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MBA-Thesis

Diagnostic Study on Renewable Energy Potential and Feasibility in South East Asia

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AAEP	Asia Alternative Energy Programme
ADB	Asian Development Bank
APE project – PV solar and Biomass	Asia Pro Eco Project “Diagnostic Study on Renewable Energy Potential and Feasibility in Southeast Asia”.
ASEAN	Association of South East Asian Nations
BCEL	Banque pour le Commerce Exterieur Lao
BLA	Bilateral Agency
BOO	Build Own Operate
BOOT	Build, Operate Own, and Transfer
BOT	Build, Operate, and Transfer
BSRP	Banking Sector Reform Programme
BTF	Build, transfer, and finance
BTL	Build, Transfer, Lease
CDEA	Community Development and Environment Association
COD	Commercial Operation Date
DOE	Department of Electricity (Ministry of Industry and Handicrafts)
DSCR	Debt Service Coverage Ratio
DSM	Demand Side Management
EBIT	Earnings before Interest and Tax
EBRD	European Bank for Reconstruction and Development
ECA	Export Credit Agency
EDL	Électricité du Laos
EGAT	Electricity Generating Authority of Thailand
EIA	Environmental Impact Assessment
EPF	Electric Power Forum
ESCOs	Electricity Service Company
ESCOs	Electricity Service Companies
EVN	Electricity of Vietnam
FDI	Foreign Direct Investment
FEA/NUOL	National University of Laos, Faculty of Engineering
FIMC	The Foreign Investment Management Committee
FMAC	Financial Management Adjustment Credit
FMCB	Financial Management Capacity Building
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GMS	Greater Mekong Subregion
GOL	Government of the Lao PDR
GTZ	Deutsche Gesseltschaft für Technische Zussamenarbeit
GWh	Gigawatt-hour
IFC	International Finance Corporation
IMF	International Monetary Fund
IPP	Independent Power Producer (with Export Mandate)
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau (German bilateral agency)
kW	kilowatt
kWh	Kilowatt hour
LDC	Less Developed Countries
LIRE	Lao Institute for Renewable Energy
LNCE	Lao National Committee for Energy
MAF	Ministry of Agriculture & Forestry
MDG	Millennium Development Goals by the UN
MIGA	Multilateral Investment Guarantee Agency
MIH	The Ministry of Industry and Handicraft
MIH-WB	Ministry of Industry and Handicraft – World Bank
MOF	The Ministry of Finance

MPO	The Prime Ministers Office
MTCPC	Ministry of Transport Communication Post and Construction
MV	Medium Voltage (22 kV in Lao PDR)
MW	Megawatt
NGO	Non-Governmental Organization
NPEP	National Poverty Eradication Programme
NTPC	Nam Theun Power Company
NUOL	National University of Laos
O&M	Operation and Maintenance
OCO	ADB's Office of Cofinancing Operations
ODA	Official Development Assistance
OPIC	Overseas Private Investment Corporation
OPS	Off-grid Promotion and Support Office
PDP 2004-13	EDL's Power System Development Plan 2004-2013
PPA	Power Purchase Agreement
PPIAF	Public Private Infrastructure Advisory Facility
PPP	Public-Private Partnerships
PRG	Political Risk Guarantee (ADB) or Partial Risk Guarantee (World Bank)
PRGF	Poverty Reduction and Growth Facility
PRI	Political Risk Insurance
PSDP	Power Sector Development Plan
PSFS	Power Sector Financing Strategy ("PSFS Study")
PV Solar	Photo Voltaic Solar
RE	Renewable energy
RED	Rural Electrification Division, Department of Electricity, MIH
RES	Renewable energy sources
RESDALAO	Renewable energy for sustainable development association
SPC	State Planning Committee
SPP	Small Power Producer (developers of small power generation projects)
SPRE	Southern Provinces Rural Electrification
STEA	Science Technology and Environment Agency
Sunlabob	Sunlabob rural electrification systems Co. LTD
SVO	straight vegetable oil
SWER	Single Wire Earth Return
THPC	Theun Hinboun Power Company
TOR	Terms of Reference
TRI	Technology Research Institute
TRI/STEA	Technology Research Institute/Science Technology Environment Agency
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
VEM	Village Electricity Manager
Wp	Watt peak

1 Introduction

1.1 Aim of this study

Rising oil prices have received much public attention in recent months. The impact of higher prices affects disproportionately developing countries in Southeast Asia constrained by their reliance on oil imports and limited budgets. On the other hand, Southeast Asian countries have abundance of two renewable energy (RE) sources – sun and biomass. Sunlight used in PV solar systems is an efficient source of electricity. Biomass from agricultural crops and live stock manure can be converted into biogas, electricity and fertilizer.

The aim of this thesis is to carry out a Potential Analysis and feasibility Evaluation of the further Introduction of Solar and Biomass Energy in South East Asia. This is serving the purpose of assisting the affected nations in South East Asia to tap into their abundantly available potential. Only if the right technologies are chosen and the right strategies pursued, the nations in South East Asia are able to direct their economic growth and the pairing energy hunger into a sustainable direction by drawing on the advantages of renewable energies.

Advantages of Renewable Energy Sources:

- Decentralization of energy production
- Value-adding of domestic agricultural products
- Capital savings on oil imports
- Employment creation
- Greater independence from the world oil market

Acknowledgements to the partners of the study:

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1.2 Approach of the study

Since the study is supposed to give general and credibly founded comments on the implementation of renewable energy generation technology in South East Asia it is important that the scope of the analysis is chosen right. The Study will focus un two countries in South East Asia which both typically represent the different development levels present in the region.

1. Lao PDR one of the least developed countries on this globe
2. Thailand a growing economy in South East Asia

Both nations were chosen due to their respective statuses and because they have put in place policy goals which are promoting the use of renewable energies in economic growth and rural development:

1. Thailand is to achieve the 2011 aim to in-crease the quota of RE to 8% and
2. Laos is to achieve the 20020 aim to electrify 90 % of the country’s households

and hence asked the European commission to support the data gathering with a thorough analysis of the matter. The studied areas are the utilization of bioenergy with the whole biomass chain and the implementation of solar energy projects.

The Biomass Chain

Analysis of the biomass chain in the study will focus on the availability, suitability and production possibility of the input materials. In addition to technical data collection on wasted biomass research will be carried out on the wider social and economic potential of biomass cultivation for energy production. Appropriate technologies for biomass treatment will be identified in both Laos and Thailand and an evaluation completed on the transfer possibility of European technologies.

The PV Chain

The study analysis of the PV solar chain will carried out by a compilation of the solar irradiance to provide accurate calculation of the annual output. Furthermore a thorough analysis of the existing technologies and the experienced performance during applications within the respective country and environment. Data collection from two urban areas in both Laos and Thailand will enable the formulation of appropriate technical interventions improve the cost efficiency and environmental benefits of the technology.

1.3 Content of the study

In order to analyse the concrete potential and demand of biomass and PV solar energy in South East Asia a thorough analysis of the existing status quo must be performed in the following fields:

1. General information on the participating nations concerned
2. General situation of the national energy sectors
3. Legal situation of the relevant laws affecting the sectors
4. Statistics and cost structure of the national energy sectors
5. Financing and funding of energy related projects

Furthermore the study needs to gather and evaluate the technical possibilities of the renewable energies in view of the study. This means for solar energy and bioenergy the following information needs to be gathered in the concerned countries.

1. Solar irradiation data and biomass availability
2. Technology available and experience with photovoltaics and bioenergy utilization

It these tasks are thoroughly performed the basis for the formulation of an energy concept in two selected pilot cities is to be formulated. The study will be rounded off with the recommendation for a national implementation of renewable energies.

The study will end in a concrete evaluation of the possibilities and economic chances that lie within the implementation of renewable energy projects in the region. The goal of the action is the generation of guidelines for the implementation of such renewable energy projects in South East Asia. The guidelines are supposed to be of a general nature and will cover the necessary technical and economical areas to enable policy makers and investors to judge the success of applications in their respective fields.

2 Present Situation in South East Asia

This chapter is divided in 3 main parts:

- General Information
- PV Solar information
- Biomass to energy information.

2.1 General Country Information Lao PDR

The general country information includes all relevant information on the energy sector, as relevant institutions, energy production, consumption, export, import, renewable energy application, etc.

2.1.1 The Country

Laos is bordered by China, Vietnam, Burma, Thailand and Cambodia. The Capital of Laos is Vientiane. On a total area of about 236.800 km² live about 5,621 million people with a growth rate of 2,7 % (NSC, 2005). Only 27 % of the population lives in urban areas (NSC, 2005). The rural, and often remote areas are characterised by poor development indicators such as high infant mortality and malnutrition (UNDP 2001). As such the country is ranked among the poorest in the Southeast Asia in terms of both GDP and Human Development. The population comprises three main ethnic groups: the Lao Loum (lowland), 68%, the Lao Theung (Low Mountain), 22% and the Lao Soung (high mountain), 10%. The population density is 23 persons per square kilometers. The adult literacy rate is 62% and life expectancy at birth is 57 years for males and 61 years for females. The major cities are Vientiane, the capital, Savannakhet, Pakse, and Luangprabang. Buddhism is the dominant religion with more than 85% of the population as believers. The official language is Lao.

2.1.1.1 Geography

Laos is divided into 16 provinces (khoueng) and 1 prefecture (kampheng nakhon), Vientiane Capital. Until recently, Lao PDR had no administrative separation between urban areas and rural areas with provincial towns forming (part of) a district. Thus, the newly formed urban areas as Vientiane Capital consist of urban and peri-urban and rural districts or sub-districts.

The Lao PDR is a small landlocked mountainous country in the middle of Indochina peninsula with an area of 236,800 sq. km. Terrain is 80% comprised of rugged mountains, plateaus and alluvial plains, with about 55% forest coverage.

2.1.1.2 Climate

The climate in Laos has clearly different two seasons:

- Wet humid season with high precipitation (May – October). Usually at this time cloudy, less sunshine hours, especially in northern provinces.
- Dry warm season (November-April) with good sunshine but less precipitation

The Lao PDR is located in the zone of relatively high precipitation and good sunshine, thus serves the abundance of hydro potential and rich tropical biodiversity. Main Natural resources are hydroelectric power, timber, and minerals.

2.1.1.3 The Laotian Economy

Since the late 1980s, the government's economic policy has been to move rapidly from a centralized, planned economy toward an open, liberalized, market-oriented economic system. The foreign exchange markets were also opened and formal exchange controls lifted, and the Lao currency (kip) now floats freely based on supply and demand. Gross Domestic Product (GDP) has been growing annually at 4% to 7% since the crisis and the economy is expected to continue on this trajectory for the next few years. Real GDP growth over the last few years has been in the range of 5.5 – 6.5 % per year .

GNP in 2002 was US$ 320 / capita in 2002, and is estimated to have increased to about US$ 370 / capita in 2004. The main economic sectors in Laos in 2003 were agriculture, forestry, power generation, mining and small industries, whereby agriculture contributes to 50% of the GDP, while the Industry is 24% and Services 26 % (NSC 2004). Electricity was with 33 % next to garments 34 %, wood products 21 % and coffee 5,5 % one of the four main export products of the country in 2002 (Dahanayake, 2005).

Lao PDR is one of the poorest countries in the East Asia region. Nearly 77 percent of its population lives on less than US$2 a day, and 29 percent are below the national poverty line of $1.5 a day (in 2002/03). Social indicators remain low and among the worst in the region. Particularly rural areas suffer from poor or even no social services.

Domestic savings are low, forcing Laos to rely heavily on foreign assistance and concessional loans as investment sources for economic development.

2.1.1.4 The Laotian Rural Society

The rural area comprises of the main part of the territory and is inhabited by the majority (about 80%) of the population. Living conditions in rural area have maintained largely unchanged for several generations. The majority of the rural population living in unhygienic conditions is illiterate and has low cultural awareness, particularly in the case of ethnic minorities. The Lao PDR has approximately 46% and 53% of the total and rural population, respectively, living in poverty with a per capita income of less then $100 per annum (World Bank survey, 1995).

The situation in rural areas is exacerbated by a lack of income generating opportunities because of weak linkages to markets and production centers combined with poor access to infrastructure. Since 1995, important area development initiatives have been implemented bringing about material improvements in several aspects, such as road construction and maintenance, the construction of schools and free health clinics, small water reservoirs, maintenance and development of small scale irrigation systems, electricity supply, etc. But in general, Lao rural areas still remain poor with dominance of unproductive agriculture and underdeveloped infrastructure.

Some characteristics of Lao rural society can briefly be described as following: About 80% of un-electrified villages have less then 100 households. In the Lao villages, usually the houses are built close to one another. Average size of Lao family is 6.1 persons per household. A typical rural house has a living room, sleeping room and a kitchen, with floor raised above ground (1-2 m). Woven bamboo is often used as wall. The roof of traditional houses is made of bamboo or straw, some times corrugated galvanized steel sheets are used for roofing.

Remote villages in Laos usually have strong unity among villagers. Village leaders and elderly are respected and have leadership. Normally, skilled technicians are difficult to find in remote villages. Major income sources of rural villagers are from farming and selling livestock. Rural households in Laos, in general, depend on subsistence level of agriculture, mainly low productive rice farming. Depending on each local condition, there are other possible sources of income, such as gardening, weaving, fisheries, service, commerce, etc. It can bee inferred from these facts that any rural electrification program must take into account this lack of financial reserves and earning possibilities. The laotian rural population is in intense need for money generation concepts in order to put electric power provided to a useful concept.

2.1.2 Relevant Organisations

The organization of the Power Sector and relevant Agencies involved in Renewable Energy in the Lao PDR is shown in Figure 1.

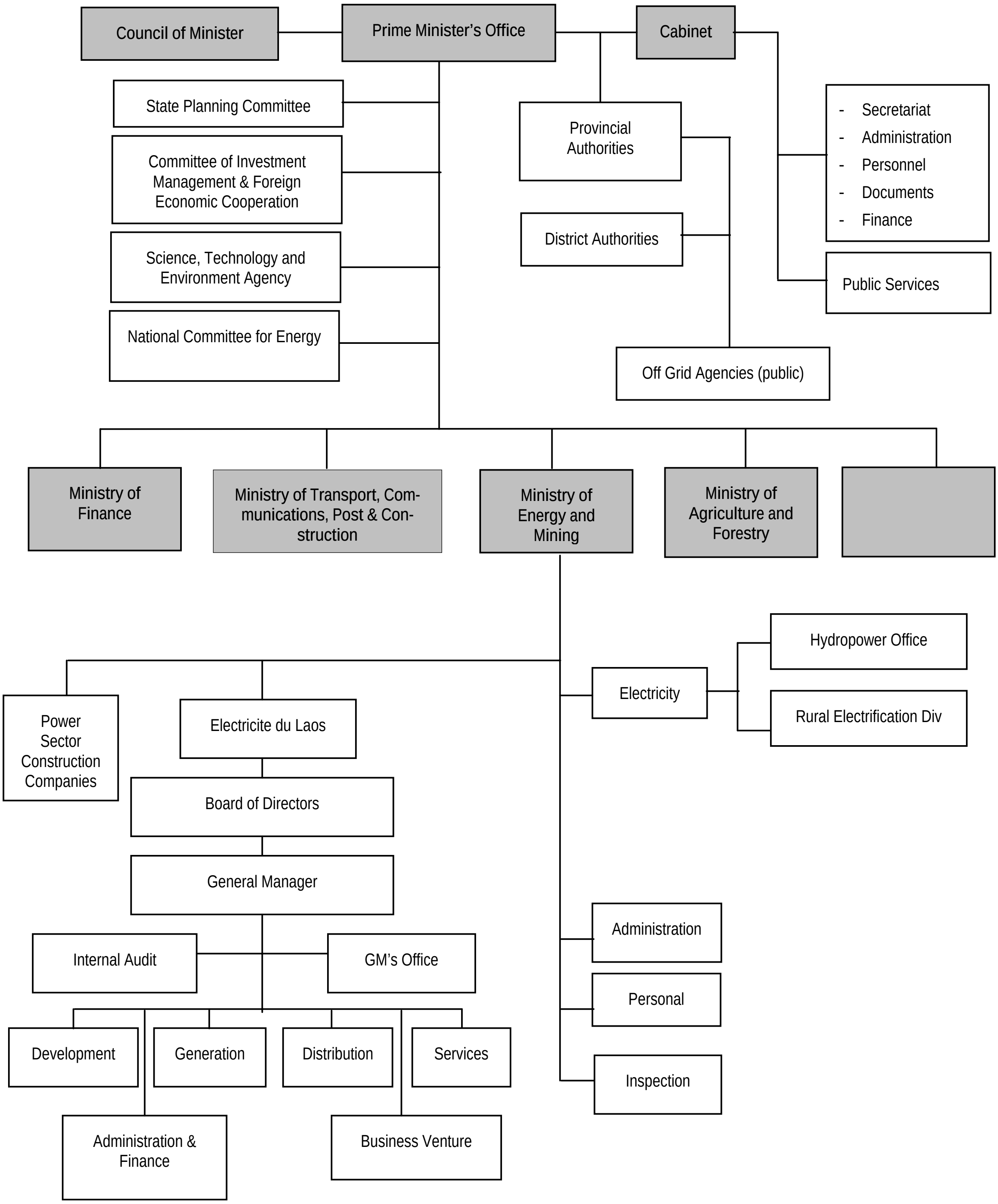


Figure 1: Lao Energy Organisations

Figure 1 already includes the new Ministry of Energy and Mining, wich was establiched in the middeld of 2006. The data research for the presented chapter already were closed beginning 2006, when still all the energy related departments belonged to the Ministry of Industry and Handicraft, thus the Ministry of Energy and Mining is not presented in detail in the explanations below.

2.1.3 Power Policy and Legislation

The overall government policy aim is to: 1. Increase the household electrification ratio from the current level of approximately 45% to 90% by the year 2020, with intermediate targets of 70% in 2010 and 79% in 2015 (Number of Households electrified: 1.140 396); and **2. Reduce the use of imported fuels for electricity generation** and other uses by substitute indigenous energy resources principally hydropower but also solar, coal, and biomass energy.

The policy states that low cost and r**eliable electricity is needed to promote social development and to overcome Lao PDR' s comparative disadvantages in attracting industries and investment.** On the national level, electrification is slowly developing and the government policy is to increase this as quickly as possible by focusing on four priorities areas:

- Maintain and expand an affordable, reliable and sustainable electricity supply in the country to promote socio-economic development
- Promote power generation for export to provide revenues to the government development objectives.
- Enhance the legal and regulatory framework to effectively direct and facilitate power sector development.
- Reform institutions and institutional structures to clarify responsibilities, strengthen commercial functions and streamline administration.

The Electricity Law which became effective on August 1997 set out the regime for the administration, production, transmission, and distribution of electricity, including export and import, through the use of highly productive natural resources potential to contribute to the implementation of the national socio-economic development plan and to upgrade the living standards of the people (Article 1, Electricity Law). In addition it provides a suitable framework for the promotion and implementation of electrification.

The Law defines electricity systems those “connected to a common system, or is any area’s separate electrical system that produces electricity by small-scale hydropower, with petroleum-operated machinery, by solar energy, by wind power, or by some other form of energy” (Article 38, Electricity Law). **The law therefore makes adequate provision for the development of renewable electricity, with a specific focus on rural areas.**

The Law stipulates that the pricing of electricity is set differently to rural and non-rural areas, subject to socio-economic conditions and allowing for periodic reviews. In the long term the government policy indicates that tariff policy is to move the cost recovery pricing over a period of time. The GoL shall agree to / approve all electricity tariffs. (Article 32).

2.1.4 Energy Status in Lao PDR

Fuel wood–based energy sources dominate the energy consumption pattern in Lao PDR. The main energy sources are fuel wood, hydropower generated electricity, and coal. In addition, Laos imports refined petroleum products from its neighbouring countries, having no production sources or refining capacity of its own. However, the country is abundant of several renewable energy resources. **Table 1** gives and overview about the different available fossil and renewable energy source.

Table 1: Primary Energy Resources in Lao PDR

Resource	Reserves	Potential for Use in Power Generation
Oil and Gas	Three exploration concessions in central and southern Laos. Mapping and geophysical investigations carried out, including one deep drill hole (2.560 m). Results not yet evaluated	Possibly in the longer term (10-15 years), if sufficient reserves found
Coal (Lignite)	Major resource located at Hongsa in northwest Lao PDR. About 810 million tones proven reserve, of which over 530 million tones is deemed economically recoverable. Energy content 8-10 MJ/kg, relatively low sulfur content of 0,7-1,1 %	Sufficient reserves for about 2,000 MW installed capacity
Coal (Bituminous and Anthracite)	Reserves, mainly anthracite, dispersed in various fields throughout Lao PDR. Exploration ongoing. Total proven reserve to date about 100 million tones Energy content 23-35 MJ/kg	Current annual production of 130.000 tones, used for local factories or export. Possible longer-term option for around 500 MW installed capacity, depending on results of exploration
Solar	Annual solar radiation received in Lao PDR about 1800 kWh/m^2, possibly less in mountain areas Corresponds to conditions in southern Europe (Italy, Spain)	Photovoltaic modules have been already used for small-scale off-grid applications in remote areas
Wind	Mean wind speeds at Luang Prabang and Vientiane around 1 m/s, in mountain areas likely to be somewhat higher	Costs in areas of less than 4 m/s likely to be in upper end of range US$ 0.05-0.25 per kWh, hence limited potential
Biomass (waste)	Biomass resources dispersed throughout the country	Current share of biomass (mainly wood fuel) in total energy consumption about 88%. Wood-fired cogeneration (heat and power) plants could be economic for self-supply in wood processing facilities
Hydropower	Average annual precipitation about 2,000 mm. Total runoff around 240,000 million m^3 Theoretical hydropower potential of 26.500 MW	Exploitable hydropower potential, including share of mainstream Mekong, around 18.000 MW

2.1.4.1 Total Energy Consumption

Fuel wood has remained as the most important energy source of Lao PDR over the years 1996 to 2002, while the use of natural gas with less than 1 % of the total energy consumption is negligible small. Fuel wood and charcoal account to about 75 % of the total energy consumption. Wood fuel is mainly used for cooking and space heating and its use in rural areas are still accounts to up to 90% of the energy consumption (Nanthavong, 2005).

Table 2: Energy consumption by type in KToe (Koopmans et al, 2005)

Year	Total*	Electricity*	Fuel Oil	LPG	Coal	Fuel wood	Charcoal	Sawdust
1996	1.677,44	32,65	590,3	1,76	21,75	847,46	179,4	4,12
1997	2.003,15	37,32	895,63	2,68	11,34	868,65	183,7	3,83
1998	1.702,95	44,15	561,62	1,6	13,76	890,36	187,9	3,56
1999	1.513,92	48,65	339,56	1,07	16,33	912,6	192,4	3,31
2000	1.537,38	53,88	301,2	1,37	53,03	930,8	197,1	N/A
2001	1.569,72	61,10	325,7	1,37	30,45	949,5	201,6	N/A
2002	1.664,46	65,96	301,2	1,37	53,03	1031,5	211,4	N/A
2002	Share	3,96%	18,10%	0,08%	3,19%	61,97%	12,70%	

*The data on electricity consumption of this source were not equal to the EDL data presented in chapter 2.1.5

Electricity Generation. Thus, the electricity data and the total consumption were adapted. Anyway, it can be assumed that the date on the other energy sources can be used to give a general picture on the use of those sources.

Table 2 shows the energy consumption by type of energy source in Lao PDR. Although the different available source give different figures on the yearly energy consumption, the distribution of the different energy sources is similar in all sources, see the data for the year 2002 exemplarily in Table 3. The overall 2002 energy consumption according the different sources ranges from 1490 to 1812 kToe.

Table 3: Share of the energy consumption by type of energy source in 2002

Electricity*	Fuel Oil	LPG	Coal	Fuel wood	Charcoal
4-12%	17-18 %	0,01-0,08 %	0,03-3 %	57-62 %	12-15 %

Sources: Koopmans et al, 2005; Department of International trade, Ministry of Commerce 2005; EDL, 2005

The share of firewood as cooking fuel ranges from 55.1% in urban to 88.4% in rural areas followed by charcoal with 34.6 % in urban and 7.4 % in rural areas. The overall distribution is shown in Figure 2.

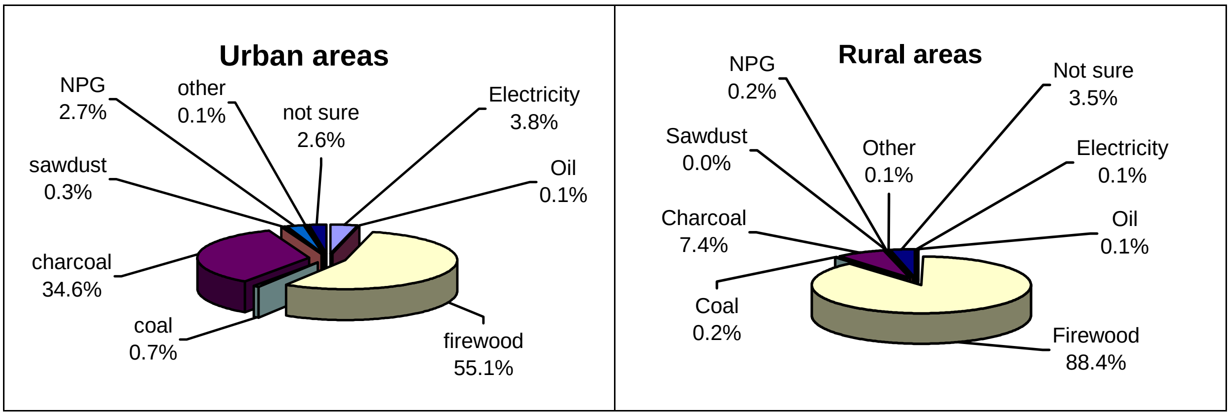


Figure 2: Energy Sources for cooking (National Population and Households census 2005. National Statistic Centre 2006)

2.1.4.2 Cost Structure of Gasoline and Diesel

Before 2002, there was a specific lump-sum tax for each litre of gasoline, collected in the form of custom duty and a turnover tax. The government introduces an excise tax in percent of price per litre and a road fund (levies to finance the maintenance of road infrastructure) in 2003. Most of the rates introduced in 2003 have been subject to revisions since with temporary exemptions introduced to the tax/duty rates in order to slow the pass-through from increasing world prices. However, the Government of Lao PDR recently removed these exemptions and increased the fuel fund levy on November 18, 2005[1]. (Nanthavong, 2005)

[1] Correspondences with Dr. Khamphone Nanthavong, Faculty of engineering, National University of Laos, Vientiane

Table 4: Taxes and duties set in 2003 (World Bank, 2005)

Fuel type	Import duty	Import excise tax	Turnover tax	Road fund fee in LAK/litre
Premium gasoline	20 %	23 %	5 %	100
Regular gasoline	15 %	24 %	5 %	100
Diesel	5 %	12 %	5 %	100

The retail prices of gasoline and diesel have been increasing in the Lao economy since 2003. The Lao Government do not subsidize fuel retail prices but the diesel taxation is significantly lower that the gasoline taxation (Nanthavong, 2005). Thus, the retail price of diesel is about 15 percent lower than that of regular gasoline.

