plan

The terms to be issued are as follows, although there are many topics. Major macro-economic index and primary production and export index are favored for setting target values because a long-term "Energy Master Plan" needs to cover 20 to 30 years.

(1) Setting long-term target values for a macro-economic index and social infrastructure needs to be consistent with a five-year plan.
1) Export Strategy: target values of production/exports and foreign revenues required by the Power sector, Non-ferrous sector, and Others
2) Enhancing Social infrastructure (electrification in rural areas and housing policy and transportation planning in urban areas)
3) Enhancing Logistics (road, rail, pipeline, and network in GMS)
4) Investing in each sector
5) Fiscal, financial, and exchange rate policy

(2) Energy demand and supply projection for the long term
1) Developing energy demand and supply model and its operation
2) Overall energy demand projection for the long term in each sector（2012-2035）
3) Analysis and policy-making for energy conservation, changes in life-styles, and modal shift in public transportation

(3) Energy-supply planning for the long term
1) Power Development Plan and power policy (Embodiment of National PDP)
2) Petroleum stockpiling, logistics in petroleum products, and import policy
3) Exploration and development plan for coal
4) Review of current "Renewable Energy Development Strategy" (REDS)

(4) Energy Investment (amount of value, ROI, and financial resources)
1) Investment plan for power development and transmission system
2) Investment plan for petroleum stockpiling and improving petroleum logistics

3) Investment on exploration and development plan

(5) Tax and subsidy policy
1) Rationalization of electricity tariff system
2) Pricing and taxation of fossil fuels such as petroleum and coal for promoting energy saving and protecting the environment
3) Formulation of subsidy regulations for introducing renewable energy

(6) Compilation of energy basic policy (legislation) and establishment of ministerial council for planning and coordinating energy policy
1) Formulation and approval of energy demand and supply plan, and investment plan
2) Role of DEPP (MEM) as executive office secretariat for the council
3) Coordination among GMS countries on energy policies of each country

(7) Public aid from overseas for implementing energy master plan

(8) Public technology assistance and support for capacity building from overseas

7.4 Closing remarks

This study developed demand projection models that cover the entire energy sector and estimated energy demand in 2025. It also developed various supply scenarios based on analytical results for each supply sector including electricity, oil, coal, and renewable energy; presented future options in Lao PDR; and, presented a desirable balance of energy supply and demand. The study discussed the profitability of some renewable energy sources and how the government should support energy investment. As for statistical data, which is the basis of demand projections, recommendations were made concerning the future direction to develop statistics and databases. Although the main goal of this study was a basic survey on energy data collection, it also identified key issues for future energy policies and showed directions for discussions by presenting a model of the "Lao National Energy Plan" ("Energy Master Plan"). However, because this survey is still at the initial stage, another study for policy-making based on a more comprehensive analysis needs to be implemented in the future.

Finally, the basic concept of energy policy planning is that energy policies should be formulated taking into account a balance of consistency with other social and economic policies and priorities. It is also necessary to establish further in-depth policies for improving the industrial structure and standards of living, in order to improve policies for energy and the environment with the accuracy required in the modern world. It is at least necessary to calculate target values for demand and production volumes of basic necessities and important items on a quantitative basis. A Road Map and an Action Plan are to be formulated within the "Master Plan" to show detailed directions on how policies are structured and implemented toward final target values. The main premise is that these plans are based on reality and feasibility. It is also necessary to make revisions as needed, incorporating environmental changes.