Table 5: Average gasoline and diesel retail prices, in LAK and EUR (Nanthavong, 2005)

Year	2003	2004	2005	01/06	04/06	2003	2004	2005	01/06	04/06
	Retail price in LAK/liter					Retail price in EUR/liter				
Premium gasoline	4.279	6.024	7.924	8.318	8.810	0,35	0,43	0,62	0,64	0,71
Regular gasoline	3.950	5.445	7.294	7.784	8.260	0,33	0,39	0,57	0,60	0,66
Diesel	3.553	4.798	6.276	6.870	7.210	0,29	0,35	0,49	0,53	0,58
LAK/EUR Exchange rate according Infor€uro:						12133,	1389	1272	1289	12455,
Due date						12/03	12/04	12/05	01/06	04/06

Retail prices differ slightly in different areas in the country to compensate for transportation costs to the concerned areas; hence while a litre of diesel cost 7,010 Lao kip in the capital, Vientiane on 31 January 2006, it cost 7,080 Lao kip in Khammuane.

2.1.4.3 Typical Householde Expenditure for Cooking

Despite dwindling forest resources in Lao, for most farmers fuel wood is still available in abundance, and free of costs. But there are some regions, Vientiane province e.g., where households have no access to free wood. Their, they pay up to 6 US$ per year. The cost of other cooking fuels are compiled in the table below.

Table 6: Household expenditure for cooking fuels (Ghimire et al, 2003)

Type of fuel	Consumption per Household and month	Price per unit	Expenditure per year
Wood	25 to 35 kg	Free available	Free or up to 6US$
Charcoal	25 to 40 kg	0,02-0,04 US$/Kg	6,00 - 19,20 US$
Kerosene	2 to 4 l	0,40-0,50 US$/l	9,60 – 24,00 US$

2.1.5 Electricity Generation

2.1.5.1 Electricity Generation by Sources

The total installed electric generating capacity in 2005 was 682,02 MW of which 667,5 MW (98.64 %) are from hydropower plants and the remaining 9,29 MW (1.36%) are Diesel generation and other sources. Figure 3 shows the distribution of the hydropower plant to Electricité du Laos (EDL), Independent Power Producer (IPP) and provincial authorities and communities.

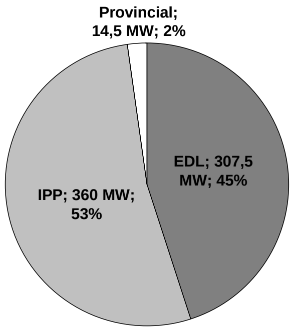


Figure 3: Installed Capacity in year 2005

Nam Ngum I (1971), Nam Leuk (2000) and Nam Mang 3 (2005) Hydro power stations have supplied energy for domestic demand in Vientiane areas and in some part of Thailand. Two provinces (Thakhek and Savannakhet) in the centre part are supplied by power imported from Thailand ‘s grid and then Luangprabang areas, supplied by Nam Dong hydro power after 1970 and from 1994 a 115KV transmission line connected the region with Nam Ngum station. Since 1998-99, large scale of hydropower plants (Theun-Hinboun: 210 MW and Houay Ho: 150 MW) were completed under IPP (Independent power producer) form. It has exported their energy to Thailand. The existing power plants, including IPP plants are listed below.

Table 7: Existing Power Plants in 2005 Laos (DOE, MIH, EDL, 2006)

No	Power Plants	Location (Province)	Max. Output in MW_{el}	Production (GWH_{el}/year)	Owner	Year of Commission
	I Pig hydropower plants					
1	Nam Ngum 1 (H)	Vientiane	155	1025	EDL	1971
2	Nam Leuk (H)	Vientiane	60	245	EDL	2000
3	Nam Mang 3(H)	Vientiane	40	147	EDL	2005
4	Xe Set 1 (H)	Saravane	45	181	EDL	1991
	II Small and micro hydropower plants					
5	Se Labam (H)	Champasak	5	34	EDL	1969
6	Nam Dong (H)	Luangprabang	1	5	EDL	1970
7	Nam Phao (H)	Borikhamxay	1,6	7	EDL	1995
8	Nam Ko (H)	Oudomxay	1,5	8	Provincial	1996

No	Power Plants	Location (Province)	Max. Output in MW_{el}	Production (GWH_{el}/year)	Owner	Year of Commission
9	Micro-Hydro	37 locations	3,63	-	Provincial	-
	III Other Sources					
10	Solar	106 locations	0,178	-	Provincial	-
11	Diesel	47 locations	9,108	-	Provincial	-
I	**Total EDL and Provincial**		**322,02**	**1652**		
12	Theun-Hinboun (H)	Khammouane	210	1620	IPP	1998
13	Houay Ho (H)	Attopeu	150	617	IPP	1999
II	**Total IPP**		**360**	**2237**		
I+II	**Total**		**682,02**	**3889**		

2.1.5.2 Electricity Generation, Consumption, Import and Export

EDL produced 1416,4 GWh, 42 % and IPPs 1931,2 , 58 %, of the 3347,6 produced GWh in 2004. 73 % of the generated electricity, 2424,7 GWh, was exported by EDL and IPPs in 2004. Additionally, 277,6 GWh, 31 %, of the local consumption had to be imported for isolated areas from Thailand (EGAT, PEA) and partly from Vietnam and China. The electricity generation, consumption, import and export from 1998 to 2004 are presented in Table 8 and Figure 4. Additionally, an overall overview from 1962 to 2004 is attached in Appendix 1.

Table 8: Generation, Import, Export and Consumption of Energy, (EDL, 2005)

	Generation (GWH)			Growth	Export	Import	Con-sumption	Losses
Year	EDL	IPP	Total	%	(GWh)	(GWh)	(GWh)	(GWh)
1998	947,7	1208,8	2156,5	76,94%	1613,4	142,3	513,3	172,1
1999	1168,7	1637,5	2806,2	30,13%	2228,8	172,2	565,5	184,1
2000	1337,0	2101,3	3438,3	22,53%	2792,8	180,2	639,9	185,8
2001	1553,6	2100,0	3653,6	6,26%	2871,4	183,8	710,3	255,7
2002	1570,2	2033,9	3604,1	-1,35%	2798,3	200,8	766,7	239,9
2003	1316,9	1861,3	3178,2	-11,82%	2284,6	229,3	883,7	239,2
2004	1416,4	1931,2	3347,6	5,33%	2424,7	277,6	902,7	297,8
Percentage 2004	42,3%	57,7%	100 %		72,4%	30,8%[1]	18,7%[2]	8,9 %

[1] percentage of consumption, [2] percentage of locally generated electricity

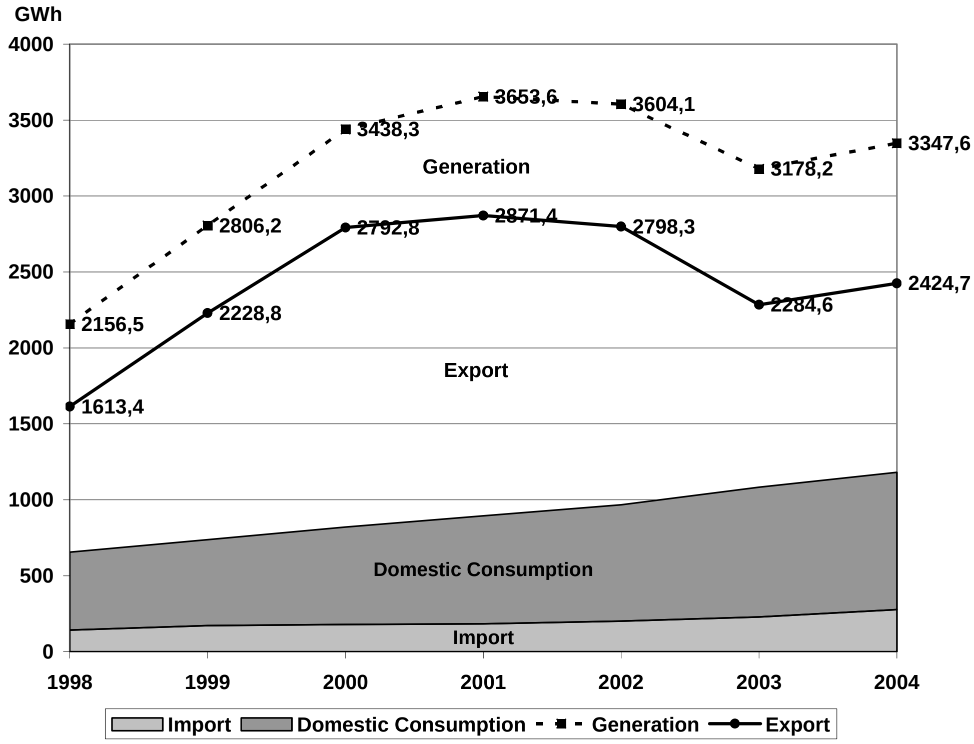


Figure 4: **Generation, Import, Export and Consumption of Energy, (EDL, 2005)**

2.1.5.3 Electrical Energy Consumption by Consumer Categories and Provinces

The total electricity consumption in Laos in 2004 accounted to 902,76 GWh (EDL, 2004). As shown in **Figure 6** it rose permanently since 1990 when it only was 165 GWh. The distribution of the energy consumption to the different sectors: Industry, Agriculture, Entertainment, Government office, residential and Embassies did not changed significantly from 1990 to 2004. The share of the total energy consumption by sector in 2004 is show exemplarily in Figure 5. Remarkable is, that since 1991 the biggest electricity consumer have been residential areas with between 49 to 53 %, whereby the share of the electricity consumption of the industrial sector rose from 9 to 23 %. It is likely that industrial consumption will increase further its share in the coming years.

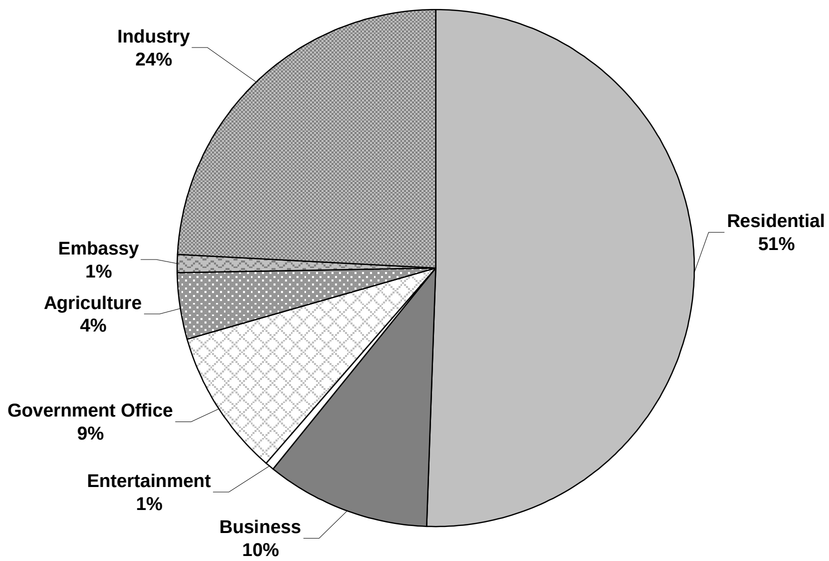


Figure 5: Shares of energy consumption by category of consumers in 2004

Due to the countries electrification programme and the economy growth the energy consumption increased. More consumers within the different categories and an increasing energy demand per consumer are the main reason for the increased energy consumption.

Table 9: Number of Electricity consumers by Category (EDL, 2004; EDL, 2005)

Category	1996	1997	1998	1999	2000	2001	2002	2003	2004
Residential	125.080	151.785	183.660	209.783	231.419	254.445	266.443	343.678	386.871
Business	3.373	7.010	7.446	8.439	9127	9.442	10.019	8.872	11.051
Entertainment	-	149	125	100	132	142	146	265	528
GOL. office	3.328	3.558	3.856	4.145	4.581	4.962	5.099	4.779	6.444
Agriculture	144	282	420	580	637	708	736	792	828
Embassy	422	393	339	299	261	241	242	108	205
Industry	1.737	2.131	2.484	2.971	3.491	3.875	4.010	4.647	8.835
Total	**134.084**	**165.308**	**198.330**	**226.317**	**249.648**	**273.815**	**286.695**	**363.141**	**414.762**
Growth		23,29%	19,98%	14,11%	10,31%	9,68%	4,70%	26,66%	14,22%

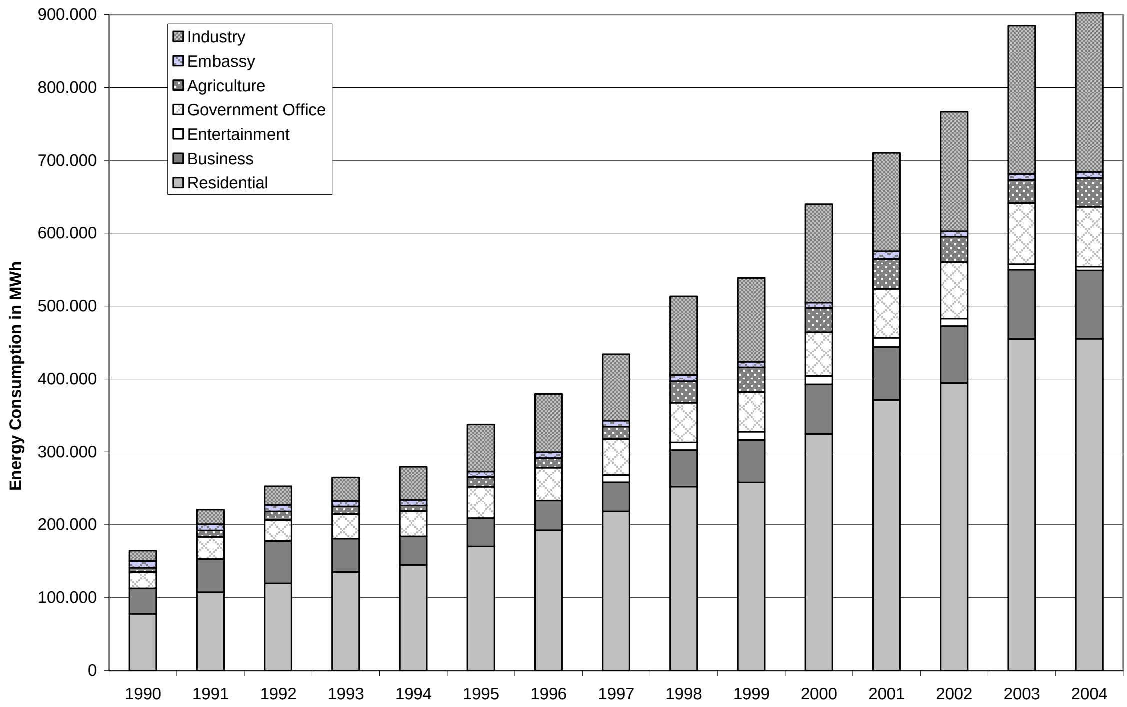


Figure 6: Electricity consumption by category of consumers (EDL, 2004)

In 1995 the peak load for the whole country was 85 MW it has increased since than to 241 MW in 2004.The annual average growth rate of peak load was 12 % during the period between 1999-2003 and 13% for the nine last years 1995-2003. The peak load occurs in two periods in a day. The first occurs in the day time between 11:00 AM to 15:00 PM for supplying mainly industrial and commercial loads in the metropolitan areas, the second peak load occurs between 18:00 PM to 20:00 PM during the night time for residential load. (EDL, 2004)

Energy Consumption by the Provinces

The energy consumption of Vientiane Capital, Khammouan, Savanakhet and Chamoasak province accounts to 87,35 % of the local energy consumption in 2004.

Table 10: Energy consumption by provinces in 2004 (on-gid)

	Name of Province	Households (NSC 2004)	GWh	Percentage	Growth 2003 to 2004
1	**Vientiane Capital**	119.000	467,11	51,7%	-3,49%
2	**Phongsaly**	28.000			
3	**Luangnamtha**	25.000			
4	**Oudomxay**	42.000	4,38	0,5%	13,77%
5	**Bokeo**	25.000	6,1	0,7%	6,27%
6	**Luangprabang**	67.000	29,02	3,2%	6,38%
7	**Houaphanh**	43.000	5,69	0,6%	1,79%
8	**Xayaboury**	60.000	13,11	1,5%	53,69%
9	**Xiengkhouang**	35.000	6,96	0,8%	415,56%
10	**Vientiane**	67.000	103,08	11,4%	8,33%
11	**Borikhamxay**	37.000	27,63	3,1%	26,92%

	Name of Province	Households (NSC 2004)	GWh	Percentage	Growth 2003 to 2004
12	**Khammouane**	61.000	58,46	6,5%	-7,03%
13	**Savannakhet**	128.000	83,21	9,2%	7,12%
14	**Saravane**	53.000	21,24	2,4%	13,46%
15	**Sekong**	13.000			
16	**Champasack**	103.000	76,72	8,5%	7,84%
17	**Attapeu**	19.000			
18	**Xaysomboon SR**	6.000			
	Total	**931.000**	**902,71**		**2,15%**

Only 13 of the 18 Lao provinces have access to the electricity grid. Table 10 and Figure 7 give an overview about the location and consumption of the electrified provinces.

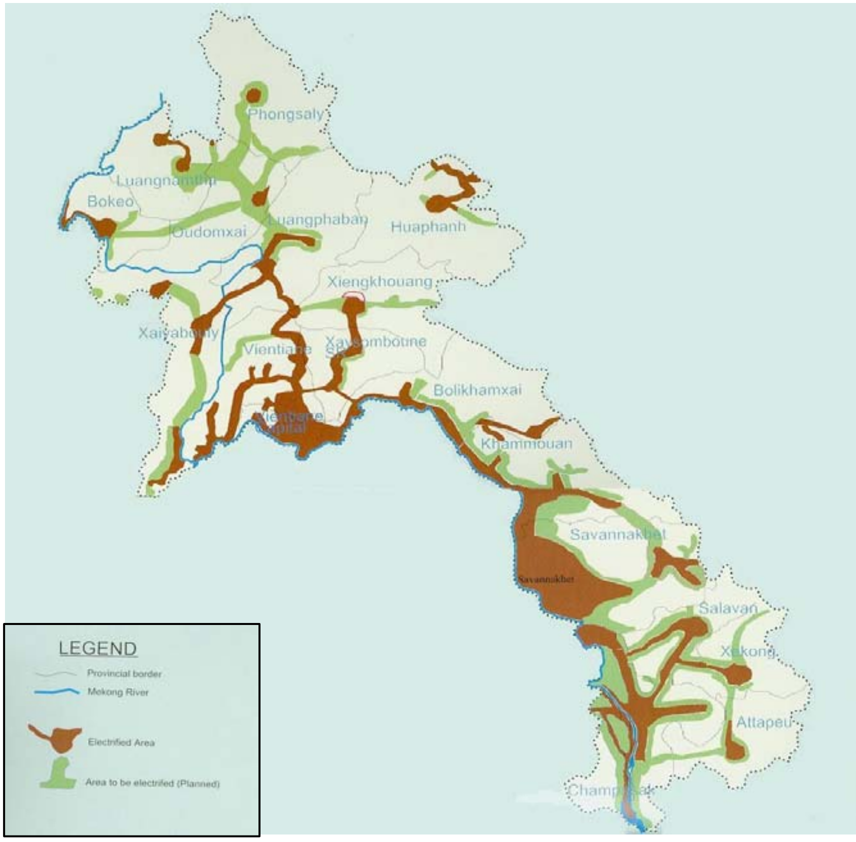
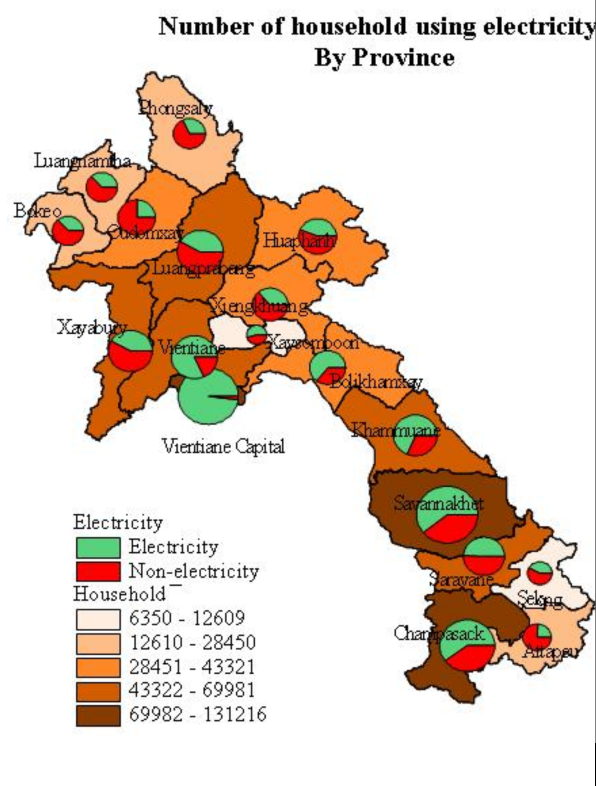


Figure 7: Geographical electrified area in 2004 (EDL, 2005)

Anyway, next to the households electrified by the grid also about 10 % of the Lao households have electricity access by generators, car batteries and other off-grid facilities (NSC, 2005). Figure 8 gives an overview about the total households with off-grid and on-grid electricity access in each province in 2003. Besides Vientiane Capital with an electrification ratio of almost 100 % the average electrification ratio is only 30 %. Especially, the provinces in the north and in the south east have very low electrification ratios under 25 %.



Name of Province	Total-House-holds	Total Electrified households	
		Amount	Percent
Vientiane Capital	105.675	104.302	98,7%
Phongsaly	26.842	2.854	10,6%
Luangnamtha	24.965	6.835	27,4%
Oudomxay	40.080	4.012	10,0%
Bokeo	23.631	5.443	23,0%
Luangprabang	66.622	22.770	34,2%
Houaphanh	41.058	10.442	25,4%
Xayaboury	59.112	13.823	23,4%
Xiengkhouang	31.232	7.083	22,7%
Vientiane	61.080	43.746	71,6%
Borikhamxay	36.486	15.461	42,4%
Khammouane	55.231	26.251	47,5%
Savannakhet	124.222	50.244	40,4%
Saravane	51.810	17.115	33,0%
Sekong	13.267	3.854	29,0%
Champasack	98.388	41.016	41,7%
Attapeu	18.432	2.482	13,5%
Xaysomboon SR	5.222	1.376	26,4%
Total	883.355	379.109	42.9%

Figure 8: Number of households using on- and off-grid electricity by provinces (NSC, 2005; MIH, 2003)

2.1.5.4 Electrical Energy Demand Forcast 2004-13

An electricity demand forecast was conducted in each province (18 provinces) in the frame of the EDL Power System Development Plan 2004-13 (PDP2004-13). The reference point for preparation of the demand forecast is the government's goal to increase the electrification ratio from the current level of 45% of households electrified in 2005 to 70% by the year of 2010 and 90% in year 2020. Table 11 shows the electricity forecast for the whole country where average growth rate of energy demand and peak load is estimated at 21%, while peak load is at 19% for the period of 2003 to 2005. For the period 2010 to 2020 Energy demand is estimated at 6% to 11% while peak load is at 6% to 9%.

Table 11: Summary of Electricity Demand forecast according PDP2004-13 (EDL, 2004)

Items	Unit	2010	2015	2020
Energy Consumption	GWh	2.684,1	3.650,8	4.854,7
Average growth rate	%	11	6	6
Peak Load	MW	510,7	694,6	923,6
Average growth rate	%	9	6	6
Load Factor	%	60.0	60.0	60.0

The Lao PDR Power sector is still in low level with only 45% (2005) of the population having access to electricity, and the power energy consumption is 177 kWh per capita in 2005 (EDL, 2006).

2.1.6 Rural Electrification

Energy consumption in Lao rural areas basically is for cooking and lighting. In some areas small entertainment devices and small machinery tools are also observed. Normally lighting hours at the villages are around three hours from 18:00 to 21:00 in the evening and about 1 hour from 5:00-6:00 in the morning.

Rural electrification marks one of the remarkable achievements in the socio-economic development of Lao PDR with the connection rate increasing from approximately 120.000 households in 1995 to about 420.000 households by the end of 2005. However, as electrification moves to increasingly remote areas, grid connection becomes less viable. Thus grid extension projects in remote areas do not proceed smoothly. Most un-electrified villages would not be connected to grid for more than 20 years. Rather, it would be more realistic to develop off-grid electrification systems on the base of locally available energy sources, to meet basic electricity needs of the rural people.

Therefore, GoL has embarked on an off-grid electrification program to complement grid electrification by using renewable energy resources, mainly from small-scale hydro and solar energy. Notwithstanding, a complete picture of available energy resources is still missing. There is general agreement that the rural electrification strategy must build on a combination of grid and off-grid solutions. For this purpose a Rural Electrification Fund is under review at ministerial level. While the short-term strategy will predominantly focus on grid extension and off-grid solar systems, long-term plans are to introduce differentiated delivery models and tariff schedules, depending on willingness-to-pay and local endowments.

The off-grid model currently being undertaken by the Ministry of Industry and Handicraft (MIH) is still in its infancy and up until now lacks a firm regulatory and sustainability foundation and technology and planning basis. Thus, it will be a big challenge for MIH to increase rate of off-grid connection from current about 6.3% of electrified households to 20% in 15 years.

2.1.6.1 Current Rural Electrification Systems

Current rural electrification systems and technologies in use in Lao PDR are described below. (Maunsell, 2004) Their are no statistics available on the off-grid electrification in rural Lao. Sources for the available data are field trip reports and pilot project surveys.

Main Grid Distribution Systems (EDL)

Main -grid distribution owned and operated by EDL which distributes electricity to most principal centre and villages within economic reach of the system. EDL's power planned power system diagram 2007-2011 (see Figure 13) gives an overview about the present grid and the targeted extension.Isolated Distribution Grid Systems

Isolated/mini distribution grid systems are powered by either diesel gen-sets, cross-border supplies, mini-hydropower stations (i.e. 100 KW - 5 MW), micro-hydropower installations (i.e. < 100KW) or hybrid systems (Hydropower combined with PV solar). These systems are generally focused on provincial or district towns that are beyond the reach of the main distribution system and are in some cases owned/operated by EDL and in most cases owned/operated at the provincial or district level. There is one Japanese Ministry of Foreign Trade funded hybrid project: a 100 kW PV Solar park combined with hydropower (Invest 5 Mill US$). The Solar energy is used to pump water from a lower to a higher basin to produce cautiously hydropower for a local grid.

The EDL owned girds generally follow the EDL standards whereby the not EDL owned grids often lack basic standards. Those are constructed using untreated timber boles, inadequate conductor sizes, etc.

Village Grid Systems

Besides the big potential of village grid systems powered by micro-hydro or diesel gen-sets so far there are only very view systems installed. There is e.g. one micro hydro system supplying 58 housholds in Luang Phrabang and another diesel gen-set system supplying 94 housholds in Xieng Khouang. Both installed in the frame of the MIH Off-grid Rural Electrification Promotion and Support Programme (see 2.1.6.3). The supplied power of this micro-grid distribution systems range from 1 to 10 kWh. They generally serve villages, or small clusters of villages that are beyond the economic reach of the main or isolated distribution systems.

PV Systems

Solar PV systems supplying individual households, health clinics, institutional facilities, etc. Their application will be discussed in detail in chapter 4.1.

Pico hydro generator units

Pico hydro generator (typically of 100-300 Watts output), generally supplying individual households or small group of households. These systems are mainly found in the northern provinces of Phongsaly, Houaphanh, Oudomxay, Luangnamtha, Luangprabang and Xiengkhouang. The climate of those provinces with the higher rainfall and lower solar irradiation is more suitable for small hydro than for Solar home systems. More than 50 % of households own these hydro generators in many villages of the mentioned provinces.

Pico hydro units are generally purchased by individual households for their own use, are low –cost (less than $30 USD/ Unit) provide a relatively unsafe supply, unreliable (require fairly frequent repairs) and have a relatively short lifespan (about three years) .They are usually used for lighting only, since the incorrectly and varying voltages produced from these Pico units makes use of other small appliances difficult. Individual Pico hydro usage is not promoted or support by any government agencies or programs, and Pico hydro usage has therefore developed on a purely commercial basis.

Battery Charging Stations

Battery systems based on motorcycle, car and truck batteries are in common usage in the rural areas of Lao PDR. They are usually owned by individual households to provide lightening for a view hours or to run radios or small televisions. Small rural enterprises provide battery re-charging services using small diesel or petrol gen-sets as energy source. Some re-charging is also done by grid connected small scale entrepreneurs.

Traditional Fuels

Traditional fuels / lighting (kerosene, candles, dry cell batteries etc.) which are typically found in most rural households.

Biogas Systems

Biogas systems will be discussed in detail in chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**.

2.1.6.2 Targets and Costs for Rural Electrification

The government of Lao PDR' s aims to increase the electrification ratio for the whole country from the current level of about 45% (2005) to 90% by 2020, with intermediate targets of 45% in 2005 and 70% in 2010. This goal will be achieved through the dual approach:

- To electrify 150.000 household off-grid by year 2020 and
- By the main transmission and distribution grid extensions to 90% coverage by 2020, after deduction of off-grid installations.

Table 12: Targets of electrified households until 2020 according PDP 2004-13

Year/Description	2004	2005	2010	2013	2015	2020
Number of villages electrified	3.464	3.574	5.584	6.434	7.024	8.906
% of villages Electrified	31%	32%	50%	58%	63%	80%
Number of Households electrified	395.598	595.598	733.926	858.794	914.894	1.140.396
% of Households Electrified	43%	45%	70%	76%	79%	90%

It is currently estimated that some 100.000 off-grid systems will need to be delivered to households that will never be electrified by the main grid EDL. Furthermore, 50.000 households eventually shall be electrified by the main grid. Those 50.000 households will be provided with off-grid systems for the short term, to provide them with electricity already before they get their grid-connection.

2.1.6.3 Off-Grid Rural Electrification Procedure

The Off-grid Promotion and Support Office (OPS) was founded within the Department of Energy of the MIH in the frame of the GEF funded Southern Provinces Rural Electrification I Project (SPRE I). Within a 5 year pilot phase the OPS was establish, structures for rural electrification involving the private sector developed and documented in an OPS Operation Manual and 4.600 households in 46 villages electrified.

The SPRE I program were implemented in 6 provinces only, including Chamassak, Oudomxay, Luang Namtha,. Saiyaboury, Vientiane and Xieng Khouang. The SPRE II Programme covers all provinces except Vientiane Capital.

The SPRE I pilot project focussed on the development of structures focussing on cost recovery from operation and the use of low cost technologies. Possible off-grid delivery system were developed and test it in 46 villages. Ten pilot installations were undertaken and were extremely valuable in developing low cost and robust technologies and delivery mechanisms using villages entrepreneurs. Based on the pilot phase the MIH off-grid electrification model was developed, see Table 9. The model includes the structures and responsibilities for off-grid rural electrification.

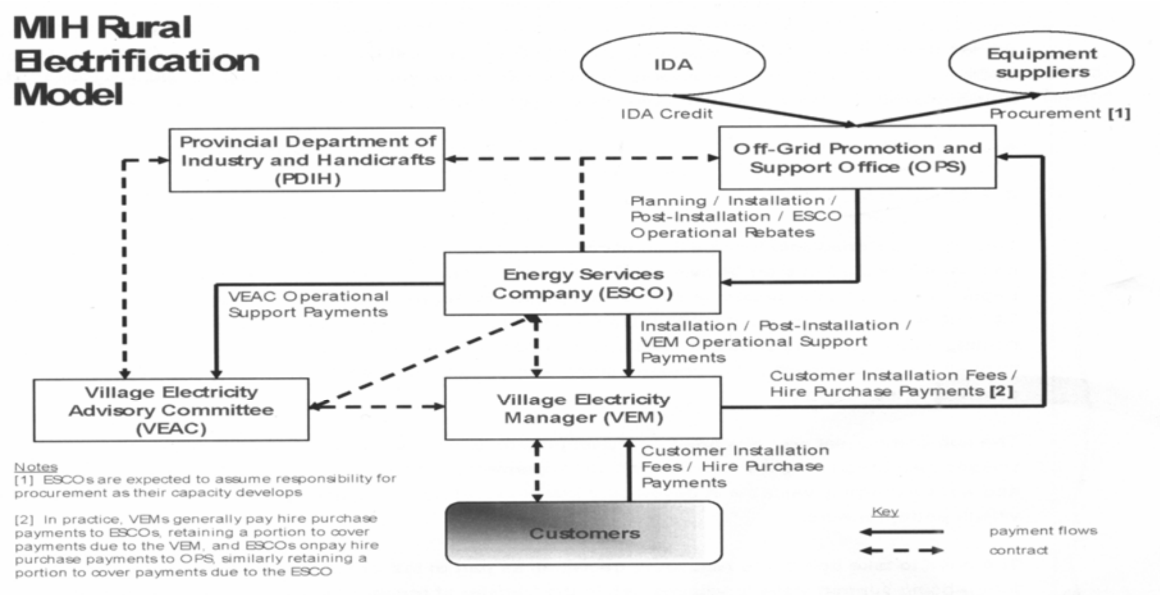


Figure 9: The model of MIH Rural Electrification (Maunsell, 2004)

OPS investigated various models for establishing Energy Service Companies. Initial attempts to implement national ESCOs failed due to the reluctance of private companies and NGOs to adopt this role. OPS then adopted a model involving the appointment of new provincial ESCOs, contracted to OPS and supporting a network of Village Electrification Managers (VEMs). The ESCOs and VEMs are required to follow a participatory planning process designed by OPS and to install and service systems, as well as collecting payments for remittance to OPS. Performance based payments to the ESCOs and VEMs are linked to their performance in planning, installation, payment collection and reporting.

The bottleneck of long term operation of the MIH rural electrification model in the whole country is the availability of financing, as it was difficult to attract investment from the private sector during the pilot phase and the governmental sources are limited. The pilot phase itself was financed within the SPRE I programme and follow-up activities are financed now under the SPRE II programme. The average expenditure for household electrification by SHS, gen-sets and small hydro were 270 US$ per household.

2.1.6.4 Safety and Operational Awareness

Pico Hydropower

Electricity is often generated by villagers at their own initiative, using their personal water turbines, as described before. Unfortunately serious, often dealdy accidents occur frequently, 2 or 4 people were electrocuted every year. These are due to unregulated voltage (non voltage regulator cost about $ US 100 each) combined with use of un-insulated cable and lack of grounding wire or other protection automatic safety trips. Users lack knowledge of basic electricity safety and energy efficiency.

The Provincial Department of Industry and Handicrafts in Houaphanh province (Workshop 03/2004) indicated that an awareness building program would be useful to build knowledge of electrical safety and disseminate information on the correct installation of the Pico hydro units and correct/safe wiring of house.

PV Solar

In the case of Solar home system (SHS), there are not accidents from the electricity due to the very low voltage (only 12 volts) but we had impact on the environment from acid liquid of the batteries. The main difficulties with SHS systems are as followed:

- The most common in solar home systems failure is lack of proper maintenance service, spar parts supply and replacement
- Lack of user awareness: unauthorized installation of inappropriate appliances by unauthorized people (usually by users selves), over discharging battery are often observed in solar PV project in Lao PDR
- another rather familiar causes of solar home system failure: wrong systems sizing, (usually due to lack of proper information on solar irradiation or system properties), wrong installation (by unskilled village technicians),

2.1.6.5 Barriers experienced of the Mini and Macro Hydro and Diesels Projects

The policy states that the Electricity Law provides a suitable basis for promotion of off-grid supplies. But recognizes certain clarifications, and some reviews and revisions are necessary to account the growing commitment administration and policy development in such areas. Past mini and macro hydropower projects faced the following barriers:

- Introducing regulations to give effect to sections of the law.
- Developing ownership and solicitation modalities to encourage expansion and durability of power sector investments.

- Adopting flexible pricing within the framework established by the regulation.
- Introducing systematic and sufficient capital subsidy and tax incentives to establish off-grid development on a sound commercial and affordable footing.
- Introducing regulations governing application of disbursements from the off-grid fund.
- Constraints of Financing (limited finance availability) for construction and operation due to insufficient revenue covered the cost of repairs operation.

Another problem is, that the existing rural electrification models are not economical viable. Actually, the Lao PDR has three (3) current Rural Electrification models, one by conventional government -owned Model by EDL. The Nam Ngai HPP (1,5 MW) in Phongsaly Province, the Nam Ko (1,5 MW) in Oudomxay Province, it had extended its grid to the rural area operates isolated grids with his owned generation units. EDL has reasonable capacity for management, operation and maintenance of small and medium scale hydro. However, past experience has been that EDL is reluctant to engage in electrification of remote regions. Because, the national uniform tariff is not enough to compensate both the capital cost and operation & maintenance cost.

The second is conventional government-owned Model by PDIH (Provincial Department of Industry and Handicrafts). The most generations operates with isolated systems by diesel plants. Operation & maintenance (O & M) of diesel units relatively easy but the revenue is not enough to compensate both capital cost and O & M expense, operating loss is compensated from recurrent cost of local authorities.

The third is commercial sales Model managed by private vendors, the electricity are sold directly to individual household, the most by diesel generator.

2.1.6.6 Summary

According to several survey studies, the typical figure of average monthly energy expenditure throughout the country is about 4-15% of household income. Major energy sources for lighting are fuels, such as kerosene, and automobile batteries. The batteries are normally charged by small diesel generator, run by battery charging shop in a village, or to be carried far away to electrified villages for charging. As for lighting, kerosene and diesel are used most frequently throughout the country. In northern provinces the use of Pico hydros (capacity 200-5000 W) is quite popular. Battery possession rate is usually high: women need light for weaving at night times; better light for children to do homework. Both activities however are not directly connected with income generation. Usage of batteries and small hydro generators (Pico hydros) depends on regional conditions. Many people in central region of Laos use batteries while people in northern region hardly use them, but pico hydros are more popular there. In general, electric lights are most strongly desired among villagers. Villagers, who have already been using batteries, favour solar systems most.

2.1.7 Electricity Tariffs and Price Structure

2.1.7.1 Electricity Tariffs on-grid

As a policy the Government with regard to electricity tariff is to keep intentionally domestic tariffs as low as possible (below economic cost) in order to encourage the socio- economic development, thus the profit of Electricity du Laos (EDL) is pending on the export of electricity. EDL was particularly hard hit by financial crisis and ensuing inflation of the late 1990's because of a currency mismatch: its revenues are largely in Kip while costs are mainly in US Dollars. A financial recovery plan was implemented during the subsequent years; the main features of this plan included conversion of government debt to equity and **tariff adjustments of 2,3% per month**, see Table 13. Consequently, EDL is now reasonably good footing and was able to pay annual dividends to government in the order of 3-5 million USD in 2003 and 2004. **The average domestic tariff rate is 17% below the rate required for full cost recovery given existing costs.** Residential and agricultural consumers are cross-subsidized by the others. However, part of net returns of exports is covering the gap in full cost recovery. In 2006 the electricity tariffs ranged from 0,01 for residential users to 0,1 US$ for embassies and international organisations, see Table 14.

Table 13: The EDL' s Tariff of Domestic Electricity charges 2004 (EDL, 2004)

	Calendar Year 2004										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
	Kip/kWh										
Residence											
0 - 50 kWh	101	103	106	108	110	**113**	116	118	121	124	127
51 - 150 kWh	236	242	247	253	259	**265**	271	277	234	290	297
> 150 kWh	682	698	714	731	747	**765**	782	800	818	837	857
Commercial	737	754	772	790	802	**826**	845	865	885	905	926
Business	977	999	1022	1046	1070	**1095**	1120	1146	1172	1199	1226
GOL Offices	630	645	660	675	690	**706**	722	739	756	773	791
Agriculture	263	269	275	282	288	**295**	302	309	316	323	330
Industry	567	580	594	607	621	**636**	650	665	680	696	712
	US Cent/kWh**										
Embassy, Foreigner	9,9	9,9	9,9	9,9	9,9	**9,9**	9,9	9,9	9,9	9,9	9,9

*business and entertainment, ** Exchange rate Kip/USD 2004: 10.800 kips = 1 USD

The application of the 2,3 % rate increased electricity charge per month has suspended since June 2004, the main reason was that customers could not afford to follow this type of tariff adjustment. Thus, another level of tariff adjustmend was found by the MIH and published in the notice from the MIH No 302/MIH, dated 24/06/2005. The new Electricity tariff is show in Table 14 below.

Table 14: Electricity tariff in KIP (MIH, 2005)

Category of Customer	**From 06/2004 to 06/2005**	**From 07/2005 to 12/2005**	**2006**	**2007**

	KIP per kWh	US$ per kWh	KIP per kWh	US$ per kWh	KIP per kWh	US$ per kWh	KIP per kWh	US$ per kWh
Residential users of low Voltage power								
From 0 - 25 kWh	113	$0,01	115	$0,01	132	$0,01	152	$0,01
From 26 - 150 kWh	265	$0,02	265	$0,02	273	$0,03	281	$0,03
> 150 kWh	765	$0,07	765	$0,07	765	$0,07	765	$0,07
Non Residential users of low Voltage power								
Agriculture, Irrigation	295	$0,03	295	$0,03	310	$0,03	325	$0,03
State' Office & Building	706	$0,07	706	$0,07	696	$0,06	686	$0,06
Industry	636	$0,06	636	$0,06	627	$0,06	6187	$0,57
Business in general	826	$0,08	826	$0,08	826	$0,08	826	$0,08
Embassies & International organizations	1.066	$0,10	1.066	$0,10	1.066	$0,10	1.066	$0,10
Entertainment	1.095	$0,10	1.095	$0,10	1.095	$0,10	1.095	$0,10
Non Residential users of middle Voltage power (22 KV)								
Agriculture, Irrigation	266	$0,02	251	$0,02	263	$0,02	276	$0,03
Industry	572	$0,05	541	$0,05	533	$0,05	526	$0,05
State' Office & Building	653	$0,06	600	$0,06	592	$0,05	583	$0,05
Business in general	743	$0,07	702	$0,06	702	$0,06	702	$0,06

Remark: The rate shows in this table is in Lao Currency, KIP/KWh. Exchange rate: $ 1 USD = 10.860 Kips in year 2005

In September 2005, EDL' s Power Sector Plan was approved by the Deputy Prime Minister, the Plan includes three components:

- Tariff adjustments in real terms;
- Settlements of accumulated arrears of government and rescheduling of EDL' s debts to government and
- Avoidance of future arrears by the government.

The Ministry of Finance and the Ministry of Energy and Mining (Ministry of Industry and Handicrafts up to 2006) are working to ensure that there is no slippage in implementation of the action plan for financial sustainability of EDL. The Ministry of Finance has paid almost $1million USD to EDL and has approved a phased write-off of an additional $ 4 million USD of arrears.

2.1.7.2 Electricity Tarifs off-grid (PV, Hydro, Gen-set and car batteries systems)

There exist no statistics on the off-grid electrification costs. Put, the Off-grid Promotion and Support Office (OPS) of the MIH collected data on the costs of the main off-grid applications, PV, gen-set and small hydropower. OPS collected the date in the frame of a 5 year training programme for small companies to become village energy service specialists (OPS, 2004).

Solar Home Systems

PV Solar Home Systems in Laos where installed in Programmes funded by Japan International Co-operation Agency (JICA) and by the world bank (within SPRE). Additionally, the

Lao company Sunlabob Rural Electrification Co. Ltd. is purchasing and leasing SHS. The different projects will be discussed in detail in chapter 4.1.1.6. Table 15 shows the initial and monthly cost of the different systems.

Table 15: Price structure of SHS in Laos

	JICA	World Bank				Sunlabob Co Ltd.					
Watt	50	20	30	40	50	20	30/32	40	50/ 55	75/80	100/110
System costs	$300	256	308	359	411	276	329	412	517	650	938
Direct Subsidy		56%	31%	19%	5%						
Initial Payment[2]	$20	$16	$16	$19	$22	$10	$10	$10	$10	$10	$10
Monthly Fee[3] (20 years leasing)	$1,62					$3,5	$5,4	$6.4	$9,2	$15,2	$16
Monthly Fee (10 years Leasing)	$2,63	$1	$1	$1,5	$20						
Monthly Fee (5 years leasing)	$ 4,98	$2	$2	$3	$4						
Monthly Mainte-nance cost	included above	$0,5-1,2				included above					
Price per Watt (20 years leasing)	0,06	$0,10	$0,08	$0,06	$0,05	$0,23	$0,21	$0,20	$0,21	$0,22	$0,18

Source: PROCAT, 2001; OPS, 2004; Sunlabob Co., 2006

The electricity price for the 20 year leasing or rental PV Solar home systems based on the system costs and monthly fees range from 0,05 to 0,23 US$/Watt. The initial payment ranges from 10 to 22 US$.

Hydro and Gen-set tariffs

Hydro and gen-set tariffs are paid based on electricity consumption and not for buying hardware as in the case of SHS. Anyway, it is not possible to state the costs per kWh, as there is no metering system and the produced electricity is limited. The electricity is sold by the Village Electricity manager (VEM) by units, see Table 16. The table shows the maximum and minimum price per night unit, recommended to the VEMs and ESCOs. (OPS, 2004). The night units for hydro are usually 12 hours from dusk till dawn and for gen-sets 3 hours in the same time span upon agreement. The prices for day unites are set individually by the VEMs. During the day electricity is only available for a limited amount of users.

Table 16: Off-grid hydor and gen-set tariffs

[2] In case of Sunlabob: connection fees, equally for all sizes of solar home systems. Recently this charge goes into village electricity fund

[3] In case of Sunlabob: monthly rents

Units	Appliance examples	Total Watt	Initial fee in US$	Min. US$/ month	Max. US$/ month	Min. US$/ month	Max. US$/ month
1	2 7W CFL lamps	14	15	1,20	1,60	0,09	0,11
2	Ditto plus cassette-radio		15	1,80	2,20		
3	Ditto plus 30W audio CD	30	15	2,40	2,80	0,08	0,09
4	4 7W CFLs and 30W CD	58	15	3,00	3,40	0,05	0,06
5	6 7W CFLs, 30W CD or 48W colour TV	90	15	3,60	4,00	0,04	0,04
6	1 7W CFLs, 48W colour TV, 30W receiver	85	15	4,20	4,60	0,05	0,05
7	1 7W CFLs, 65W colour TV, 30W receiver	102	15	5,40	5,20	0,05	0,05

Applied exchange rate KIP/US$: 10.000

The electricity price for hydro and gen-set systems range from 0,04 to 0,11 US$/Watt. The initial payment is fixed with 15 US$. These costs do not include any system costs.

Pico Hydro Costs

Pico hydro generators are very common in the northern provinces of Phongsaly, Houaphanh, Luangprabang, Luangnamtha and Xiengkhouang. Their capacity ranges between 100-5000 Watt. The investment costs are less than 30 US$/unit for capacity lower 300 W.. Pico hydro turbines cost about 100US$/1000W for capacity ranging 300 W to 5000 W. The figures below show the installation of those hydro turbines. Figure 10 shows a installation with draft tube, which is usually is made of galvanized steel sheet. Figure 12 shows an installation without draft tube, where the turbine shaft is connected to a boat propeller and can work under smaller head but larger flow.

Figure 10: Pico hydro turbines installation with draft tube (

Figure 11: Pico hydro turbines and its spar parts on sale

Figure 12: Pico hydro turbine installation

Car Battery Systems

Battery systems based on motorcycle, car and truck batteries are in common usage throughout rural Lao. Investment costs range from 200.000 to 250.000 LAK for the 70Ah battery (20-25$); 7W saving 12 volt-bulb costs about 5 US$ and wiring costs 5 US$. The car battery has to be replaced once a year or less, depending on how deeply the battery was discharged. One charge can last for 4-5 days for one light and B/W DC 14" TV , using about 2-3 hours per day. Charging cost usually is counted by storage capacity of the battery (Ah). Typically, for 50 Ah battery, charging cost is about 3000 LAK, 70 Ah – 4000 LAK, 100 Ah – 5000 LAK.

2.1.7.3 Export and Import Tariffs

There are committed exports to neighbouring countries under project-specific Power Purchase Agreements (PPA) that set out strict conditions governing delivery of capacity and energy and the penalties that apply in the event of breach. At present, PPAs have been signed only with EGAT (Theun Hinboun, Houay Ho and Nam Theun 2), although negotiations are in progress with Vietnam in respect of two other proposals (Nam Mo and Xe Kaman 3). The following table shows the EDL electricity import and export rates in 2004 based on the EDL Annual report.

Table 17: EDL electricity import and export rates in 2004 (EDL, 2005)

A. Export Tariffs		
Rate	**Time**	**Costs in US$ per kWh**
115KW Transmission lines system (generated by Nam Ngum 1, Xeset 1, Nam Leuk, Nam Mang 3)		
Peak rate	18:00h – 21:30h	$ 0,0277
Off peak rate	21:30 h – 18: 00h	$ 0,0259
A. Import Tariffs		
115 KW from EGAT (Vientiane / Xe set)TOD rate		
Peak rate	18:00h - 21:30h	$ 0,0320

Off peak rate	21:30h – 18:00h	$ 0,0302
22KV from EGAT (Khammouane) TOD rate		
Peak rate	18:00h - 21:30h	$ 0,035
Off peak rate	21:30h – 18:00h	$ 0,033
22KV from PEA (Houaysai/Bokeo-Kenthao, Muong Ngeun) TOU rate		
Peak rate	18:00h – 21:30h	$ 0,0800
Off peak rate I	21:30h – 18:00h	$ 0,0325
Off peak rate II	0:00h – 24:00h	$ 0,0325
35 KW from EVN (Samneu Houaphanh, Sepone Savannakhet, Sanuei/Sekong)		
Flate rate		$ 0,06
35 KW from China (Muonh Sing/Muong Namtha)		
Flate rate		$ 0,06

2.1.8 Transmission Line and Substation Facilities

Based on the particular characteristics of the Lao PDR and the existing power grids as well as to facilitate the process of conducting electricity demand forecast, the whole country has been divided into 4 regions (according to EDL Power Development Plan PDP 2004-2013).

Central 1: Vientiane Prefecture, Vientiane province, Xaysomboun special Zone and the provinces of Luangprabang, Sayabury, Xieng Khouang and Borikhamxay

Central 2: The provinces of Khammouane and Savannkhet

Northern: The provinces of Phongsaly, Oudomxay, LuangNamtha, Bokeo and Hua Phanh

Southern: Champasak, Saravane, Attapeu and Sekong

2.1.8.1 Transmission Lines

The four transmission voltage systems in operation for domestic power supply in the four regions are not interconnected, and function separately, the four main 115 kV Transmission lines systems are: Vientiane’115 kV transmission line System, Thakhek’115 kV transmission line system, Savannakhet’115 kV transmission line system and Saravane’115 kV transmission line system. The present and planned transmission lines and power plants are shown in Figure 13.

Vientiane '115 kV transmission line system

Vientiane region is provided by 3 major hydropower plants: Nam Ngum 1 with 155 MW, Nam Leuk: 60 MW, and Nam Mang 3: 40 MW of which plays the important role in this system and it is the largest system of the four regions. At the present time the system supplies energy for Vientiane/Paksan, Vang vieng/Luangprabang and it is planned to link up Nam Ngum substation to the provinces of Oudomxay, Luang Namtha, Phongsaly and Saysomboun/ Xieng Khouang areas, by building new substations for each location.

Actually, at Nam Ngum 1 there are 3 circuits of 115 kV transmission lines in operation, one line, set up for export purpose is connected Phone tong substation to Egat power station in

Thailand, the second circuit is set up in Thakhek and Savannakhet in order to import power back from Thailand through Nakhonephanom and Mukdahan, the third new reinforced circuit is connected Tha Lat station (Nam Ngum 1) to Luangprabang substation, extended over 212 km via Vang Vieng substation in order to supply the Northern region.

Thakhek' 115 transmission line system

Actually, the 115/22 kV Substation is in operation in Thakhek in replacement of the former 22 kV submersible line, in order to import power from Nakhone Phanom substation in Thailand.

Savannakhet'115 transmission line system

Due to the insufficiency of domestic power supply, the Savannakhet'115 transmission line system is set up in order to import power from Thailand, by connecting the 115/22 kV Pak Bo substation to the Egat' system in Mukdahan through the 115 transmission line across the Mekong river, to feed Savannakhet city then extended to Keng Kok district, 50 km further.

Saravane ' 115 kV transmission line system

This system is fed by 2 hydropower plants, Xeset (45 MW) and Selabam (5 MW) and another 2MW from IPP plant of Houay Ho, it is set up in order to supply power for rural areas of Saravane and Champassak provinces and the city of Pakse. In the near future Attapeu province and Siphandone area (Khong District) will be supplied by this system, actually the construction of 115 kV grid and substation are ongoing). Besides the domestic supply, the surplus of energy from the 2 Plants (Xe set 1 & Selabam) was exported to Thailand, as Xe set 1 is conceived as a run-of river type, and during the dry season, the station couldn't run in full capacity due to lack of water and to feed the system it is necessary to import back the energy from Thailand through a 115 kV transmission line.

The systems described up above are operated by EDL to provide mostly energy for local consumers of which the surplus is exported particularly to Thailand.

Figure 13: Existing and planned hydro and thermal power plants and transmission lines in Laos (EDL, 2004)

Table 18: Transmission lines

	Location		Voltage	Circuit	Circuit	Conductor
No	**Lao PDR**	**Thailand/Vietnam/China**	**(KV)**	**designed**	**Installed**	**(mm²)**
1	Theun Hinboun	Nakhonphanom (EGAT)	230	2	2	664
2	Houay Ho	Oubolrathani (EGAT)	230	2	2	664
3	Phonetong SS	Oudon 1-2 (EGAT)	115	2	2	240
4	Thanaleng SS	Nong Kai (EGAT)	115	1	1	95
5	Paksan SS	Bung Khan (EGAT)	155	2	1	240
6	Thakhek SS	Nakhonphanom (EGAT)	115	2	2	169
7	Pak BO SS	Mukdahan (EGAT)	115	2	1	240
8	Ban yo SS	Surindhorn P/S (EGAT)	115	1	1	240
9	Sam Neua SS	Pahang (EVN)	35/22	1	1	150
10	Bo Keo	Xieng Khong (PEA)	22	1	1	N.A
11	Ken Thao SS	Thali (PEA)	22	1	1	N.A
12	Hongsa	Pakmone (PEA)	22	1	1	N.A
13	Borikhamxai SS (Laksao)	Vietnam (EVN)	22	1	1	N.A
14	Dansavan(SVK)	Vietnam (EVN)	22	1	1	N.A
15	Sanamxai (sekong)	Vietnam (EVN)	22	1	1	N.A
16	Muong Sing (Luangnamtha)	China	22	1	1	N.A

Source: EGAT: Electricity Generating Authority of Thailand, PEA: Provincial Electricity Authority (Thailand), EVN: Electricity of Vietnam

2.1.9 Feed-in Conditions

There exist no feed-in regulations in Lao PDR so far. The option to introduce feed-in tariffs were discussed during the 2nd stakeholder workshop 2nd Stakeholder Dialogue on Biomass and Solar Energy potential and feasibility in the Lao P.D.R, July 2006, organised in the frame of the Asia Pro Eco Project "Diagnostic Study on Renewable Energy Potential in South East Asia". The participating stakeholders from public and private organisations agreed that the country needs special regulations on electricity feed-in. Identified obstacles for feed-in regulations were unavailability of technical expertise and funding and uncertainty about the willingness of EDL to allow local competition.

2.1.10 Financing and funding possibilities for RE projects

2.1.10.1 Off-grid promotion fund

The Off-Grid promotion fund and support programme (OPS) was set up on the request of the Ministry of Industry and Handicrafts in 2004 (MIH, 2004). The aim of the OPS is to effectively extend Off-Grid electrification to remote rural areas in order to improve the quality of life for villagers. To do so the fund aims to raise and manage finances to develop Off-Grid work for the whole country (Articles 1 and 2, Off-Grid Promotion Fund Decree). The Fund is managed by an Advisory Committee and Secretariat within the Ministry of Industry and Handicraft, now Ministry of Energy and Mining (see Figure 11).

The Committee is responsible for management of the fund by developing an overall strategy for optimum delivery and recovery systems, to organize financing, propose modifications to Off-Grid regulations tariffs and payment procedures and disseminate information to the public about funding opportunities (Articles 15, 16 and 17, Off-Grid Promotion Fund Decree).

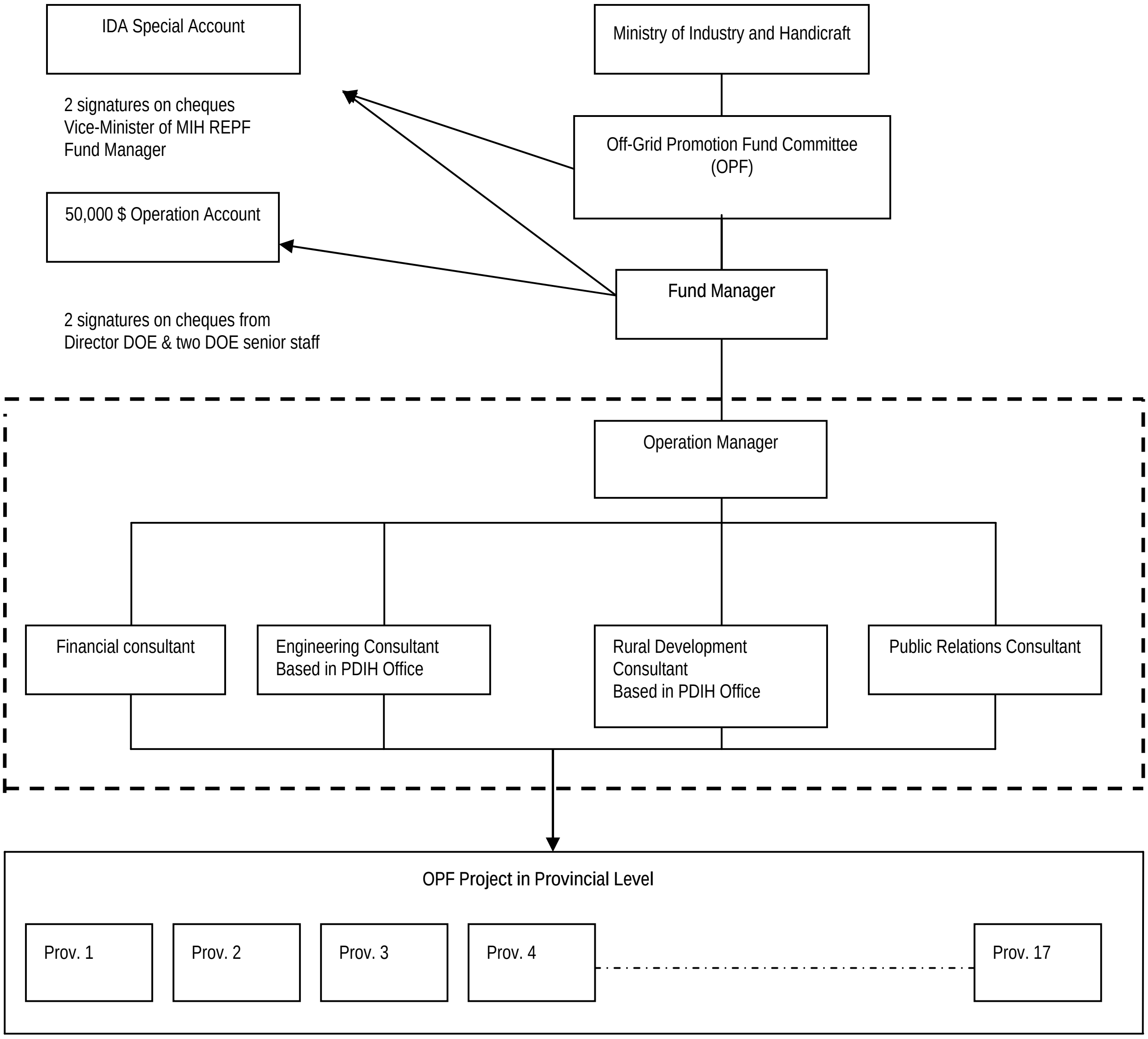


Figure 14: Organisation and disbursement of the Off-Grid Promotion Fund

2.1.10.2 Poverty Reduction Fund

The objective of the poverty reduction fund is to finance small-scale investment and services and strengthen local capacity in respect of village development. The fund acts as a vehicle to channel finances from both foreign and domestic donors in the form of grants, loans, budget allocations, contributions from international government and organizations, giving priority to villages located in isolated rural areas with high rate of poverty. Projects should be designed, proposed and approved by village or sub-district and, where appropriate, the skills and participation of the eligible business and social entities should be considered. Furthermore, eligible projects should meet “efficient price standards”, “has adequate technical quality”, and be “of appropriate project design, and suite to ease of operation and maintenance”.

2.1.10.3 SNV Biogas Programme

The Netherlands Development Organisation and the MIH singed a Memorandum of Agreement on the implementation of a Biogas Pilot Programme in Lao PDR. The with 1,1 Million EUR supported programme will be in operation from 2006 to 2010 and aims to support the installation of 6.000 household biogas plants. Within this programme SNV co-finances the installation of household biogas plants for the treatment of human excrements and livestock manure with 100 $. The total costs are 400 $. Additional SNV gives technical support on the implementation of the plants.

2.1.10.4 Credit Facilities

At present different not very affordable credit schemes are available in Laos. The sources of the following information were individual persons met in the frame of the implementation of the Asia Pro Eco project "Diagnostic Study on Renewable Energy Potential in South East Asia".

Agricultural Promotion Bank

The Agricultural promotion bank provides loans to farmers with interest rates of 12 % per year for agricultural purposes and livestock and 15-18 % for commercial purposes. The procedure to get his loans is very bureaucratic and time consuming.

Village Saving Funds

Most Lao villages operate a village saving fund. The villagers (village saving fund members) of each village develop their own rules for their funds and take care of the fund by themselves. Almost always the village chief and village management committee is involve in the fund development and management too. These funds provide maximum loans to their members between 1 to 10 Mill. LAK (10 to 100 US$). The maximum duration of the loan period is usually 6 month with a very high interest rates between 3 to 5 % per month. The fund is feed by member deposits and interest rates.

The interest rates of the village saving funds are between 3 to 5 % per month!

Fund for Agriculture in Champasak Province

In Champasak province credit is available through a Co-operative Fund for Agriculture (Lao-Sweden agriculture project). These funds are channeled trough the districts. The credit has 5% interest and the maximum amount is 1 million LAK. Pay back period is 6 – 12 months. Credit can be taken for construction of irrigation systems, construction of new rice fields and livestock. The credit scheme has outstanding loans due to the limited maximum amount. The required maximum amount would be 4-5 million LAK (400-500 US$).

2.1.11 Power Sector Investment

2.1.11.1 Power Sector Investment Plan

The investment Plan is based on an optional sequence of investment to meet GOL’ s power sector objectives of:

- Least-cost expansion of domestic supply to achieve its 90% electrification target by 2020
- and export development to honor its export commitments to Thailand and Vietnam.

The investments are spread across the following categories of projects:

- Export generation development (IPP)
- 500KV GMS Grid development
- Domestic generation expansion
- National (EDL) transmission and distribution development
- Off-Grid development

The investment plan identifies sources of finance for future power sector development. The Investment Plan builds on the system expansion plans described in the Power System Development Plan (PSDP) and the EDL Power Development Plan (PDP 2004–2013) and outlines financing plan for the different types of project included in these plans. The Lao power projects grouped generically according type (hydro, transmission, distribution, off-grid etc…) and investment characteristics (export/domestic, risk exposure, location etc…) and a financing plan developed for each group, suitable financing models for each project grouping are determined on attractiveness of projects to different lenders and investors.

Table 19: Total Power Sector Investment needs (2005–2020)

No	Description	Total investment in USD million
1	Domestic Generation	447,41
2	Export Generation	4.212,14
	Total Generation	**4.659,55**
3	115 KV National Transmission / Distribution	645,77
4	500 KV Regional Transmission	400,00
5	Off-Grid development	51,00
	Total	**5.756,32**

Sources: PSDP, EDL, PDP, GMS Master Plan, RE Framework Study.

All figures in nominal terms based on assumed commissioning dates and 1,5% escalation rate

The methodology for choosing financing is maximizing the number of projects to be financed privately leaving residual projects to be financed by the public sector. This approach is to use International Finance Investment (IFI) and bilateral donor resources to best effect by leveraging off the private sector where possible and directly funding projects where it is not. Of the USD 5.75 billion that the Lao power sector need over the next fifteen years.

Figure 15 represents current investment expectations by sub-sector over the next fifteen years. The peak financing requirements over the period 2006 to 2009 pose a particular challenge. Though the burden in these years falls largely on the private sector, it will be a time when Lao PDR is still establishing itself in the international and regional financial markets and there may be a limit that they set on overall exposure to Lao risk. A quantitative assessment of the market's appetite at a given point in time is difficult to obtain.

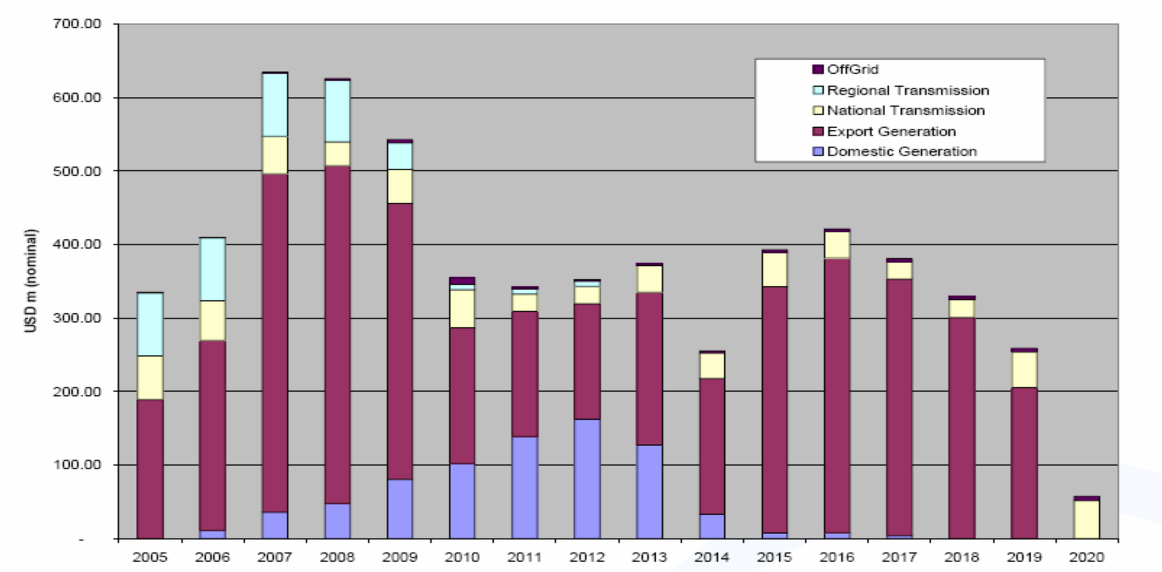


Figure 15: Total Estimated Sectoral Funding Requirement (2005 - 2020)

Of the USD 5,75 billion that the Lao power sector needs cover 2005-2020, the Government of Laos (GOL) through its various entities might expect to invest some USD 1,25 billion in the sector (see Table 20), funded from Independent Power Producers (IPP) dividends (USD 100 million), Elecrticity du Laos (EdL) internal resources (up to USD 150 million) and public lenders such as International Finance Investment (IFI) and Bilateral agencies (up to USD 1 billion, averaging USD 66 million per year until 2020). Table 20 tabulates these requirements. This contrasts with an approximate allocation of IFI and bilateral support for Lao PDR's energy sector that is averaging around USD 25 to 35 million per year at present.

Table 20: Potential GOL Investment Requirement (2005 - 2020)

GOL Funding Vehicle	Required Investment (USD million)	Internally Generated Funds (USD million)	IFI/ Bilateral Support (USD million)
Power Sector Fund	321,5	99,04	222,46
EDL	651,02	150	501,02
LNGC	220,8	0	220,8

OGPF	51	0	51
Total	**1.244,32**	**249,04**	**995,28**

Note: Sources: PSDP, EdL PDP, GMS Master Plan, RE Framework Study; All figures in nominal terms based on assumed commissioning dates and 1,5% escalation rate

Of the remaining requirement of approximately USD 4,5 billion, some USD 1,125 billion is projected to be raised from investors by way of equity and the balance of around USD 3,375 billion is projected to require raising as debt capital. The level of appetite for private sector lending to projects in Lao PDR has not been fully tested. The Nam Theun 2 financing will set a major precedent for project lending in Lao PDR if the project achieves financial close as expected. The project is likely to be analyzed a great deal to see how future projects can be streamlined, with much of the focus being on actions GOL can take to improve the investment climate.

IFI and bilateral support will also be required through direct loans and guarantee products to support these external capital requirements of the power sector. It is anticipated that lending and loan guarantee support will feature particularly highly in this regard. If debt for export IPP projects is raised equally from regional lenders and the international debt capital market, and assuming that regional lenders do not have the benefit of Political Risk Insurance (PRI) cover, a project might have a debt financing plan as indicatively shown in Table 21.

Table 21: Composition of a Typical Lao PDR IPP Debt Finance Plan

Debt Finance Plan Component	% of Debt	USD million
Commercial Loans with PRI	20%	675
IFI Loans	15%	506
Bilateral Loans	25%	844
Uncovered Regional Loans	40%	1.350
Total	**100%**	**3.375**

On this basis, if approximately USD 3,375 billion of external debt needs to be raised mainly by IPP developers, then it can be expected that USD 1,350 billion will need support from IFI and bilateral agencies in the form of direct loans and/or PRI cover. On average, this demand for IFI and bilateral agency support is equivalent to USD 112,5 million per year (assuming PRI cover is risk weighted equal to direct lending as is the case with International Bank for Construction and Development (IBRD) countries).

Figure 15 describes the suggested overall funding program over the period 2005 to 2020 in greater detail. Though this Investment Plan matches demand for capital against a range of sources of finance aimed at maximizing private sector involvement, certain questions remain. A central problem is whether GOL can attract the very substantial IFI and bilateral support required. On the basis of the numbers in the Investment Plan, this support would need to be up to USD 2,345 billion (averaging over USD 150 million per year to 2020), comprising approximately USD 995 million for power sector investments made directly by GOL, and approximately USD 1,350 billion for investments made indirectly through developers.

More details on the power sector investment plan are published in the RESDALAO report “Financing and Funding Sources for the Investment on Energy Sector in Lao PDR” at the project website.

2.1.11.2 Off-grid Investment according the PDP 2004-13

EDL's Power System Development Plan 2004-2013 includes the following presented detailed planning on off-grid investment. The Power Sector Investment Plan (51 Mill. US$ 2005-2020) and the EDL's Power System Development Plan 2004-2013 (60 Mill. US$ 2004-2013) do not target the same investment for off-grid installation. Anyway, the presentation of both plans gives an general insight in the planned investment, on the approximately share of off-grid installation and the targeted technologies.

The estimated cost of achieving the government's rural electrification targets is about 328 millions USD, see Table 22. Total Cost of the off-grid component (about $60 millions US) that included all costs relating to hardware/equipment purchase, system installation, program management/overheads, and international and local consultants. Of this, about $20 millions will be provided by households as up front deposit, about $28 millions will be repaid by households by monthly instalments and the remaining (about) $12 millions will be directly subsidized, funded from grants. About $28 millions in soft loan and financing will be required to enable financing of off-grid systems to be repaid by householders' monthly instalments.

Table 22: Total cost for rural electrification according the PDP 2004-13 (EDL, 2004)

Component	**Total Cost in (US million dollar)**
Main grid Electrification	
Sub- transmission	132
Sub-Stations	62
Distribution rehabilitation	11
Rural electrification	63
Sub Total (in million US$)	268
Off-Grid Rural Electrification	
Solar home systems & Village hydro/generator systems	60
Grand Total	**328**

According the PDP 2004-13 the 268 Mill. US$ shall be used to electrify 465.000 households. Thus, the electrification cost per household would be 576 US$ per household. Whereby, the estimated cost for off-grid electrification are about 400 US$ per household. The PDP 2004-13 targets to electrify 142.500 households with 10 W SHS systems, 4500 households with village hydro and 3.000 households with village gen-sets.

2.1.12 Summary

In this chapter the main results of the analysis of the present situation of the Lao energy sector is summarised.

Relevant Organisations

The current institutional arrangements of the government support the ongoing development of the energy sector. Provision is made to promote investment, technical support, environmental protection, and policy. The government's aim of promoting greater commercial viability of EDL may be further strengthened through renewable energy technologies. The promotion of market-based approaches to rural electrification, as exemplified through the government's support of ESCOs and the emergence of SUNLABOB, may prove an area that EDL may choose to support in the future.

Power Policy and Legislation

- The overall government policy aim is to: 1. Increase the household electrification ratio from the current level of approximately 45% to 90% by the year 2020, 2. Reduce the use of imported fuels for electricity generation.
- The policy states that low cost and reliable electricity is needed to promote social development and to overcome Lao PDR' s comparative disadvantages in attracting industries and investment.
- The Law stipulates that the pricing of electricity is set differently to rural and non-rural areas, subject to socio-economic conditions and allowing for periodic reviews. However, it is aimed to that tariff policy is to move the cost recovery pricing over a period of time.
- The GoL shall agree to / approve all electricity tariffs. (Article 32)
- Off-grid supply is defined as systems supplying a customer base with an aggregate peak demand of less than 2 MW of which have no immediate prospects of connection to the main grid.
- Maximum duration of license shall not exceed 30 years, upon expiration of such period, applicants shall transfer all rights of such enterprise to the government without compensation. Extension of 10 years possible. Exemptions: hydropower below 2.000 kilowatts and thermal production equipment using power below 500 kilowatts.
- The government is willing to provide tax reduction or exemption policies for equipment, operation and vehicles to further promote Off Grid Development.
- The government aims to strengthen capacity within the provinces for planning, management and maintenance of Off-Grid supply initiatives. Capacity strengthening will be achieved by primarily by:
- There is particular interest in incentive systems that motivate village managers and ESCOs (Electricity Services Company)to maintain reliability and increase connections
- A key government objective for power generation is for export revenues as a means of funding wider state development objectives. Thus the government has adopted an active policy by promoting the development of hydropower resources for export.

Policy and Legislation Relevant to Biomass Energy

- Provision for alternative agricultural crops including energy crops are allowed
- Organic fertilizers are defined in the Agricultural law as a combination of substances derived from the decomposition of vegetable or animal matter (also include minerals)
- The law regulated the type and quality of fertilizers, administer importation, transportation, distribution, storage, packing and other activities related to fertilizers
- There are five land categories in Lao PDR: agricultural, forest, construction, industrial and communication (Article 10, Land Law).

- The agricultural law defines five land categories including agricultural (suitable for plantation of crops and raising livestock) and industrial (factories, water filtering industrial waste sites as well as land used for energy resources and electricity transmission lines).
- The district administration transfers the right to use agricultural land to individuals and organizations, by issuing land titles for three year terms (Article 18, Agriculture Law).
- A central aim is to promote the expansion of agricultural production to guarantee the food supply and commodity production (Article 1, Agriculture Law).
- In order to achieve food security, the government grants individuals and families access to not more than one hectare per family member of land (Article 17, Agriculture Law).
- The government also wishes to create favourable conditions for building and expanding agro-industrial processing that will contribute to national economic growth while ensuring the protection of the environment (Article 1, Agriculture Law).
- Investment in agricultural production is divided into small, medium and large scale production and agri-business.
- There is also provision under the Law to develop Capital and Promotion Funds for the promotion of new forms of agricultural production (Article 50).

Energy Status in Lao PDR

- There are different figures on the yearly energy consumption available in different sources, but the distribution of the different energy sources is similar in all sources. The overall 2002 energy consumption according the different sources ranged from 1490 to 1812 kToe.
- Share of the energy consumption by type of energy source in 2002 according different available sources:

Electricity*	Fuel Oil	LPG	Coal	Fuel wood	Charcoal
4-12%	17-18 %	0,01-0,08 %	0,03-3 %	57-62 %	12-15 %

- Fuel wood and charcoal account to about 75 % of the total energy consumption. Wood fuel is mainly used for cooking and space heating and its use in rural areas are still accounts to up to 90% of the energy consumption.
- The share of firewood as cooking fuel ranges from 55.1% in urban to 88.4% in rural areas followed by charcoal with 34.6 % in urban and 7.4 % in rural areas. (See Figure 2.)
- Household expenditures for cooking fuels range from max. 6US$ per year for fire wood, 6-19US$/year for charcoal and 10-24 US$ for kerosene.
- The taxes and duties for fuel products account to 48% for premium gasoline, 44 % for regular gasoline and 22 % for diesel. The retail price in 2006 was 0,71 EUR for premium gasoline, 0,66 EUR for regular gasoline and 0,58 EUR for diesel. (see Table 4, Table 5)

Electricity Generation (on-grid)

- EDL produced 1416,4 GWh, 42 % and IPPs 1931,2 GWh, 58 %, of the 3347,6 GWh produced in 2004. 73 % of the generated electricity.

- 2424,7 GWh, was exported by EDL and IPPs in 2004. Additionally, 277,6 GWh, 31 %, of the local consumption had to be imported from Thailand (EGAT, PEA) and partly from Vietnam and China. (See Table 2 and Figure 3)
- The Lao PDR Power sector is still in low level with only 45% (2005) of the population having access to electricity, and the power energy consumption is 177 kWh per capita in 2005 (EDL, 2006).
- The on-grid energy consumption of Vientiane Capital, Khammouan, Savanakhet and Chamoasak province accounts to 87,35 % of the local energy consumption in 2004. (Table 10, Figure 7)
- Besides Vientiane Capital with an electrification ratio of almost 100 % the average electrification ratio (on-grid plus off-grid) is only 30 %. Especially, the provinces in the north and in the south east have very low electrification ratios under 25 %. (Figure 8)
- Only 13 of the 18 Lao provinces are electrified so far.
- Since 1991 the biggest electricity consumer have been residential areas with between 49 to 53 %, whereby the share of the electricity consumption of the industrial sector rose from 9 to 23 %. It is likely that industrial consumption will increase further its share in the coming years.
- According the EDL Power System Development Plan 2004-13 the average growth rate of energy demand is estimated at 21% from 2004 to 2010 and 6 % from 2010 to 2020.
- IPPs for export purpose have to deliver 5% of the total energy and power produced at its plant for the domestic consumption.

Rural Electrification

- Their are no statistics available on the off-grid electrification in rural Lao.
- The present status of rural electrification is dominated by Main Grid Distribution Systems (EDL), PV Systems, Pico hydro generator units and Car Battery Systems. Additionally Isolated Distribution Grid Systems, Village Grid Systems, Traditional Fuels and Biogas Systems are installed.
- The Off-grid Promotion and Support Office (OPS) was founded within the Department of Energy of the MIH in the frame of the GEF funded Southern Provinces Rural Electrification I Project (SPRE I). Within a 5 year pilot phase the OPS was establish, structures for rural electrification involving the private sector developed and documented in an OPS Operation Manual and 4.600 households in 46 villages electrified. (Figure 9)
- The bottleneck of long term operation of the OPS rural electrification model in the whole country is the availability of financing, as it was difficult to attract investment from the private sector during the pilot phase and the governmental sources are limited. The pilot phase itself was financed within the SPRE I programme and follow-up activities are financed now under the SPRE II programme. The average expenditure for household electrification by SHS, gen-sets and small hydro were 270 US$ per household.
- Wrong installation, low security standards and unskilled technicians often cause accidents with installed PV and pico hydro power installations.
- According the PDP 2004-13 the 268 Mill. US$ shall be used to electrify 465.000 households. Thus, the electrification cost per household would be 576 US$ per household.

Whereby, the estimated cost for off-grid electrification are about 400 US$ per household. The PDP 2004-13 targets to electrify 142.500 households with 10 W SHS systems, 4500 households with village hydro and 3.000 households with village gen-sets.

Electricity Tariffs and Price Strucure

- On-grid electricity tariffs in 2007 range from 0,01 US$/kWh for households to 0,08 US $/kWh for business user and even 0,10 US$ for embassies and international organisations. (see Table 14)
- Off-grid: The electricity price for the 20 year leasing or rental PV Solar home systems based on the system costs and monthly fees range from 0,05 to 0,23 US$/Watt. The initial payment ranges from 10 to 22 US$. (see Table 15)
- Off-grid: The electricity price for hydro and gen-set systems range from 0,04 to 0,11 US$/Watt. The initial payment is fixed with 15 US$. These costs do not include any system costs. (see Table 16)
- Off-grid: The investment costs are less than 30 US$/unit for capacity lower 300 W. Pico hydro turbines cost about 100US$/1000W for capacity ranging 300 W to 5000 W.
- Off-grid: Recharging cost for a care batteries range from for 50 Ah battery, charging cost is about 3000 LAK, 70 Ah – 4000 LAK, 100 Ah – 5000 LAK. Investment costs for a 70Ah battery range from 20-25US$, 7W saving 12 volt-bulb costs about 5 US$ and wiring costs 5 US$. Yearly replacement. One charge can last for 4-5 days for one light and B/W DC 14” TV , using about 2-3 hours per day.
- Electricity export tariffs with 0,0259 to 0,0277 US$ underlying the import tariffs, which range from 0,0302 to 0,06 US$.

Transmission Line and Substation Facilities

- The four transmission voltage systems in operation for domestic power supply in the four regions (Central 1, Central 2, Northern and Southern) are not interconnected, and function separately.
- The four main 115 kV Transmission lines systems are: Vientiane’115 kV transmission line System, Thakhek’115 kV transmission line system, Savannakhet’115 kV transmission line system and Saravane’115 kV transmission line system.
- EDL’s distribution systems are principally the 22 kV medium voltage (MV) systems. Feeders are extended to urban and rural areas from 22 buses of 115/22 kV substations or from diesel and small hydropower plants of the provincial authorities through overhead lines or underground cables.
- The low voltage (LV) distribution systems is 380/220 V, 3 phases, 4 wires is used to supply power to customers in general.

Feed-in Conditions

- No feed-in regulations established so far but required by the local stakeholders

Financing and funding possibilities for RE projects

- The off-grid promotion fund and the poverty reduction fund are the 2 available funds for off-grid promotion. Both funds act as a vehicle to channel finances from both foreign and domestic donors in the form of grants, loans, budget allocations, contributions from international government and organizations
- The Off-Grid promotion fund and support programme (OPS) was set up on the request of the Ministry of Industry and Handicrafts in 2004 (MIH, 2004). The aim of the OPS is to effectively extend Off-Grid electrification to remote rural areas in order to improve the quality of life for villagers. The Fund is managed by an Advisory Committee and Secretariat within the Ministry of Industry and Handicraft, now Ministry of Energy and Mining (see Figure 14).
- The poverty reduction fund is to finance small-scale investment and services and strengthen local capacity in respect of village development, giving priority to villages located in isolated rural areas with high rate of poverty.
- Loan: The Agricultural promotion bank provides loans to farmers with interest rates of 12 % per year for agricultural purposes and livestock and 15-18 % for commercial purposes. The procedure to get his loans is very bureaucratic and time consuming.
- Loan: Additionally their exist micro credit facilities on the local level as village promotion funds and the Fund for Agriculture in Champasak Province. Those funds gives loans between 10 to 500 US$ to very unfavourable conditions: interest rates of 3 to 5 % per month and short duration often only 6 month.

Power Sector Investment

- According the Total Power Sector Investment needs (2005–2020) the Lao government needs to invest 5,75 billion US% in the power sector development.
- Of the USD 5,75 billion that the Lao power sector needs cover 2005-2020, the Government of Laos (GOL) through its various entities might expect to invest some USD 1,25 billion in the sector (see Table 22), funded from Independent Power Producers (IPP) dividends (USD 100 million), Elecrticity du Laos (EdL) internal resources (up to USD 150 million) and public lenders such as International Finance Investment (IFI) and Bilateral agencies (up to USD 1 billion, averaging USD 66 million per year until 2020).
- The Power Sector Investment Plan (51 Mill. US$ 2005-2020) and the EDL's Power System Development Plan 2004-2013 (60 Mill. US$ 2004-2013) do not target the same investment for off-grid installation. Anyway, the presentation of both plans gives an general insight in the planned investment, on the approximately share of off-grid installation and the targeted technologies.
- According the PDP 2004-13 the 268 Mill. US$ shall be used to electrify 465.000 households. Thus, the electrification cost per household would be 576 US$ per household. Whereby, the estimated cost for off-grid electrification are about 400 US$ per household. The PDP 2004-13 targets to electrify 142.500 households with 10 W SHS systems, 4500 households with village hydro and 3.000 households with village gen-sets.

Research and development, pilot projects and studies

- There were almost no classical research projects or RE performed in Laos so far, but several pilot projects and studies on the potential of RE based off-grid electrification. (**Fehler! Verweisquelle konnte nicht gefunden werden.**, Appendix 2).
- The pilot projects mainly focused on implementation and not on long-term financial feasible operation.
- Most of the implemented biogas plants are out of order now due to unsuitable technologies, high costs and missing skilled human resources to operate and maintain them.

3 Present Situation in Thailand

3.1 General Country information

Source: CIA World Fact book, 2006

The Kingdom of Thailand is situated in Southeast Asia, with Laos and Cambodia to its east, the Gulf of Thailand and Malaysia to its south, and the Andaman Sea and Myanmar to its west. The country's official name was Siam, until 24 June 1939. The Capital of Laos is Bangkok. On a total area of about 514,000 sq km live about 64,631,595 people with an estimated growth rate of 0.68 % for 2006 [CIA World Fact book, 2006] Other sources [DENA 2006] mention 61,5 million inhabitants. Thailand is divided into 76 provinces (changwat), which are gathered into 5 groups of provinces by location. There are also 2 special governed districts: the capital Bangkok (Krung Thep Maha Nakhon in Thai) and Pattaya, of which Bangkok is also at a provincial level, while Pattaya is part of Chon Buri Province. Each province is divided into smaller districts. As of 2000 there are 796 districts (amphoe), 81 minor districts (king amphoe) and the 50 districts of Bangkok (khet). [Wikipedia] Those districts are divided again in communes (tambon) and villages (muban). Thailand is home to several distinct geographic regions, partly corresponding to the provincial groups. The north of the country is mountainous, with the highest point being Doi Inthanon at 2,576 metres.

The northeast consists of the Khorat Plateau, bordered to the east by the Mekong river. The centre of the country is dominated by the predominantly flat Chao Phraya river valley, which runs into the Gulf of Thailand. The south consists of the narrow Kra Isthmus that widens into the Malay Peninsula. The local climate is tropical and characterised by monsoons. There is a rainy, warm, and cloudy southwest monsoon from mid-May to September, as well as a dry, cool northeast monsoon from November to mid-March. The southern isthmus is always hot and humid. Major cities beside the capital Bangkok include Nakhon Ratchasima, Khon Kaen, Udon Thani, Nakhon Sawan, Chiang Mai, Surat Thani, Phuket and Hat Yai (Songkhla Province) [Wikipedia].

With a well-developed infrastructure, a free-enterprise economy, and pro-investment policies, Thailand appears to have fully recovered from the 1997/98 Asian financial crisis. The country was one of East Asia's best performers in 2002-04. Boosted by increased consumption and strong export growth, the Thai economy grew 6.9% in 2003 and 6.1% in 2004 [DENA 2006] despite a sluggish global economy. An economic growth of 5% is intended for 2005 to 2009 [DENA 2006]. Bangkok has pursued preferential trade agreements with a variety of partners in an effort to boost exports and to maintain high growth. In 2004, Thailand and the US began negotiations on a free trade agreement. In late December 2004, a major tsunami took 8,500 lives in Thailand and caused massive destruction of property in the southern provinces of Krabi, Phangnga, and Phuket. Growth slowed to 4.4% in 2005. The downturn can be attributed to high oil prices, weaker demand from Western markets, and severe drought in rural regions, tsunami-related declines in tourism, and lower consumer confidence. Moreover, the Thaksin administration's expansionist economic policies, including plans for multi-billion-dollar mega-projects in infrastructure and social development, has raised concerns about fiscal discipline and the health of financial institutions. On the positive side, the Thai economy performed well beginning in the third quarter of 2005. Export-oriented manufacturing - in particular automobile production - and farm output are driving these gains. In 2006, the economy should benefit from an influx of investment and a revived tourism sector; however, a possible avian flu epidemic could significantly harm economic prospects throughout the region [CIA World Fact book, 2006].

Main trade partners of Thailand are Japan, Malaysia, China, Singapore, Hong Kong and Taiwan. Thailand is a member of the Association of South East Asian Nations (ASEAN) and ratified member of the Kyoto protocol [DENA 2006].

The main natural resources of Thailand are tin, rubber, natural gas, tungsten, tantalum, timber, lead, fish, gypsum, lignite, fluorite, and arable land. Industry is basing on these resources: textiles and garments, agricultural processing, beverages, tobacco, cement, light manufacturing such as jewellery and electric appliances, computers and parts, integrated circuits, furniture, plastics, automobiles and automotive parts; world's second-largest tungsten producer and third-largest tin producer. Another industry is the tourism. The GDP (purchasing power parity) is at $550.2 billion, per capita $8,600, with a growing rate of 4.5% (. The GDP composition by sector is as follows: *agriculture:* 9.9% *industry:* 44.1% *services:* 46% (2005 est.). The unemployment rate 2005 was at 1.8% and the population below the poverty line was approx. 10% [CIA World Fact book, 2006].

3.2 Relevant institutes and Contacts for Energy Matters

Energy matters, at the origin, were rather minor concerns amongst Thai administrations. Every separate issue or utility like EGAT, MEA, PTT etc. depended upon the closest (historically) concerned ministry, be it Industry, Transportation, Natural Resources, Interior etc. or Prime Minister’s Office.

The first oil crisis in the 80s appealed more coordination, but political situation was not that stable and it took up to 1992 to gather all Ministers in charge of main aspects of energy and establish the National Energy Policy Committee, NEPC, and its related administrative unit, NEPO, National Energy Planning Office, under authority of the Prime Minister. A direct tax of 0.07 Baht was levied on every litre of oil to create the ENCON Fund, Energy Conservation Fund, (over 400 million $) and implement some of the energy policies decided by the NEPC [N.N. RECIPES 2005A].

A major step in energy policy and planning has been taken in 2002 with the creation of the Ministry of Energy, MoE, gathering under its authority agencies and utilities of very different origins:

- National Energy Policy Office, Office of the Prime Minister, renamed as EPPO, Energy Policy and Planning Office
- Natural Fuels Division, Department of Mineral Resources, and Oil Industry Division, Ministry of Industry, renamed as Department of Mineral Fuels
- Department of Energy Development and Promotion, Ministry of Science, Technology and Environment, renamed DEDE, Department of Alternative Energy Development and Efficiency
- Fuel Storage Safety Regulation Division, Department of Public Works, Ministry of Interior, split into DEDE and Department of Energy Business
- Bureau of Fuel Oil, Department of Commercial Registration, Ministry of Commerce, renamed Department of Energy Business
- Electricity Generating Authority of Thailand (EGAT), transferred from the Office of the Prime Minister to the Ministry of Energy, PEA and MEA, the three state enterprises on the way to privatization
- The natural gas and a petrol state enterprises, PTT Public Company Limited and the Bangchak Petroleum Public Company Limited, in which the Ministry of Finance and PTT are major shareholders, transferred from the Ministry of Industry (http://www.energy.go.th/en/aboutus.asp)

It is not the least achievement of Prime Minister Thaksin Shinawatra's government, regarding the huge differences in corporate culture, economic weight, staff number and other characteristics between all these units, some being partly driven by their autonomous ambition rather than public interest.

The role assigned to DEDE is particularly interesting; although not comparable in size with the conventional energies linked department, RE are given a strong visibility, are associated with energy efficiency and with improved planning techniques development/capacity building.

Today's MoE strategic plan concentrates on four issues:

- Improve efficiency of energy usage, especially in industry and transportation
- Secure energy supply for the next 50 years by
    - encouraging private participation
    - Developing production in neighbouring countries with more resources (Myanmar, Lao PDR, Cambodia,...)
- Exploiting RE
    - producing 3 million litres/day gasohol
    - generating 154 MW mini hydro power from 594 irrigation dams
    - promote waste-to-energy, PV cell, etc

- Enhance value creation from energy resource
- Provide energy to all citizens at fair rate by
    - Decentralizing management
    - Setting up a power regulatory agency
- Transform Thailand in a regional energy centre through infrastructures development:
    - Sri Racha Regional Hub and Strategic Energy Land Bridge (short-cut pipeline through peninsular Southern region) (
    - Grid connection with Malaysia and other neighbours, up to South China

The main institutes of the Thai energy policy, planning, R&D and promotion, particularly in the field of Renewable Energy, are the Ministry of Energy among others as the Department of Alternative Development and Efficiency (DEDE) and the Energy Policy and Planning Office (EPPO). An overview of the number of institutions involved in the development of renewable energy in Thailand can be seen in Table 23: below.

Table 23: Institutes [source: COWI 2006]

Institution	Relevant to RE Activities
Ministry of Energy Energy Policy and Planning Office, Department of Alternative Energy Development and Efficiency, Department of Energy Business, State Enterprises: Electricity Generating Authority of Thailand, PTT Public Company Ltd., Bangchak Petroleum Public Company Ltd., Electricity Regulatory Board, National Energy Policy Council	RE political target, Revolving Fund, Designated energy and implementation, License of Electricity Business, Grid connection, RPS, PPA and power generation, Regulating of tariff, Filter energy law to the Cabinet
Ministry of Interior Department of Provincial Administration Department of Local Administration Department of Public Works and Town and Country Planning Department of Lands State Enterprises; Metropolitan Electricity Authority, and Provincial Electricity Authority	Provincial Juristic person Tambon Juristic person Building permission Land accessibility Grid connection, RPS, PPA and power distribution
Ministry of Social Development and Human Security Department of Social Development and Welfare	Self-help Land Settlements
Ministry of Natural Resources and Environment Office of National Resources and Environment Policy and Planning, Pollution Control Department, Wastewater Management Authority	Environmental Fund, EIA, Regulating of emission, Wastewater management
Ministry of Agricultural and Cooperatives Department of Livestock, The Cooperative Promotion Department	Manure treatment, Public private partnership
Ministry of Industry Department of Industrial Work, Federal Thai Industry, Board of Investment	Factory license, RE industrial coordinator, Tax exempt and ESCO

Institution	Relevant to RE Activities
Ministry of Science, Technology and Environment DEDP, Department of Energy Development and Promotion	has to develop energy saving building code, electrical appliances standards, energy management policies in 3500 designated factories and public buildings
Ministry of Finance Department of Revenue	Depreciation
Ministry of Commerce Department of Business Development	Memorandum of association
Ministry of Public Health Department of Sanitation	Waste disposal
Ministry of Education Commission on Higher Education	Energy education

The energy sector in Thailand is managed by the National Energy Policy Council (NEPC), established under the National Energy Policy Council Act, B.E. 2535 (1992), with the National Energy Policy Office (NEPO) acting as the Secretariat. To enhance efficient energy sector management, the Energy Policy Committee (EPC) has been established to assist with the work of the NEPC. Additionally, the NEPC is responsible for the promotion of energy conservation and the management of the Energy Conservation Promotion Fund as per the Energy Conservation Promotion Act, B.E. 2535 (1992). Accordingly, the Energy Conservation Promotion Fund Committee has been established to assist with the management of the Fund and ensure that allocations are made in compliance with the regulations stipulated in the Act.

National Energy Policy Council (NEPC)	national energy policies and national energy management
Energy Policy Committee (EPC)	comments on the energy-related programs and projects set petroleum prices and premium rates to be collected for the Petroleum Fund policies and measures on energy pricing and monitor tariff adjustments
Energy Conservation Promotion Fund Committee	propose to the NEPC guidelines, criteria, conditions and priorities for the disbursement of funds
National Energy Policy Office (NEPO)	Secretariat to the NEPC develop policies, management and development plans and measures

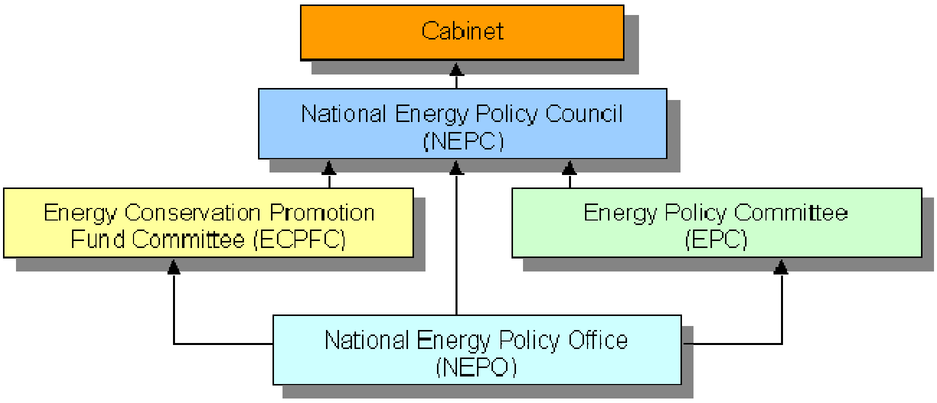


Figure 16: Organisational chart of the energy sector in Thailand [source Kanoksak 2006]

Some new actors were imposed by International Monetary Fund as a condition to support Thailand's 17 billion $ need arose from the 1997/98 financial crisis:

- PTT underwent partial privatization (PTT PLC with 30% shares sold by Bangkok Stock Exchange in 2001) and sat up Bangchak Petroleum Public Company Limited. Bangchak is now the leader for biofuels development [Bangchak 2006] http://www.bangchak.co.th/en/
- EGAT promoted EGCO, Electricity Generating Public Company Limited, an IPP, Independent Power Producer, with private shares from Hong Kong and Thai investors (EGAT 25%). This is considered as a partial privatization of EGAT.

In the meanwhile, other actors appeared:

- NGOs became more active and interested in energy and RE, like ATA, Appropriate Technologies Association, started in 1985, and bringing up issues like gender and social awareness together with energy management.

Federation of Thai Industries, former Association of Thai Industries backed by the Ministry of Industry, started an Institute of Industrial Energy.

International cooperation actions in the field of energy were quite numerous:

- COGEN, an EC-ASEAN project promoted cogeneration in Asian countries and was based in Bangkok, at AIT, Asian Institute of Technology (the project was closed in 2005). Two cogeneration power plants have been built in Thailand under that programme and widely advertised [Cogen 2006]
- The Danish cooperation agency (DANCED, restructured into DANIDA) has also involved deeply in energy matters, amongst others by providing experts who collaborate closely in evaluation, planning and capacity building inside the energy administrations [MFA 2006].
- The Swedish SIDA is also supporting energy/RE programmes of AIT (N.N. RECIPES 2005A].

3.3 Legislation in the Energy Sector

In the past, Thailand has had a very unregulated energy sector, with a traditional monopolistic electricity production structure. New energy and environmental laws and legislations were enacted in 1992, in response to the high economic growth at that time. Later, following the economic crisis in the late 1990s, new regulations and laws concerning corporate structure and behaviour were introduced. Also, as a result of the crisis, legislation was passed to in-crease public sector performance and governance (including Ministerial Re-structuring Act that has led to the establishment of e.g. the Ministry of Energy (MoE), and the Ministry of Natural Resources and Environment (MoNRE).

However, the recent "2003 Energy Strategy for Thailand's Competitiveness" and the 9th Development plan 2002 – 2006 (National Economic and Social Development Plan) do outline a target for the share of RE energy in the final energy consumption which has to climb from 0.5% in 2002 to 8% in year 2011. This is equivalent to 2400 MW installed capacity [DENA 2006]. The development plan focuses especially on the investigation and development of renewable energies in the field of biomass including MSW and biogas. Four basic strategies were defined:

- Promotion of electricity and heat generation by commercial and modern technologies
- Promotion of private investments into rural energy production
- Reduction of tariffs on efficient equipment
- Promotion of Small Power Producers SPP and Very Small Power Producers VSPP

Some of the important issues in the strategy include among others the obligation of the electricity utilities to allow SPP's and VSPP's to be connected to the grid and to sell their electricity production together with the legal enforcement of the Renewable Portfolio Standard (RPS) for new power plants.

The most important laws and regulations are the Energy Conservation and Promotion Act, the Small Power Producer Programme and the Very Small Power Producer Programme as well as the Renewable Portfolio Standard.

3.3.1 Laws and Regulation

Thailand has a lot of laws and regulations tackling energy matters. Table 24 lists a variety of them.

Table 24: Laws and regulation related to energy in Thailand (source MoE 2006]

Law/regulation/order	Contents
Thai Constitution [1997]	Natural resources and environment, conserve natural resources, Decentralisation of power to local administrative bodies, maintenance and utilisation of natural resources within its jurisdiction.
Energy Conservation and Promotion Act B.E. 2535 [1992]	Defines the basics for providing financial and logistic support to energy conservation, to energy efficiency and renewable energy projects, ENCON programme and ENCON fund. This law is the backbone for a relatively modern energy policy basing on energy conservation

Law/regulation/order	Contents
	and efficiency. It intends to reduce the dependence from energy imports and an increase of the supply guarantee by including environmental aspects and renewable energy sources.
National Energy Policy Council Act B.E. 2535 [1992]	devise the National Energy Policy and the National Energy Management and Development Plan; monitor, supervise, coordinate, and expedite the operations of all energy-related units; evaluate the results following the implementation of the National Energy Policy and the National Management and Development Plan.
Fuel Oils Trading Act B.E. 2543 [2000]	Determines types of oil traders.
Fuel Oils Control Act B.E. 2542 [1999]	Protects or suppresses the affliction / irritation or damage / danger to persons, animals, plants, property and environment. Regulates the impact on environment, economic and social conditions.
Fuel Oils Ration Act B.E. 2483 [1940]	
Electric Business Promotion Act B.E. 2484 [1941]	promotes the electric business and bestow the convenience and safety to people.
The National Executive Council's Decree No. 28 Dated 29 December B.E. 2514 [1971]	regulates the filling of gas regarded as hazardous fuel.
The National Executive Council's Decree No. 58 Dated 26 January B.E. 2515 [1972]	stipulates that the activities pertaining to the railway, aviation, water supply, irrigation, electric business, and production for disposal or disposal of gas by pipeline system linking to the buildings s
Electricity Generating Authority of Thailand Act B.E. 2511 [1968]	The Electricity Generating Authority of Thailand (EGAT) shall be a juristic entity with the power and duty to generate and transmit electric energy to the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA), other electric energy consumers as prescribed by the Royal Decree, and neighbouring countries. EGAT shall have the power to use or occupy immovable property of other persons for the purposes of investigating energy sources and determining the locations for the generation and development of electric energy. In such case, EGAT shall pay a fair compensation. In case of disputes or disagreements, EGAT shall deposit the compensation with the court or the Property Deposit Office. The Act also empowers EGAT to specify conditions concerning electricity quality, electricity engineering and safety technique, in such case where the private sector requests for electricity connection with EGAT, MEA, or PEA.
Metropolitan Electricity Authority Act B.E. 2501 [1958]	The Act entitles the Metropolitan Electricity Authority (MEA) the power and duty to generate and commercially distribute electric energy; undertake businesses concerning electric energy, relating businesses, or other businesses supporting EGAT operations in the metropolitan

Law/regulation/order	**Contents**
	Bangkok and its vicinity. In the performance of duties under this Act, MEA officers shall have the power to use or occupy immovable property of other persons in order to create, maintain, and protect the electric energy transmission system. In addition, the Act defines the level of authority and qualifications of MEA Board of Directors and MEA Governor, operational procedures and punishments of MEA officers or any individual who threatens the safety and rights of the government and the general public. It also specifies types of MEA activities that must obtain approval from the resolutions of Cabinet prior to implementation, such as the increment or decrement of capital, loan, etc.
Provincial Electricity Authority Act B.E. 2503 [1960]	The Act prescribes that the Provincial Electricity Authority (PEA) shall have the power and duty to generate, transmit and commercially distribute electric energy; undertake businesses concerning electric energy, relating businesses, or other businesses supporting PEA operations in the area outside the responsibility of MEA. In the performance of duties under this Act, PEA officers shall have the power to use or occupy immovable property of other persons in order to create, maintain, and the electric energy transmission system. In addition, the Act determines the level of authority and qualifications of PEA Board of Directors and PEA Governor, operational procedures and punishments of PEA officers or any individual who threatens the safety and rights of the government and the general public. It also specifies types of PEA activities that must obtain approval from the Cabinet prior to implementation, such as the increment or decrement of capital, loan, etc.
Royal Decree on Determination of Time of Ending the Enforcement of Petroleum Authority of Thailand Act B.E. 2544 [2001]	Establishment of PTT Public Company Limited (PTT) by converting the capital of Petroleum Authority of Thailand into shares as prescribed by State Enterprises Capital Law and the transfer of businesses under the Petroleum Authority of Thailand to PTT. The Royal Decree determines the repeal of the following Acts and Emergency Decree as of B.E. 2544 [2001]: 1. Petroleum Authority of Thailand Act B.E. 2521 [1978] 2. Emergency Decree on Petroleum Authority of Thailand B.E. 2523 [1980] 3. Petroleum Authority of Thailand Act (No.2) B.E. 2537 [1994].
Royal Decree on Determination of Power, Rights, and Benefits of PTT Public Company Limited B.E. 2544 [2001]	establishment of PTT Public Company Limited (PTT) by converting the capital of Petroleum Authority of Thailand into shares as prescribed by State Enterprises Capital Law and the transfer of businesses under the Petroleum Authority of Thailand to PTT.
Royal Decree on Establishment of Energy Fund Administration Institute (Public Organization) B.E. 2546 [2003]	Stabilizes domestic retail oil prices according to the rate determined by the Cabinet, and to implement other tasks in compliance with government policies that are relevant to the Energy Fund Administration. Energy Fund Administration Institute (Public Organization), or EFAI, shall have the power to carry out any act in accordance with principles and methodologies as specified by the National Energy Policy Council (NEPC), the Energy Policy Committee (EPC) designated by the NEPC, or the EFAI Committee; and to co-ordinate with government agencies

Law/regulation/order	Contents
	and relating organizations, or to allocate relating operations to designated units. The Royal Decree also specifies that the EFAI Committee has the responsibility of overseeing EFAI's operations and management. The Committee shall have the power and duty to determine EFAI's management policy; supervise its operations in accordance with objectives, principles and methods stipulated by NEPC or EPC; approve plans and budgets; issue rules, regulations or notices concerning general administration.
Emergency Decree on Remedy and Prevention of Shortage of Fuel Oils B.E. 2516 [1973]	Response to the occasional escalations in world crude oil price as well as the shortages of crude oil resulting from the unavailability of fuel oils in Thailand.
Environmental Quality Enhancement and Conservation Act [1992]	Establishes provincial authorities as responsible for their own natural resources and environmental quality management action plans. These plans are the basis for Government funds. Defines the Environmental Fund.
Energy Development and Promotion Act B.E. 2535 [1992]	determines the powers and duties of the Department of Energy Development and Promotion (Department of Alternative Energy Development and Efficiency, in present) with respect to the exploration, data collection, analysis, and audit regarding energy in term of sources of energy; the monitoring and supervision, carrying out operation, and determination of rules and standards concerning energy production, transmission and distribution; and the alteration of raw materials or natural materials used in energy production, taking into account of the impact on environment, economic and national security.
Ministerial Regulation - Compulsory programme for designated facilities [under the ENCON fund 1995]	Requires designated factories and buildings (> 1 MW electricity capacity or 20 million MJ heat) to comply with Government regulations to manage energy use, and establish energy conservation tar-gets and plans. Energy conservation includes con-version from fossil fuel to renewable energy fuel.
Regulation for purchase of power from small power producers [published 1992, revised 1994 and 1998]	Defines obligation for electricity companies to let SPP's (< 60MW) connect to the grid and purchase power from SPP producing on wind, PV, hydro, biogas and biomass including municipal waste. Pricing not fixed but depends on certain criteria and bids of EGAT/MEA/PEA. June 2003: 1.49 THB + subsidy + capacity payment (for firm capacity). The first round bids included a 5-year tariff subsidy of up to 0.36 THB/kWh - later projects receive 0.15-0.18 THB/kWh.
Regulation for the purchase of power form the very small renewable energy power producers [2001]	Defines obligations for electricity companies to let VSREPPs (generator cap. < 1 MW) connect to the grid and to purchase electricity from VSREPPs producing on solar, wind, hydro, biomass and biogas. Can sell to the grid on a net settlement basis - ex-cess electricity to the grid will be bought by PEA or MEA at the rate that PEA or MEA buys from EGAT plus flat rate.

Law/regulation/order	Contents
Law on community forests [1996]	The communities that directly or indirectly own the forests must ensure that their sources of supply are sustained.
Regulation on civil participation [2001]	Regulation requiring the developers of biomass projects to seek the opinions of people living within a 10 km radius of a planned plant. If 80% of respondents within 3 km support the project, then it would qualify for a state subsidy.
Regulation on transportation of organic waste under Sector 71 of the National Environmental Quality Act 1992	In any pollution control area or locality where a central waste water treatment plant or a central waste disposal facility has been brought into operation by the administration concerned, the owner or possessor of the point source of pollution who has not yet constructed, installed or brought into operation the on-site facility for waste water treatment or waste disposal according to the prescription of the pollution control official, or may not want to construct or make arrangements for such a system, shall have the duty to send the waste waters or wasted generated by his activities to the central waste water treatment plant or central waste disposal facility in the pollution control area or in that locality for treatment or disposal and shall have the duty to pay the service fees at the rates fixed by virtue of this Act or the other related laws.

3.3.2 Small Power Producer Programmes

3.3.2.1 Small Power Producer Programme

The energy market was principally opened for private energy producers in the frame of the legislation of 1992. The SPP Programme was formulated concurrently. It provides the grid connection to small power producers.

SPPs are power plants up to 60 MW of installed capacity, in exceptional cases up to 90 MW, either using renewable energy as primary energy source or using efficient power heat coupling. In contrast to bigger commercial electricity producers, they are permitted to sell the energy to bigger consumers. Initially, the monopolistic energy company EGAT, limited the cumulative grid uptake at 300 MW. This was extended to 3200 MW in 1996. Grid access was no longer restricted since 1997.

The programme was newly emitted in 1999 and the quantity of SPP basing on renewable energy increased significantly. Subsidies are paid up to five years basing on the power purchase agreement [DENA 2006].

3.3.2.2 Very Small Power Producer Programme

Very small power producers can deliver energy into the grid since 2002. VSPP means an installed capacity up to 1 MW and the primary resource should be renewable energy. Great advantages of this program are the simplified and flexible regulations. A VSPP has no need to for a contract with the EGAT and can sell its energy after registration directly to the MEA or the PEA.

3.3.2.3 Renewable Portfolio Standard

The RPS, a quota system was introduced in the frame of the 9th National Economic and Social Development Plan (NESDP). New investments in conventional energy systems must include at least for 4% of the capacity for the use of renewable energy. The motivation for this programme is of economic, social ecological intentions. It was calculated to save 490 Mio. € per year by the substitution of fossil resources. Small power plants create income chances for small and enterprises. Beside this more incentives like subsidies and feed-in tariffs are planned [DENA 2006].

Renewable portfolio standard, RPS, already considered as nearly implemented, would be imposing a NRE power generation of 3-5% capacity for any new (after 2008) fossil fuel power generation. The NRE capacity might be produced or purchased from another producer, or even purchased under the form of “RECerts” (green certificates). NRE facilities would have to register under the authority of a Regulator Agency still to be formed. One problem feared if this incentive enters into action is again related to the monopolistic position of EGAT on the power market (the only “big one” and no Regulator with superior authority). EPPO and others are emphasizing that EGAT, unlike any small power producer, would feel no real constraint in setting up its own NRE facilities, efficient or not, costly or not, as it is anyway transferring the final costs to the consumers. Another problem is that NRE would definitely get left beyond their potential by getting tied to additional fossil fuels consumption! In addition, the proposed RPS is formulated as capacity and provides therefore no insurance of actual production [N.N. RECIPES 2005a].

3.3.3 Incentives for Renewable Energies

The ENCON fund installed in the frame of the Energy Conservation and Promotion Act (1992) is financed by taxes on fossil fuels with the exception of natural gas. The ENCON fund provides financial support for project developers, plant operators, universities, organisations and other groups investing in energy efficiency and renewable energies. The total budget between 2000 to 2004 was 29110,61 Mio Baht (572 Mio €). 70 Mio. € were used to support renewable energies and 40,5 Mio. € for the support of SPPs [DENA 2006].

3.3.3.1 Fiscal Incentives

The government provides fiscal incentives for investments of foreign companies in areas, assessed as priority areas in the frame of the NESDP. One priority is, among other, renewable energy.

Activities of these priority areas can receive certain tax privileges:

a) reduction of the corporate income tax for 8 years
b) reduction of the customs duties on imports
c) 100% exemption of the customs duties on imports for private electricity producers, possessing a license of EGAT
d) 100% exemption of the customs duties on imports for machinery with an intended use in economic zone II

Structural target is the decentralisation of economic activities as most of them happen in

Table 25: Economic zones and its provinces [DENA 2006]

Zone	Provinces
I	6 Provinces: Bangkok, Samut Prakarn, Nakorn Pathom, Nonthaburi, Pratum Thani, Samut Sakorn
II	10 Provinces: Suphan Buri, Ayudhya, Nakorn Nayok, Chachoengsao, Chonburi, Ratchburi, Samut Songkram, Saraburi, Kanchanburi, Ang Thong
III	Remaining provinces: Laem Chabang Industrial Estate in the province Chonburi

Qualified bodies to obtain tax incentives are Ltds., foundations and societies. Two types of incentives exist: exemption or reduction of taxes on imported machines, equipment, raw material and Exemption of the income tax on net profits [DENA 2006].

Table 26: Reduction of custom duties [DENA 2006]

	Red. Custom duties		Cancellation of imcome tax [years]		
Zone	Machines	Raw Materials	General	Conditional	Total
I	50%	100%	0	3	3
II	50%	100%	3	4	7
III	100%	75 or 100%	8	-	8

3.3.3.2 Clean-Development-Mechanism

The Kyoto protocol was ratified by Thailand in 2002. The Designated National Authority (DNA) is the Ministry of Natural Resources and Environment (MoNRE) and the Office of Natural Resources and Environment (ONEP). The National CDM Steering Committee is working under the presidency of the MoNRE and has established two working groups: Energy and Industry and reforestation and agriculture.

Criteria for CDM projects were defined as follows:

- consistency with national development strategies

- Capacity building
- Technology transfer and know-how
- Environmental and technical expertise needed in advance
- Planning and implementation with public participation

Thailand has a high potential of CDM projects though none of the project ideas was realised. Approval of CDM projects is difficult and long lasting. Nevertheless some projects are in preparation:

Table 27: CDM projects in preparation – Oct. 2004 [DENA 2006]

Name	Typ		CER buyer
Korat Waste to Energy	Methane bond	Waste water	Netherlands
Rubber Wood Residue Power Plant in Yala	Renewable energy	Wood waste	Japan
Green Power from Swine Farms	Methane bond, electricity	manure	Denmark
Thai Agro energy ethanol and biogas plant	Ethanol Methane bond	Waste water	Denmark
Natural Palm Oil 640 kW electricity and biogas plant	Methane bond electricity	Waste water	Denmark
Siam Cement biomass gasifier with waste heat recovery	Substitution of fossil fuel, efficiency		Denmark
Ratchasima small power producer expansion project	Biomass power plant	Bagasse	Denmark

3.3.3.3 COGEN/EC-ASEAN Cooperation

The COGEN program existed in the frame of the EC-ASEAN cooperation from 1991 to 2004. It was an economic cooperation program to support the implementation of efficient power heat coupling plants using biomass, coal and gas for energy generation. Target was the implementation of European technologies in South East Asia. Business contacts were established, projects were initiated and financial support was granted. The first phase (COGEN I) started 1991 and identified possible partners and business field. In the second phase (COGEN II) 16 demonstration plants were installed, four of them in Thailand.: Dan Chang Bio-Energy Co. Ltd. (41 MW Bagasse), Karoon Farm Biogas (0,3 MW pig manure), Phu Khieo Bio-Energy Co. Ltd. (41 MW Bagasse), Rayong Municipality (625 kW anaerobic digestion). Third phase started 2002. The program is continued with the cooperation program EC-ASEAN Energy Facility (EAEF).

The EAEF was founded 2002 to implement the ASEAN Plan of Action for Energy Cooperation 1999-2004 and its continuation 2004-2009. The program targets partnerships between European and ASEAN organisation to support projects in the energy sector. Categories of projects are supported:

- improvement of market sense
- improvement of the institutional frame
- feasibility studies
- demonstration projects

Private companies are only permitted as partners of non profit organisation. Guidelines for applicants may be revised at the website of the EAEF office of the ASEAN Center for Energy (ACE) [DENA 2006].

3.3.3.4 Biomass-One-Stop-Clearing-House (BOSCH)

A program to support the biomass use was established under the mandate of UNDP and the Global Environment Facility (GEF) in cooperation with the MoE. The program is carried out by the foundation Energy for Environment (EFE). Target is the promotion of the energetic use of biomass by provision of technical and financial services for biomass producers and investors. Target groups are biomass producers, investors, project developers, equipment deliverers, academic institutions etc. The Biomass Technical Network was founded to bundle competences. Members are the Energy and Policy Planning Office (EPPO) and the Department of Alternative Energy Development and Efficiency (DEDE) of the MoE, the Pilot Plant Development and Training Institute and the Joint Graduate School of Energy and Environment of the King Mongkut University of Technology (KMUTT), the Thermal Engineering Center, the Energy Research Institute of the Chulalongkorn University, the EGAT, the Institute of Industrial Energy of the Federation of Thai Industries, the Energy Conservation Center of Thailand (ECCT) and the company Bangkok Industrial Boilers Co. Ltd.

Two demonstration plants were supported in the frame of this program: Roi-Et power plant with a capacity of 9,8 MW and the power plant Gulf Yala with a capacity of 23 MW [DENA 2006].

3.3.4 Licenses, Concessions and Project Approval Cycle

3.3.4.1 Power Purchase Scheme

Power producers are classified into 3 categories:

- (Large) Independent Power Producer (IPP) normally based on natural gas or coal;
- Small Power Producer (SPP) with power capacity less than 60 MW and based on the following fuels:
    - Natural gas
    - Fuel oil
    - Coal
    - Biomass, wind, solar and hydro;
- Very Small Power Producer (VSPP) with power capacity less than 1 MW (to be eventually changed soon to 6-10 MW) and normally based on the following fuels:
    - Biogas

- Solar
- Hydro.

Independent power producers (IPPs) can sell electricity to EGAT, PEA or MEA. However, for RE power producers, only the 2nd and 3rd categories as above mentioned are relevant.

The National Energy Policy Council (NEPC) has concluded that electricity generation from non-conventional energy, waste or residual fuels and co-generation increases efficiency in the use of primary and secondary energy sources, and helps reducing the financial burden of the public sector with respect to investment in new electricity generation and distribution facilities. The NEPC has therefore approved the policy that allows SPPs to generate and sup-ply electricity, and has drawn up a regulation for the purchase of power from Small Power Producers using the above mentioned energy sources and processes for electricity generation. EGAT will purchase power from each SPP not exceeding 60 MW of capacity, to be supplied to the Utility at the connection point. EGAT will purchase power at the rates specified in the EGAT's Announcements on Purchase Price for Power Supplied by SPPs. The sale of electricity stated in VSPP PPAs follows the regulations on "Purchase of Power from Very Small Renewable Energy Power Producers" and on "Synchronization of generators with net output under 1 MW (to be eventually changed soon to 6-10 MW) to the Distribution Utilities".To apply for a PPA, it is necessary to follow the instructions stated in the request form of PEA and MEA [COWI 2006].

3.3.4.2 General Administration and Approval Procedures in the Energy Sector

The Ministry of Energy (MoE), the Ministry of Natural Resources and Environment (MoNRE), the Ministry of Science and Technology (MoST), the Ministry of Finance (MoF) and the Ministry of Industry (MoI) are principally responsible for support programmes. The EPPO is the central planning and administrational office for the ENCON fund. Organisation and execution of support programmes were mostly assigned to universities or non-profit organisations.

A project proposal has to be applied to obtain a funding by the ENCON fund. In case of a positive evaluation, a first funding of 100 000 Baht (2000 Euro) can be granted to produce the required energy audit. This may be increased up o to 500 000 Baht to generate a detailed energy and investment plan. Funding of up to 10 Mio. Baht (200 000 Euro) can be approved by the ENCON Sub-Committee, a funding exceeding this amount has to be approved by the ENCON Committee.

The Board of Investment (BOI) is responsible to grant and to manage fiscal incentives. Structure and principles are basing on the Investment Promotion Act von 1977 [DENA 2006].

The EPPO has established detail guidelines for the SPP and VSPP programme. Details are provided at www.eppo.go.th and www.netmeter.org [COWI 2006].

3.3.4.3 Process for Grid Connection to EGAT (IPP and SPP)

When making a request to EGAT for grid connection, the following information has to be provided:

- Company registration;
- Power plant layout;
- Location for generator;
- Process of power production;
- Total input thermal per total output energy;
- Details of generator and power machine with their specifications;
- Diagram of the electrical system and of the protection systems to avoid damaging EGAT's system - Power and energy to be sold;
- Duration of the contract;
- Number of generator's operators including details on education and engineering professional licenses;
- Estimation of annual fuel consumption and its heating value.

For the evaluation of the request, the following criteria will be taken into consideration: technical and engineering feasibility; experience of bidder, investor, and head office of bidder company, financial feasibility of project and sources of income of the project, considering both revenues from electricity and steam, reliability of fuel supply; appropriation of fuel storage and transportation; appropriation of location and grid connection; environmental impact assessment and acceptance from the surrounding community, including future benefits; starting date of purchasing power, including operational time frame.

The criteria for selling electricity to EGAT are:

- producer must sell electricity to EGAT only;
- Producer must get the permit for: factory construction, installation of generator, production of electricity, and sell of electricity within 18 months after signing power purchase agreement;
- EGAT will identify the starting date for buying electricity;
- On the signing date of the power purchase agreement, the producer has to submit a guarantee equal to 5% of the total energy to be produced along the period of contract (discount rate equals to the interests of 12-month fixed duration deposit from Krung Thai Bank). The guarantee will be returned after the project is finalized.

The purchasing tariffs are published through official announcements by EGAT [COWI 2006].

3.3.4.4 Process for Grid Access to PEA and MEA (VSPP)

For VSPPs, the process for achieving grid access to PEA and MEA networks is as follows:

- Submit a request form for selling electricity and also a request form for grid connection at MEA or branches of PEA;
- MEA or PEA considers to accept or reject the request;
- MEA or PEA informs about the results of the request within 45 days after all documents are completed and informs on the costs to be charged to producers within the following 15 days;
- Signature of the contract within following 60 days;
- Producers inform about the intended date for connection to the grid;
- MEA or PEA checks if the grid connections follow the requested standards within 15 days;

The connection costs to the grid are stated on following Table 28 for a 1 MW VSPP. For capacities below 1 MW, the connection costs will be reduced correspondingly.

Table 28: Connection costs to the grid for a 1 MW VSPP [COWI 2006]

	Cost (Bht)	
Description	**MEA**	**PEA**
Construction and Improvement (Proceeding Period)	Depend on distance and transformer capacity (In case of high voltage)	Depend on distance and transformer capacity (In case of high voltage 40-45 days)
Synchronization for high voltage (Proceeding Period)	<15,000 Bht (3-5 days)	<15,000 Bht (3-5 days)
High Voltage Testing (Proceeding Period)	<50,000 Bht (3-5 days)	<50,000 Bht (3-5 days)
Metering Installation Low Voltage 1 phase Low Voltage 3 phase Hi Voltage	 1,000-1,500 Bht 1,600-25,000 Bht 10,000-25,000 Bht	 1,047-1,985 Bht 2,093-11,457 Bht 25,468 Bht

3.3.4.5 Direct Sale to Industry, Construction, Operation and Permits

Direct sale of electricity to third party consumers (industries) is presently not possible.

To build RE power plants, it is necessary to ask for permits from the following governmental organizations:

Power Purchasing Agreement: Request to be submitted to EGAT, PEA or MEA.

Concession for Electricity Business: Request to be submitted to the Department of Energy Business (DoEB), MoEN. Procedure: 2 months.

Upgrading of Capacity: Request to be submitted to the Department of Industrial Work, Ministry of Inustry or its Provincial Representative, Procedure: 2 months.

Construction for Building or Factory: Request to be submitted to the TAO or its Provincial Representative from the Department of Public Work and/or City Town Planning. Procedure: 2 months.

Storage of Petrol: Request to be submitted to the Department of Energy Business, MoEN, Procedure: 2 months.

Production of Controlled/Designated Energy for more than 200 kVA: Request to be submitted to the Bureau of Energy Regulation and Conservation, DEDE, MoEN. Procedure: 2 months.

Environmental Impact Assessment (EIA for more than 10 MW): Request to be submitted to ONEP, Office of Natural Resources and Environment Policy and Planning, Ministry of Natural Resources (MoNRE). EIA must be carried out for combined heat and power plants with capacities higher than 10 MW. Procedure: 0,5 - 1 year.

Work Permit for foreigners: Request to be submitted to the Immigration Bureau, Royal Thai Police, Procedure: 2 months.

Employment: Request for new job creations to be submitted to the Department of Employment, Ministry of Labour. Procedure: 2 weeks.

Registration for Ownership of Machineries (if machineries are used as loan guarantee): Request to be submitted to the Department of Industrial Work, Ministry of Industry or its Provincial Representative. Procedure: 2 months.

Report of Testing and Installation of Boiler: Request to be submitted to the Ministry of Industry. Procedure: 2 months.

Request for Tax Privilege: Request to be submitted to the Committee of Investment Promotion of the Board of Investment (BOI). Procedure: 2 months.

Following activities, relevant for the promotion of RE projects, are included on the list of activities eligible for investment promotion (and tax exemptions):

- Manufacture of alcohol or fuel from agricultural products;
- Public utilities and basic services, including production of electricity or steam power.

3.3.5 Action Plan for the Development of Renewable Power in Thailand

The Action Plan was prepared and written by the Danish Ministry of Foreign Affairs (DANIDA), Department of Alternative Energy Development and Efficiency (DEDE) and Ministry of Energy, Thailand. Aim is the Promotion of Renewable Energy Technologies in Thailand (PRET).

Participating bodies were: Department of Alternative Energy Development and Efficiency (DEDE), Power Generating Authority of Thailand (EGAT), Energy Policy and Planning Office (EPPO), Biomass One Stop Clearing House, the Energy for Environment Foundation, PRET Project Steering Committee, Participants to the Renewable Energy Development Model Workshop, Participants to the Workshop for Recommendation on Action Plan for RE Power in Thailand.

Part I of the Action Plan is divided into six chapters: Chapter 1 gives an introduction to the Action Plan (with particular focus on Part I). Chapter 2 includes an overview of the vision and strategy including also specific RE targets for 2011. Chapter 3 includes a description of the existing framework for RE technologies in Thailand. Chapter 4 describes rules about land accessibility and Chapter 5 focuses on licenses, concessions and project approval. Chapter 6 focuses on existing measures and barriers for promoting RE, and finally, Chapter 7 focuses on renewable energy resources and technologies.

Part II of the Action Plan is divided into four chapters: Chapter 1 gives an introduction to the Action Plan (with particular focus on Part II). Chapter 2 describes the recommended general actions relevant for all RE technologies. Chapter 3 describes recommended technology-specific actions, relevant for single technologies. The general actions are actions that promote RE in general, whereas the specific actions are actions that should be implemented in order to support and reduce barriers for specific RE technologies. Chapter 4 describes the monitoring and evaluation of the Action Plan.

The Action Plan encompasses a rather extensive list of proposed actions identified within the PRET project. While many of the actions are closely connected and complementary, the specific choice of actions and their detailed design is of course to be decided by the relevant national authorities, depending on further decisions on issues such as RE targets; technology prioritization; and types of policies and measures preferred.

The purpose of this Action Plan is to achieve a renewable power production target of approximately 5,800 GWh for the Incentive Scheme by year 2011. The primary objective of the PRET project and of the present Action Plan has been to focus on the promotion of economically viable as well as commercial and near-commercial renewable energy technologies (biomass, biogas and hy-dro power), although non-commercial technologies (not economically viable) such as wind, solar PV and MSW technologies have also been included in the Action Plan.

Promotion of MSW technologies through a feed-in tariff scheme might not be the right way to solve solid waste problems. The environmental problems should be solved by local municipalities and the Thai Government, rather than financed by the electricity consumers.

Although wind technologies are not found to be economically viable compared to EGAT's base line production costs, wind farms might offer a better financial solution compared to diesel generated power (6-7 THB/kWh) in windy rural areas with no access to the public grid.

Although solar PV technologies are not found to be economically viable compared to EGAT's base line production costs, promotion of solar PV might be a good solution to solve power supply problems in some isolated rural areas and at the same time to support local solar PV panel production industry

IThe Ministry of Energy including among others the Department of Alternative Development and Efficiency (DEDE), and the Energy Policy and Planning Office (EPPO) are the main actors in the Thai energy policy, planning, R&D and promotion fields for RE technologies The

Ministry of Energy should therefore be the Institution mainly responsible for the implementation of the Action Plan.

Apart from the Ministry of Energy, however, a number of other line ministries should also be involved in the development of renewable energy in Thailand. These other ministries include: Ministry of Interior; Ministry of Social Development and Human security; Ministry of Natural Resources and Environment; Ministry of Agriculture and Agricultural Cooperatives; Ministry of Industry; Ministry of Finance; Ministry of Commerce; Ministry of Public Health; Ministry of Education.

These ministries should be involved where the implementation of the Action Plan relates to their areas of responsibility. For instance, in relation to biomass actions it might be relevant to involve the Ministry of Agriculture and Agricultural Cooperatives [COWI 2006].

3.3.6 Land Accessibility

Under the Ratchaphatsadu Land Act, immovable properties by the Department of Provincial Administration, the Department of Irrigation, the Harbour Department, and the Bangkok Metropolitan Administration have to follow the regulations of the Department of Treasury on land utilization, which is as follows:

- To get permission to use the land, it must be ensured that the land is not reserved for other national/public purposes
- The land in Bangkok can be utilized with the approval from the Department of Treasury directly. The land in provinces can be utilized by the city governor and the Department of Treasury, respectively;
- The land can be used as residence, and in that case the rental contract is limited to 3 years. If the land is used for construction, the rental contract is limited to 20-30 years, and after that all constructions will belong to the Department of Treasury;
- The minimum rental fee is defined in relation to the purpose of the land utilization.

The Crown Property Bureau: The Crown Property Act defines that the King's property will be managed by the the Crown Property Bureau, and the fee will be defined case by case

State Railway of Thailand: The State Railway of Thailand Act defines that the rental of the land has to be approved by the Governor of the State Railway of Thailand. Area besides the railways tracks beyond 40 m can be rented for 30 years. Area besides railways tracks within 40 m can be rented for 3 years only.

Port Authority of Thailand: The Port Authority of Thailand Act defines the regulation for renting land. The land of the Port Authority of Thailand can be rented only for identified objectives: for port activities, utilities, for government purpose or for non-profit organization, and other activities on a case-by-case basis. The maximum duration of the rent is 3 years, and the rental fee is identified depending on the purpose of the rent.

Bangkok Metropolitan Administration (BMA): The Bangkok Metropolitan Administration Act defines that to rent the land be-longing to the BMA, with a 3-year contract as a maximum of, it is necessary to obtain the approval of the Bangkok's Property Committee chaired by Bangkok's Governor. The rental fee follows the rates fixed by the Department of Treasury.

Local Administration Authority: To rent a land of the Local Administration Authority (PAO: Provincial Authority Organization, TAO: Tambon Authority Organization, Municipality, and oth-ers designated by law), the procedure has to follow the regulation of the Minis-try of Interior

Department of Religious Affairs: The Hierarchy Act defines that the renting for non-business purposes can be done for a 3 year contract as a maximum and needs approval from the Department of Religious Affairs. For business purposes, the approval has to be given by the Budget Committee for Religious Affairs.

Fine Arts Department: Section 1: Ancient Remains under The Ancient Remains, Antique and national Museum Act defines that to rent land from the Fine Art Department, approval from the committee for ancient remains, antique and national museum is necessary and should be done through a bidding process.

Public Area: Any land where an owner cannot be identified will be assumed to be a public area, which is responsible by The Department of Interior. The public area is classified in 2 types: (i) the first type called Deteriorated Area, e.g. useless canal and discarded land; (ii) the second type called Consistent Area, e.g. building on public area. To withdraw or to change the purpose of a public area, a Royal Decree needs to be issued. The discarded land expropriated and given back to the government will be managed by the Director General of the Lands Department. For mutual benefit, lands such as e.g. banks of a river, field, park, and public area for community, are managed by the Local Authority Organization.

Department of Forest: The area in watershed class 1A (Watershed Class 1 (Class 1A and 1B) should be particularly preserved as watershed because the area, when changed, leads to tremendous effects on the environment), which is the watershed consisting of plentiful forests belonging to the Forestry Department are the best sites for mini/micro hydro developments, but permission to access is stringent and difficult to obtain. According to the cabinet resolution, changing forest by any means is restricted in order to protect watershed. The only once compliance is the use for security reason of army which permitted on December 1989, no other actions shall be allowed again in this class

Ministry of Defence: Lands belonging to the Ministry of Defence are enormous and can be excellent potential sites for MSW provided that the accessibility is authorised.

Harbour Department: If wind towers are installed in the sea / coast, approval from the Harbour Department is needed [COWI 2006].

3.4 Energy Status in the Kingdom of Thailand

Basically Thailand is an agricultural country, rich in forests in spite of the serious deforestation that prevailed until the logging ban in 1989. Fuel wood and charcoal have long been the only major sources of energy besides man, animal power and agricultural residues like rice husk and bagasse [FAO 2006]. The use of modern fuels and electric power, introduced in the end of the 19th century, remained rather decentralized amongst several private, municipal and state companies, and of moderate importance, until the 50s when the industry expanded after WWII. Power was still mostly produced by steam turbines burning wood, rice husk or oil. Imported oil grew in importance and some minor oil fields were discovered on-shore in the North of the country. A major oil-fired plant was built near Bangkok in 1961.

In 1957 the government sat up the Yanhee Electricity Authority to provide power to Northern half of the country and a first large hydro-power plant was achieved in 1964, at Phumiphon Dam. In 1958, the government also started the MEA, Metropolitan Electricity Authority, [MEA 2006] to provide power to Bangkok and surroundings. In 1960, the PEA, Provincial Electricity Authority [PEA 2006], was initiated to provide power to all other provinces, thus a wide rural electrification programme [MoE 2006].

Oil refineries also appeared in the 60s and the minor domestic on-shore oil fields exploited in the North were followed, in the 70s, by some more, discovered off-shore, in the Gulf of Thailand, under concessions to Western companies. But the high demand caused oil imports increase faster, mostly from the Middle East. To a much lesser extent, hydro-power increased too, with an additional major plant, at Sirikit Dam and several others soon later. As early as 1960, lignite mining had started at the huge Mae Moh mines in the North for power generation under the Thai Lignite Authority. In 1969, several state enterprises, including Thai Lignite Authority and Yanhee Electricity Authority, merged to form EGAT, Electricity Generating Authority of Thailand, a state enterprise under the Prime Minister authority, sole in charge of power generation and transmission (grid) for the whole country. MEA and PEA remained in charge of distribution [EGAT 2006].

EGAT, MEA and PEA, since their creation, were three state enterprises with monopolistic position in closely related electricity businesses: electricity generation and electricity distribution in Bangkok and other provinces, respectively. Oil –and later gas- distribution was also under the control of a national body, Petrol Authority of Thailand, PTT, enjoying a monopolistic position for distribution in the country [PTT 2006b].

In the 70s, more natural gas was found in large fields offshore in the Gulf of Thailand and world’s longest submarine pipeline soon connected these fields to the near Bangkok area. US based Unocal has been dominating the gas exploration and extraction, but distribution remained under PTT. Around 1980, imported oil still provided nearly 70 % of total primary energy needs. In reaction to this upsetting dependence, natural gas development was given the priority, together with lignite fuelled power generation, causing in Mae Moh a severe sulphur dioxide pollution, uncared besides villagers complaints, until a terrible atmospheric layers inversion in the valley intoxicated hundreds of people in 1992 [N.N. RECIPES 2005A].

Thailand's primary energy consumption has started to return to the levels of the pre-1997 economic crisis period, substantially increasing at a rate of 6.0 percent per year during 2000-2005, a slightly slower rate than that of the previous decade of 7.0 percent. Modest economic recovery, relatively stable and low petroleum prices, together with the growing number of passenger vehicles each year, have contributed to the economy's growth in total oil consumption at 5.0 percent per year in 2000-2005. In addition, the growth of energy consumption was fuelled by robust consumption for natural gas for electricity generation and to a lesser extent, for industries, at a rate of 8.0 percent. About 70 percent of Thailand's electricity is generated through natural gas, reflecting the economy's heavy dependence on natural gas for electricity generation. Due to the economy's limited indigenous energy resources, Thailand relies heavily on energy imports, importing 64 percent of total energy consumption in 2005 mainly in the form of oil. Domestic procurement, however, have been accelerated to cope with the increasing consumption. Crude oil production increased 15 percent yearly from 62 thousand b/d in 2001 to 114 thousand b/d in 2005, which supplied only 10 percent of economy's total crude oil consumption. Natural gas production has also increased at a rate of 5.0 percent per year from 1,900 mmscfd in 2001 to 2,292 mmscfd in 2005. About 30 percent of total natural gas consumption is met by imports from neighbouring economies, like Myanmar [APEC 2006]. The energy resources are shown in Table 29**.**

Table 29: Primary Energy Resources in the Kingdom of Thailand

Resource	Reserves	Potential for Use in Power Generation
Oil and Gas	Petroleum Authority of Thailand (PTT) and joint ventures with foreign oil industry Sirikit field: average oil output of 22,655 barrels per day (b/d), natural gas output of 42.6 million cubic feet per day (mmscfd) and LPG output of 247 tons per day from 17 gas fields . 83% of the natural gas comes from the fields in the Gulf of Thailand [PTT 2006a]	Limited, even if more reserves were found, oil - production: 230,000 bbl/day (2005 est.), oil - consumption: 851,000 bbl/day (2004 est.), natural gas - production:22.28 billion cu m (2003 est.), natural gas - consumption:29.15 billion cu m (2003 est.), natural gas - imports: 5.2 billion cu m (2001 est.), natural gas - proved reserves: 377.7 billion cu m (November 2003) [CIA World Factbook, 2006, DENA 2006]
Coal (Lignite)	proved recoverable reserves of Lignite (1999): 1268 million t [WEC 2001] 80% produced by EGAT in mines in the province of Lampang and Krabi, 8% produced by Lanna Resources Public Co. Ltd. With mines in Lamphun and Phetchaburi, 12% by other mining companies in the provinces of Lampang, Phayao and Phetchaburi [Wu 2001]	Domestic coal demand (2001) was 19.9 Mt, of which 15.7 Mt was consumed by EGAT, 4.2 MT by the industry, import of 4.9 Mt of coal [Wu 2001]
Solar PV	Individual systems for remote areas, battery charging systems, solar home systems, demonstration plants for schools and hospitals Installed capacity approx. 5,5 MW [DENA 2006](2004)	Photovoltaic modules already used for small-scale (e.g. 100 W) remote applications. Increase of installed capacity to250 MW until 2011 [DENA 2006]
Solar thermal	Hot water applications for household widely used (2-6m³) 50000² flat collectors in hotels, hospitals and private properties [DENA 2006]	Market saturated, Australian producers dominant [DENA 2006]
Wind	EGAT operated a plant with 150 kW grid-connected capacity in Phuket [DENA 2006]	Only limited potential due to average wind velocity at 1,6 – 3 m/s, Coastal areas, central plateaus, Chao-

Resource	Reserves	Potential for Use in Power Generation
		Praya-Valley and Korat Plateau may be used for wind power, installed capacity of 100MW until 2011 intended [DENA 2006]
Biomass (waste)	Biomass resources dispersed throughout the country, 66 Mio. Ton of biomass available, use of one third, use to generate thermal power	Current share of biomass (mainly wood fuel) in total energy consumption about 88%. Wood-fired cogeneration (heat and power) plants could be economic for self-supply in wood processing facilities
Hydropower	23 micro plants operating no data about installed capacity [DENA 2006]	Potential of 25500MW, potential for micro, mini and small hydro 1000MW [DENA 2006]

Oil imports remained predominant, but their relative importance compared to domestic natural gas decreased and natural gas now covers 75% of power generation needs. From 1990 to 2000, energy consumption more than doubled and power generation by conventional thermal power plant nearly tripled.

With such an energy mix, the effect of the recent rise in oil prices could only be tremendous: oil imports value will be reaching 10% of GDP in 2005. Growth forecast have already been adapted from 5.5 to 4.5-3.5 % by the National Economic and Social Development Board due to combined oil price rise, the December 2004 tsunami and the drought affecting agriculture this year again is partly responsible for this movement. Some consider it a sign of local effect of the global climate change [Worldenergy 2006].

3.4.1 Electricity Generation and Consumption

Electricity production in Thailand predominantly relies on thermal and combined cycle generation. Based on the most recent statistical information (DEDE 2004), natural gas is a dominant fuel for electricity generation, accounting for about 70% of the total electricity generation. The remaining is made up of 17% lignite/coal-fired power plants, 9% large-scale hydropower, 3% fuel oil, and about 1% from renewable. Similar figures are stated by DENA (2006). Approximately 80% of natural gas is produced from the Gulf of Thailand, and the rest 20% is imported from Myanmar. Lignite is indigenous resource in the northern part of Thailand while coal is imported. According to the thirteen-year power development plan 2003-2016, 35% of total generation in 2016 is to be supplied by new power plants.

The Government of Thailand aims to establish a Renewable Portfolio Standard (RPS) for all new generating capacity that would require the builders of new power plants to purchase or build renewable energy equivalent to 3%-5% of the new installed capacity. The Ministry of Energy is also targeting that renewable power generation will account for 6% of total generating capacity by 2011.

Thai electricity consumption from the national grid achieved 100.173 GWh in 2002, an increase of 8,5% in relation to 2001. The total installed capacity in 2002 was 24.157 MW, more than 5,5% over the previous year. The installed capacity was shared by government or state electric utilities with 62,4% and private power producers with 37,6%. Details of 2002 electricity generation and consumption are as follows

Thermal Power Plants: Total installed capacity of thermal plants accounted to 7.917 MW. This is equivalent to 32,8% of the total capacity, 79,0% government and 21,0% private owned.

Combined Cycle Power Plants: Total installed capacity of combined cycle plants achieved 10.555 MW, forming 43,7% of the total capacity. 48,1% was owned by government and 51,9% by private power producers.

Hydro Power Plants: Total installed capacity of hydro power plants was 2.936 MW, or 12.1% of the total capacity. All hydropower plants are governmental property.

Gas Turbine Power Plant: Total installed capacity of gas turbine plants was 778 MW, or equivalent to 3.2% of the total capacity, all of them in governmental property.

Diesel Power Plants: Total installed capacity of diesel plants was 40 MW, or equivalent to 0.2% of the total capacity.

SPPs' Cogeneration Power Plant: Total installed capacity of SPPs' cogeneration plants was 1,930 MW, or equivalent to 8.0% of the total capacity.

Others: Total installed capacity of the other power plants which comprise of geothermal plants, solar cells, and wind turbines was1 MW.

The electricity generated from thermal power plants totalled 39.502 GWh in 2002, a decline of 0,5% in comparison to the previous year, and accounted for 36,2% of the total national grid generation. For generation by sector, 77,0% were generated by government and the remainder of 23,0% by private power producers. Total electricity generated from combined cycle power plants was 48.350 GWh in 2002, an increase of 11,7% compared to the previous year, and accounted for 44,4% of the national grid generation. 42,6% were generated by government and the rest 57,4% by private power producers. Total electricity generated from hydro power plants in 2002 was 7,471 GWh, an increase of 18.5%, and accounted for 6,9% of the national grid generation. All electricity generated by these plants came from government owned facilities. Total electricity generated from gas turbine power plants in 2002 was 1.105 GWh, a decline of 2,2% compared to the previous year, and accounted for 1,0% of the national grid generation. This entire amount was generated by government facilities. Total electricity generated from diesel power plants was 17 GWh in 2002. This entire amount was generated by government. Total electricity generated from SPPs' cogeneration plants accounted 12.566 GWh in 2002, an increase of 4,9%, and accounted for 11,5% of the national grid generation. Total electricity generated from other plants (such as geothermal, solar cell, and wind turbine plants) was 2 GWh in 2002. This entire amount was generated by governmental institutions.

The electricity generated from natural gas totalled 69.538 GWh in 2002, 9.4% more than the previous year, and accounted for 63,8% of the total national grid generation. Total electricity generated from coal and lignite was 16.652 GWh in 2002, 6,0% less than the previous year, and accounted for 15,3% of the national grid generation. Total electricity generated from fuel oil was 2.616 GWh in 2002, and accounted for 2,4% of the national grid generation. Total electricity generated from hydro power was 7.471 GWh in 2002, and accounted for 6.8% of the national grid generation. Total electricity generated from diesel was 168 GWh in 2002, 33,6% more than the previous year, and accounted for 0,2% of the national grid generation. Total electricity generated from SPPs' cogeneration plants was 12.566 GWh in 2002, 4.9% more compared to the previous year, and accounted for 11,5% of the national grid generation. Total electricity generated from geothermal installations, solar cells, and wind turbines in 2002 was 2 GWh.

Fuel Consumption: In term of oil equivalent, the fuel consumption for electric generation in 2002 amounted to 24.028 ktoe, 5,3% increased from the previous year. Natural gas consumption for electric generation in 2002 totalled 758.169 MMscf, or 2.077 MMscfd in average, increased 7,4%, and accounted for 77,1% of the total fuel consumption of national grid generation. The government sector consumed natural gas 42,2% and private power producers consumed the other 57,8% of the total natural gas consumption. Coal and lignite consumption for electric generation in 2002 totalled 15,954 thousand tons, or 44 thousand tons per day, declined 4,0% from the previous year, and accounted for 17,8% of the total fuel consumption of national grid generation. The 94,2% was consumed by government and the remaining 5,8% by private power producers. Fuel oil consumption for electric generation in 2002 was 656 million litres with an average rate of 2 million litres per day, and accounted for 2,6% of the total fuel consumption of national grid generation. The 76,2% was consumed by government and the remaining 23,8% by private power producers. Diesel consumption for electric generation in 2002 was 47 million litres, declined to 43,4% compared with the previous year, and accounted for 0,2% of the total fuel consumption of national grid generation. The 38,3% was consumed by government and the remaining 61,7% by private power producers. Renewable fuel consumption for electric generation in 2002 was 2.248 thousand tons with an average of 6 thousand tons per day, increased 53,3% over the previous year, and accounted for 2,1% of the total fuel consumption of national grid generation. All renewable fuel (paddy husk, bagasse, fuel wood, and agricultural waste) was consumed by private power producers. In addition, in 2002 residual gas from production processes and black liquor consumed by SPPs' cogeneration amounted to 621.962 GJ and 1.695.763 GJ respectively, which accounted for 0,2% of the total fuel consumption of national grid generation.

Import and Export: In 2002, Thailand has made an electricity deal with the neighbouring countries i.e. Lao People Democratic Republic, Malaysia, Union of Myanmar and The Kingdom of Cambodia to serve domestic demand around border area.

Thailand imported 2.812 GWh of electricity, 2,4% less than the previous year. 99,5% of which originated from the Lao PDR and the remainder of 0,5% from Malaysia. Total value of electricity import accounted for 4.481 millions Baht. Thailand sold electricity to Lao PDR, Cambodia, Myanmar and Malaysia. The total export achieved 273 GWh. 70.5% of the energy were sold to the Lao PDR, 21.8% to Cambodia. Smaller amounts were sold to Myanmar and Malaysia. Total exported value accounted for 475 millions Baht. There was no change in tariff structure in 2002 [DEDE 2002].

In contrast, the total electricity production was 114.7 billion kWh in 2003, the consumption 107.3 billion kWh. Electricity exports of 315 million kWh and imports of 980 million kWh were executed in 2003. [CIA World Fact book, 2006].

Table 30: Existing Power Plants in Thailand [DEDP/ELECTRIC POWER IN THAILAND as cited in Srisovanna 2002]

N^o	Power Plants	Installed Capacity [MW]	Total Capacity [MW]	Electricity Generation [GWh]	Fuel Types
	Thermal / steam				
1	South Bangkok	2*200, 3*310	1330	5,602	NG, Fuel Oil & Diesel
2	North Bangkok	2*75,1*87.5	237.5	299	Fuel Oil & Diesel
3	Mea Moh	3*75, 4*150,6*300	2,625	15,892	Lignite & Diesel
4	Bang Pakong	2*550,2*600	2,300	10,300	NG, Fuel Oil & Diesel
5	Ratchaburi (IPP)	2*735	1,470.0	4,818	NG, Fuel Oil & Diesel
6	Kegco (IPP)	2*75	150.0	1,098	NG, Fuel Oil & Diesel
	Total		**8,112.5**	**38,009**	
	Gas turbines				
1	Nong Chok	2*122	244.0	-	Diesel
2	Lan Krabu	2*16, 4*20, 4*14	168.5	1,151	NG
	Total		**412.0**	**1,151**	
	Combined Cycle				
1	Nam Phong	2*355	710.0	3,132	NG & Diesel
2	Bang Pakong	2*380.3, 2*307	1,374.6	4,013	NG & Diesel
3	South Bangkok	1*355, 1*623	958.0	6,043	NG & Diesel
4	Wang Noi	2*651, 1*729	2,031.0	11,060	NG & Diesel
5	Ratchaburi	4*230	920.0	147	NG & Diesel
6	Kegco (IPP)	1*674	674.0	4,682	NG & Diesel
7	Regco (IPP)	4*308	1,232.0	8,091	NG & Diesel
8	Ipt(IPP)	1*700	700.0	1,235	NG & Diesel
9	Teco (IPP)	1*700	700.0	2,222	NG & Diesel
	Total		**9,299.6**	**40,625**	**NG**
	Diesel				

N°	Power Plants	Installed Capacity [MW]	Total Capacity [MW]	Electricity Generation [GWh]	Fuel Types
1	Mae Hong	6*1	6.0	2	Diesel
2	Son Pea	36.1	1,790.9	14	Diesel
	Total	**42.1**		**16**	
	Cogeneration				
	SPP	-	1,790.9	10,148	Coal, lignite, fuel oil, Diesel, renewable & Others
	Others	0.6	0.6	2	-

Table 31: Existing and planned Power Plants of IPPs in Thailand [DEDP/ELECTRIC POWER IN THAILAND as cited in Srisovanna 2002]

Company	Mw	GWh/Yr	Fuel	Location	Status
Independent Power Thailand	1 X 700	4,513.15	Ng	Chonburi	In Operation
Tri Energy	1 X 700	4,513.15	Ng	Ratburi	In Operation
Eastern Power And Electric	1 X 350	2,256.58	Ng	Samutprakarn	In Operation
Union Power Development	2 X 700	7,358.40	Coal	Prachubkirikan	(Postpone)
Gulf Electric	2 X 367	3,857.90	Coal	Prachubkirikan	(Postpone)
Bowin Power	1 X 713	4,596.97	Ng	Chonburi	In Operation
Blcp Power	2 X 673.25	7,077.20	Coal	Rayong	In Operation
8Klcp Power - Thermal	2 X 75	1,050	Ng + F.O.	Nakon Srithammarat	In Operation
- Cogen	1 X 674	4,723	Ng + Diesel	Nakon Srithammarat	In Operation
Regco - Cogen	4 X 308	8,634	Ng + Diesel	Rayong	In Operation
Ratchaburi - Cogen	2 X 735	10,302	Ng + F.O.	Ratchaburi	In Operation

Small Power Producers in Thailand: Small Power Producers (SPP) can apply for power purchase agreement. The buyers are the Electrical Generating Authority of Thailand (EGAT), Metropolitan Electrical Authority (MEA) and Provincial Electrical Authority (PEA). 18,121 MW electrical capacity were sold on contracts in 2006,. The total installed capacity was 25,647 MW. This total capacity is divided into 15,036 MW produced by EGAT and 10,611 MW produced by private IPP and SPP. Official records in 2004 showed that there were 89 SPP that signed the sale contracts. Total installed capacity was 4,536.407 MW and the amount sold to EGAT was 2,466.2 MW. There were 15 plants using paddy husk as fuel. 37 plants utilized bagasse as the fuel. The rest are using natural gas, coal and wood chips, palm residues and hydropower. There were no reports of solar and wind power plants. The unit price of electricity range from 1.5 Baht to 2.5 Baht depending on types of contract and time during the day. IPP would get higher price with firm contract. A regulation for the purchase of power from Very Small Power Producers (VSPP) was updated and announced in June 2005. It is for power plants using non-conventional fuels with a plant capacity up to 1 MW. Price varies from 1.5 Baht to 2.2 Baht depending on the type of contract and time during the day. It is expected that price of renewable energy would be increased and plant size would be increased to 6 MW installed capacity for VSPP. Final decision, however, is not made [Kanoksak 2006b].

Actually, 38 biomass SPPs with an installed capacity of 308 MW are purchasing energy into the grid (2004). 29 of the SPPs with a capacity of 173,3 MW are using bagasse as the primary energy source. 3 SPPs are using rice groats (18,8 MW), and 4 rice groats with wood waste (41,2 MW). Two plants are using black liquor and wood waste (25 and 50 MW resp.) [DEDE 2004].

Table 32: Existing SPPs in Thailand [DEDP/ELECTRIC POWER IN THAILAND as cited in Srisovanna 2002]

Company	MW	Fuel	Location	Status
The Cogeneration Co., Ltd. (Public) 1	150	Ng	Rayong	In Operation
The Cogeneration Co., Ltd. (Public) 2	150	Ng	Rayong	In Operation
Tuntex Petrochemical Co., Ltd.	55	Coal	Rayong	In Operation
National Petrochemical Co., Ltd.	133.70	Ng + Off Gas	Rayong	In Operation
Industrial Power (1)	67.68	Ng	Rayong	In Operation
Thai Oil Power	117.20	Ng	Chonburi	In Operation
Defence Energy	10.40	F.O.	Chiangmai	In Operation
Gulf Cogeneration	111	Ng	Saraburi	In Operation
Amata Egco	150	Ng	Chonburi	In Operation
Industrial Power (2)	66.34	Ng	Rayong	In Operation
Bangkok Cogeneration	107	Ng	Rayong	In Operation
National Power Supply (1)	164	Coal + Waste Wood	Prachinburi	In Operation
NPC Cogeneration (1)	70	Ng	Rayong	In Operation
Saha Cogeneration	120	Ng	Chonburi	In Operation
Thai Power Supply (1)	105	Husk + Waste	Chachoengsao	In Operation

Company	MW	Fuel	Location	Status
		Wood		
NPC Cogeneration (2)	70	Ng	Rayong	In Operation
Thai Power Supply	10.40	Husk + Waste Wood	Chacheonsao	In Operation
Rojana Power	120	Ng	Ayudthaya	In Operation
National Power Supply (2)	164	Coal+ Waste Wood	Prachinburi	In Operation
Samutprakarn Cogeneration	160.30	Ng	Samutprakarn	In Operation
Thai Cogeneration (1)	160	Coal	Rayong	In Operation
Thai Cogeneration (2)	160	Coal	Rayong	In Operation
Thai National Power	110	Ng	Rayong	In Operation
Noangkal Cogeneration	159.50	Ng	Chonburi	In Operation
Laem Chabang Power	103.58	Ng	Chonburi	In Operation
Biomass Power	6	Rice Husk	Cahinat	In Operation
Amatu Power Banpakong	150	Ng	Chonburi	In Operation
Roiet Green	9.9	Rice Husk	Roiet	Syn.Jul' 02
TLP Cogeneration	103	Ng	Rayong	Syn.Jan' 03 S
Alpha Power	210	Ng	Chachoengsao	Syn.Mar' 03
Siam Power Supply	300	Ng	Rayong	Syn.Aug' 03
Panjaphol Pulp Industry (1)	150	Coal	Rayong	Syn.Aug' 03
Panjaphol Pulp Industry (2)	150	Coal	Ayudthaya	Syn.Apr' 03

Approx. 48 contracts between VSPP and the PEA or the MEA were actually placed. Total capacity is approx. 6 MW. New incentives were created for small rural companies by this program, especially in the photovoltaic and biomass applications [DENA 2006].

Table 33: VPSS projects and application received, Dec. 2006 [source: www.netmeter.org 2006]

	MEA				PEA			
	projects	kW	Applic.	kW	projects	kW	Applic.	kW
Solar PV	1	1,5	41	533	1	3,1	24	66,7
Biogas	0	0	1	1200	7	2690	18	6736
MSW	0	0	0	0	7	13990	9	16868
Biomass	0	0	0	0	0	0	1	1420
Total	1	0	1	1733	15	16638		25091

3.4.2 Energy Consumption by Consumer Types

Consumption: The electric consumption of end-users in national grid in 2002 was 100.173 GWh, 8,5% increased over 2001. Details are as follows:

Industrial Sector: Among economic sectors, industry was the largest electric consumer in 2002. Electric consumption in industrial sector was 45.732 GWh, increased 9.1% over the previous year, and accounted for 45,7% of the total electric consumption for the whole country.

Commercial sector (including government sector and non-profit organizations): In 2002, the commercial sector consumed electricity 31,686 GWh, increased 10.4% from the previous year, and accounted for 31.6% of the total electric consumption.

Residential Sector: In 2002, the residential sector consumed electricity 22,112 GWh, increased 4.9% from the previous year, and accounted for 22.1% of the total electric consumption.

Agricultural Sector: In 2002, the agricultural sector consumed electricity 196 GWh, increased 10.1% from the previous year, and accounted for 0.2% of the total electric consumption.

Others: Electric consumption in others (temporary consumers) in 2002 amounted to 413 GWh, increased 0.7% from the previous year, and accounted for 0.4% of the total electric consumption. Moreover, in 2002 a small volume of electricity 34 GWh was consumed in sky train in Bangkok Metropolitan Region.

Bangkok Metropolitan Region (BMR): Electricity consumption in BMR was 35,786 GWh, or 35.7% of the total consumption for the whole country, an increase of 5.7% from the previous year. Outside Bangkok Metropolitan Region: Outside BMR consumed 64,387 GWh, or 64.3% of the total electric consumption, an increase of 10.2% over the previous year [DEDE 2002].

Table 34: Total Energy and Electrical Energy Consumption by Economic Sector 2004 in ktoe [Kanoksak 2006b]

Total energy consumption		Electricity consumption	
Sector	**[ktoe]**	**Sector**	**[ktoe]**
Agriculture	3,461	Agriculture	21
Industry*	22,397	Industry*	4,340
Residential	8,598	Residential	2,287
Commercial	3,951	Commercial	3,193
Transportation	22,673	Transportation	3
Total	**61,080**	**Total**	**9,844**

* Industry = Manufacturing + Mining + Construction

Table 35: Final Energy Consumption for Economic Sector by Fuel 2004 [Kanoksak 2006b]

[ktoe]	Agricul-ture	Industry	Resident.	Commerc.	Transport	Total
Coal & Its Products	-	5,539	-	-	-	5,539
Petroleum Products	3,440	5,305	1,064	758	22,643	33,210
Natural Gas	-	1,992	-	-	27	2,019
Electricity	21	4,340	2,287	3,193	3	9,844
Renewable Energy	-	5,221	5,247	-	-	10,468
Total	**3,461**	**22,397**	**8,598**	**3,951**	**22,673**	**61,080**

3.4.3 Energy Consumption Outlook

The economy growth forces an increase of the energy consumption. The Thai government calculates with an increase of energy requirements of 7% yearly. The energy generation will be at 185430 GWh with an increasing percentage of energy imports from Laos (approx. 9,8%) [DENA 2006]

3.4.4 Rural Energy Demands

A great majority of the poor in Thailand live in rural areas, mainly in the Northern and North eastern regions. Main energy consuming activities in three different sectors, residential, productive and social, their related costs and their share in the total running costs were evaluated. The main source for this section is the survey on the energy consumption in rural Thailand, carried out every five years by the Department of Alternative Energy Development and Efficiency (DEDE).

3.4.4.1 Residential uses

The annual average energy consumption of Thai rural households, excluding transport, is summarised in **Table 36** below.

Table 36: Yearly average energy consumption per household in rural Thailand [Source Shrestha et al. 2006]

Type of energy service	Consumption (kgoe/hh)	Share (%)	Main fuels used
Cooking	518.71	60.1	Charcoal, Wood
Agriculture	224.5717	26.0	Diesel, Gasoline
Lighting, Entertainment and Convenience	87.36	10.1	Electricity, Diesel
Industry & Handicraft	14.92	1.7	Wood, Electricity
Others	17.85	2.1	NA
Total	863.41	100	

The two most energy consuming activities are cooking (60%) and self-subsistence agriculture, respectively. Biomass (charcoal and fuelwood) used in a traditional way is the most used option to cook. Pumping water for domestic uses is not a need that requires a lot of energy. Along with other uses (lighting, cooling down the space, preserving goods, etc) it does not represent more than 10% of the total consumption of an average household. This is explained by the fact that in many places, villagers collect rain water. Regarding transportation needs, the limited survey carried out for this study shows that motorbikes are very popular in rural Thailand. About two-thirds of the households surveyed had at least one motorbike. The transportation energy needs allotment comprises, on an average, about 20% of the total energy share of a household, and in some cases, it even exceeds 30% [Shrestha et al. 2006].

A summary of the yearly energy expenditures per activity is given in **Table 37** below. It shows that activities requiring the highest amount of energy are also the most expensive to satisfy. However, differences in costs between the different requirements are less pronounced than energy consumption. This is explained by the fact that, per kilogram of oil equivalent (kgoe), electricity is about 2 and 3.5 times more expensive than diesel and wood respectively [Shrestha et al. 2006].

Table 37: Yearly average energy expenditures per household in rural Thailand [Source Shrestha et al. 2006]

Type of energy service	Cooking	Agriculture	Lighting, Entertainment and Convenience	Industry & Handicraft
Cost (US$/hh)	132.9	104.9	71.6	5.3

The average expense per rural household for energy is over US$ 310 per year. As a comparison, the average annual income in rural Thailand is US$ 3,314.420 per household and the average annual expenditure is US$ 1967.621 per household [Shrestha et al. 2006]. On a yearly basis, the energy related expenses then effectively corresponds to about 9.5% of household income and represents more than 15.5% of the total household expenditures. For rural Thailand, the different types of energy uses can be detailed and prioritised as shown in Table 38 (excluding transport).

Table 38: Prioritisation of energy use in the residential sector in rural Thailand [Source Shrestha et al. 2006]

Type of energy service	Energy Consumption (kgoe/hh/yr)	Main fuel used	Cost (US$/hh/yr)	Impact
Cooking	518.08	Charcoal	132.7	Basic need
Field ploughing	174.64	Diesel	80.6	Increases production, Increases income Basic need, Increases standard of living,
Convenience	51.67	Electricity	41.6	
Water pumping for crop irrigation	39.65	Diesel	20	Increases production, increases income Increases standard of living
Entertainment	18.03	Electricity	15.46	Enables working during night time
Lighting	17.65	Electricity	14.56	

3.4.4.2 Productive uses

A particularity of rural Thailand is that it is difficult to distinguish productive uses from residential uses. The same energy requiring devices are often shared for both professional and personal activities. In this section, two different categories related to the productive sector are being considered, namely, Residential and Business (restaurants, shops, etc.) and Residential and Industry (production units: e.g. cottage industries, foodstock production, workshops, etc.). For these two categories, the different types of energy uses, the average consumptions as well as the two main fuels used are shown in Table 39: .

Table 39: Yearly average energy consumption of the productive sector in rural Thailand [Source Shrestha et al. 2006]

Type of energy service	Residential + Business			Residential + Industry		
	Consumption (kgoe/hh)	Share (%)	Main fuels used	Consumption (kgoe/hh)	Share (%)	Main fuels used
Cooking	340.75	39.56	Charcoal, LPG	409.05	25.49	Wood, Charcoal
Agriculture	236.22	27.43	Diesel, Electricity	187.33	11.66	Diesel, Gasoline
Industry & Handicraft	145.74	16.92	Electricity, LPG	830.97	51.73	Wood, Electricity
Lighting, Entertainment and Convenience	129.30	15.01	Electricity, Diesel	127.61	7.94	Electricity, Diesel
Others	9.32	1.08	NA	51.39	3.20	NA
Total	861.32	100		1,606.35	100	

In rural Thailand, the highest energy consumption activities in the productive sector (industry and businesses) are cooking, agriculture and industry/handicraft. In the business sector, cooking represents almost 40% of the total energy consumption. Charcoal is the most widely used fuel followed by LPG and fuelwood. In the industrial sector, wood and charcoal are used more than LPG. Similar to the residential sector, pumping water does not represent an important part of the total energy consumption in the productive sector. The share of the different energy end-uses is very context specific (activity, location, etc.).

The share of energy costs to the total running costs of a production unit (business or industry) depends on the type of activity. It can be as high as 70% for agricultural activities requiring large quantities of water (e.g. rose apple or lemon plantations) or foodstuff production units requiring large cold storage capacities. For small scale and more traditional activities, such as traditional fruit drying, small pig farms or paddy cultivation using rainwater, the share of energy is less significant and sometimes negligible. Low energy intensive industries have often low production rates and produce low quality goods. In restaurants, the main expenses are for food ingredients, and the energy expenditures represent only about 3% of the monthly running costs [Shrestha et al. 2006]. The yearly energy expenses, excluding transportation costs, exceed US$ 430 for businesses, and it is more than US$ 530 for industries.

Table 40: Yearly average energy expenditure in the productive sector in rural Thailand (in US$/unit/year) [Source Shrestha et al. 2006]

Type of energy service	Cooking	Agriculture	Lighting, Entertainment and Convenience	Industry and Handicraft
Residential and Business	98.7	120.8	109.2	96.7
Residential and Industry	113.2	87.1	106.7	223

The different needs for the industrial sector in rural Thailand are summarised and presented in Table 41:. As shown in the table, the most energy consuming activities (drying, baking, pasteurising, brick making, pottery, cooking, etc.) require heat. Currently, this is provided by fuel wood.

Table 41: Prioritisation of energy use in the industrial sector in rural Thailand (in US$/unit/year) [Source Shrestha et al. 2006]

Type of energy service	Energy Consumption (kgoe/hh/yr)	Main fuel used	Cost (US$/hh/yr)	Impact
Heat for thermal processes	796.58	Wood	191.4	Increases production, Increases quality, increases income
Cooking	404.05	Wood	112	Increases production, Increases income
Field ploughing	145.7	Diesel	67.2	Increases production, Increases income
Water pumping for crop irrigation	33.1	Diesel	16.4	Increases production, Increases income
Cold Storage for production conservation	7.82	Electricity	6.9	Preserves production, Increases income

Agriculture related energy needs are of lesser importance both in terms of consumption and cost. In the case of rural Thailand, activities consuming the highest amount of energy for the residential and industrial sectors are presented in the following table. For each activity, the possible REs and their competing non renewable sources are given.

Table 42: Main energy use and potential renewable energy technologies [Source Shrestha et al. 2006]

Category	Type of energy service	Renewable Technologies	Competing non-renewable
Residential	Cooking	Biomass and Biogas Solar cooker	LPG, Grid
	Lighting, Entertainment and Convenience	Solar PV Micro hydro Wind Geothermal Biodiesel Bio-ethanol	Grid, diesel, kerosene
	Transportation	Biodiesel Bioethanol	Diesel, gasoline, CNG
Industrial	Heat for drying units, bakeries, etc.	Solar dryer Biomass Biogas Geothermal	Grid, LPG, Kerosene
	Water pumping for crop irrigation	Solar PV Biodiesel Biogas Biomass gasification Wind	Grid, diesel, gasoline
	Field ploughing	Biofuel	Diesel, gasoline

3.5 Electricity Tariffs

3.5.1 Electricity Tariffs on-grid

Regulator or authority responsible for approval: Installing power plant in the country needs to get Power Purchase Agreement from Electrical Authority in the power plant location. These divided into Metropolitan area and Provincial area. Therefore, Metropolitan Electrical Authority (MEA) and Provincial Electrical Authority (PEA) are the main authorities for approval.

Average price for kWh paid (in classes, biomass, PV, hydro, if differentiated): Average price are 0,03 – 0,05 Euro/kWh depending on time of feeding and type of contract. SPP (Small power producer) would get lower price rate. VSPP (Very Small power producer) would get higher rate. Power plant with less that 1 MW capacity is entitled to VSPP permit. The VSPP permit was in effect since 2002.

3.5.2 Electricity Tariffs off-grid

Installing electrical supply unit off grid are mainly done by EGAT (Electrical Generating Authority of Thailand) and Department of Civil work, Ministry of Interior Affairs. Solar panel system would be installed based on government policy from time to time. Mini-hydro pumping system also installed but with limited number. Some projects on PV solar were done by DEDE (Department of Alternative Energy Development and Efficiency).

Average price for kWh paid (in classes, biomass, PV, hydro, if differentiated):No specific information was available for all classes. However, average price for PV solar was between 0,125 – 0,2 Euro/kWh.

Normally, EGAT and Department of Civil work handled technical work by themselves. The department of Alternative Energy Development and Efficiency usually hired private consultant for installation and inspection [REEC 2006].

3.5.3 Feed-in Conditions

3.5.3.1 Present Situation

Two types of “Power Purchase Agreement” are possible for selling power to the grid:

SPP, Small Power Producer programme, which covers 99% of the power sold to the grid; the programme is open to RE and cogeneration plant burning conventional fuels. The maximum capacity allowed for sale is 60 MW, often increased to 90MW. The plants have usually a capacity of 5MW and feed local factories (70% of the production). 41 plants were connected in 2004. The monopolistic position of EGAT, sole grid owner and power buyer, leads to problems, as commonly in this kind of situation: unfair treatments, pressures, unnecessary difficulties,... Payment depends on the “firm/non firm” status of the supplier: “firm” status requires the supplier to deliver power at least 4670 hours/year and during peak season (March to June); the payment includes a capacity payment of 480 Baht/kW/month and the payment of power at 1.3 Baht/kWh (average calculated in 2002; varies from case to case). “Non-firm” status allows to supply power any time, for 1.77Baht/kWh, without capacity payment. About 30% of SPP enjoy “firm” power purchase agreement. This common “non-firm” SPP system is often much less interesting than the “firm” or the VSPP. In addition, in order to foster the initial phase, subsidies have been available from ENCON Fund on a bidding base for a limited number of projects (0.17Bath/kWh during five years). The success of this bidding arrangement demonstrated that potential was there, but is probably not an efficient promotion tool after an initial round has succeeded.

VSPP, Very Small Power Producer programme, which covers the remaining 1% from generators under 1MW (proposed to become 6 or even 10 MW soon). Very few units succeeded in getting connected, probably for the mentioned reasons to which very small producers are even more sensitive than small ones. Payment follows a “net-metering” system, with an unique meter discounting excess power sold to the grid and counting power consumed from the grid. Time and voltage of delivery also influence the payment. Average price was 2.46 Baht/kWh in 2004.

Additional incentives are explored for the moment, and may get applied soon:

Feed-in tariffs calculated upon the specific property of the different technologies bringing different advantages in terms of time in the day or season in the year for production, typical for most NRE. Profitability of NRE power generation would reach a satisfying level in many more cases, including technologies like small biogas (large biogas is already profitable), wind and solar stirling engine, but not yet for PV cells.

externality adders in IRP (Integrated Resource Planning) programme would allow choosing the energy mix providing the optimum outcome in terms of public interest and not only the commercial (or even economic) optimum for the utility itself. (Utility is kept at its place: a tool, not a target.) This type of planning goes far beyond the current practice of EGAT which takes into account almost only the supply side and its own commercial costs through a least-cost analysis methodology (PROSCREEN software)

3.5.3.2 Feed-in conditions targeted with the Action Plan for the Development of Renewable Power in Thailand

According to the 2003 Energy Strategy for Thailand's Competitiveness, the target is to increase the share of renewable energy, in the total final energy consumption, from 0.5% in year 2002 to 8% in 2011. The sub-target for renewable power production is stated to be 6% of the electricity production in 2011 corresponding to approximately 12.400 GWh. This renewable power target shall be reached by a Renewable Energy Portfolio Standard (RPS) system and by an Incentive Scheme. The present renewable power production is approximately 5.200 GWh (2004), and the RPS system is assumed to cover further 1.400 GWh by year 2011.

The purpose of this Action Plan is to achieve a renewable power production target of approximately 5.800 GWh for the Incentive Scheme by year 2011. The primary objective of the PRET project and of the present Action Plan has been to focus on the promotion of economically viable as well as commercial and near-commercial renewable energy technologies (biomass, biogas and hydro power), although non-commercial technologies (not economically viable) such as wind, solar PV and MSW technologies have also been included in the Action Plan.

The regulation for purchase of power from small power producers (published 1992, revised 1994 and 1998) defines obligation for electricity companies to let SPP's (< 60MW) connect to the grid and purchase power from SPP producing on wind, PV, hydro, biogas and biomass including municipal waste. Pricing not fixed but depends on certain criteria and bids of EGAT/MEA/PEA. June 2003: 1,49 THB + subsidy + capacity payment (for firm capacity). The first round bids included a 5-year tariff subsidy of up to 0,36 THB/kWh – later projects receive 0,15-0,18 THB/kWh.

The power purchase obligation from SPP (1998) defines the pricing that is not fixed but depends on certain criteria and bids of EGAT/MEA/PEA. The first round bids included a 5-year tariff subsidy of up to 0,36 THB/kWh – later projects receive 0,15-0,18 THB/kWh.

Renewable Power Scheme of EGAT: The MoEN has recently assigned EGAT to handle a scheme to develop 140 MW of RE power: 10 MW of PV, 10 MW of Wind, 20 MW of MSW, 25 MW of Biomass, and built-operate-transfer 75 MW of Hydro. The electricity price (per MWh) in this scheme should be equal to EGAT's basic tariff plus the feeding tariff. The present basic tariff for conventional plants is 2,8 Bath/kWh, and the feed-in tariff will be added on top of that. The feed-in tariff might be provided for a period of 5-7 years.

A minority of renewable energy SPPs (including biomass) receives production subsidy from the ENCON Fund averaging to 0,17 Baht/kWh for the electricity sold to EGAT. In the first 5 years of operation, on a single round of bidding program evaluated in 2002, only 9 SPPs were selected from 41 proposals. On capacity basis, 282 MW were awarded contracts with production subsidy, and on energy basis, 162 MW were also awarded contracts with production subsidy. Renewable energy SPP generators that have come on-line without subsidy cover all of the range of biomass fuel types, indicating that in these cases they were commercially viable without a need for subsidy.

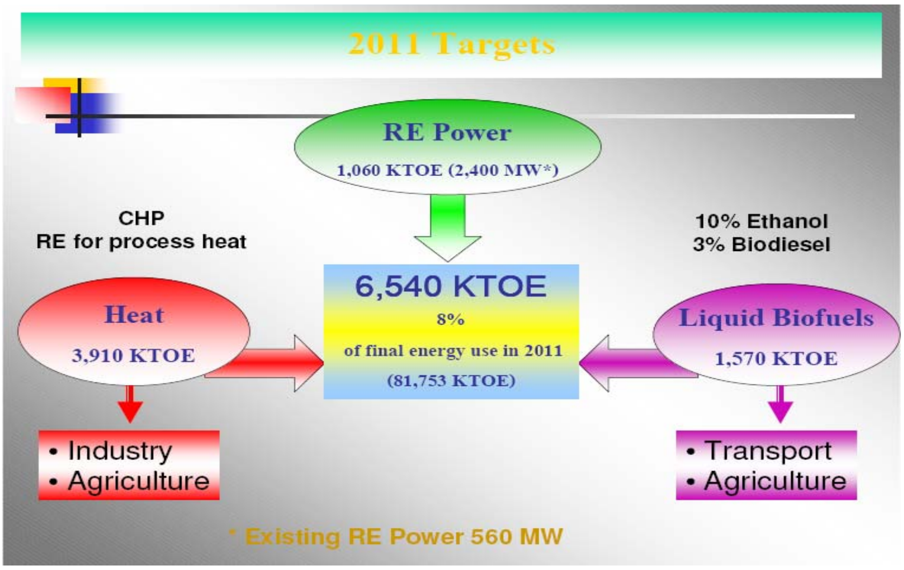
3.5.4 General

Besides traditional fuels like fuel wood and charcoal, and large hydropower, which are not considered as RE, in 2003, NRE were providing 0.5% of final energy, most of it from solid biomass used as fuel. Energy planners assume that additional RE will come from:

- solid biomass, agricultural residues and wood residues from rubber plantations,
- biogas from agro-industrial waste waters and pig farms,
- municipal solid waste (as biogas or/and fuel),
- small hydro,
- biofuels, mostly ethanol from cassava, and bio diesel from palm oil and Jatropha oil
- sun (PV cells),
- wind.

For the moment, the precise targets for RE, 8% of total primary energy in 2011, seem far from being in the reach. Today's achievement is only 2% (2005 estimates).

These targets are still widely discussed especially regarding the agricultural feasibility of biodiesel crops, the socio-economic impact of cassava use for ethanol production, and more important, the cost of final cost of power produced by the RE mix as proposed: biomass and small hydro power can compete with conventional power source, but solar and wind energy reach very expensive prices (10 and 5 Baht/KWh compared to 1.5-2 approximately for solid biomass, biogas or micro/mini/large hydro power and 1.3 for natural gas). Seen the number of conferences and seminars going on, an important capacity building process is on the way, with important exchanges amongst Thai administrations, academics, NGOs, and with foreign expertise support.



560 MW RE power = >500 MW biomass fueled power + 50 MW mini+micro-hydro

Figure 17: Targets for RE 2011

Recently several larger projects aroused, demonstrating the feasibility of large scale biogas and biomass cogeneration. The industrial sector will most probably rush into these "new" opportunities to save money on fossil fuels as soon as information spreads correctly and guidance is available. BOSCH, Biomass One-Step Clearing House, under EFE, Energy for Environment Foundation, is now providing that service. (N.N. RECIPES 2005A, EFE 2006)

Thailand's target for renewable energy, as stated in the 2003 Energy Strategy for Thailand's Competitiveness, is a very ambitious target looking at increasing the present share of renewable energy from 0.5 % in year 2002 to 8% (final energy production) in year 2011. The target implies a rate of implementation over the next decade that outstrips the current rate of implementation and as far as power production is concerned the target implies a capacity of 2,400 MW based on renewable energy to be implemented between now and year 2011. The target of 2,400 MW will be achieved through the implementation of the RPS (Renewable Portfolio Standard) programme in combination with other incentives to promote additional implementations [Jepsen et al. 2006]. Reaching the target will imply a substantial increase in the utilisation of renewable energy such as biomass, hydro power, solar energy, wind power and municipal solid waste (MSW) technologies as stated in Table 43.

Table 43: Capacity targets for implementation of RE for power generation [Source Jepsen et al. 2006]

	2004	2011		
		RPS	Incentives	Total
	[MW]	[MW]	[MW]	[MW]
Biomass	800	120	630	1.550
Hydro	60	280	280	400
Solar PV	20	20	250	250
Wind	-	65	65	100
MSW	-	55	55	100
Total	883	280	1.237	2.400

3.5.5 Renewable Energy for Power Generation

The power sector’s evolution owes much the political troubled history of South East Asia. During the Vietnam War, U.S. was heavily present in Thailand and set up several temporary infrastructures. During the cold war, US advisors considered rural electrification as a political tool to contain communist influence from Lao, Vietnam and China. Consequently, the highly centralized EGAT + MEA + PEA power structure was reinforced as electrification progressed with plenty of foreign supports. Before 1990, nearly every Thai villages had been grid connected, even if located in a very remote place with very expensive grid connection work. This was not without consequence on alternative power production, particularly small hydropower, which definitely should have been a success story in Northern Thailand tropical mountains, but pitifully failed, as it has been investigated by Greacen of the NGO Palang Thai [Greacen 2004].

Being (and willing to be more and more) a leading country in SE Asia regarding energy matters, Thailand faces even more the responsibility of developing an efficient model for NRE development. But wrested interests, bureaucratic inertia and generally rather low level of expertise in new energy planning/management practices explain why a vigorous debate is going on.

Biogas and solid biomass are the two major resources for NRE power generation, together with small hydropower. Solar PV, although too expensive, is promoted by one government project and widely present.

3.6 Financing and Funding Possibilities for RE projects

There are several sources of investment support from Government programmes, e.g. subsidies as soft loan under the revolving fund programme. These options are so far only open to "designated facilities", leaving out facilities with less than 1 MW installed electrical capacity. Furthermore, to utilise the Revolving Fund Programme (RFP), it is necessary to be accepted as a creditworthy client with a bank. As the bank is directly liable for the re-payment of the loan to the RFP, regardless of the debt performance of the client, and on top of that still a bit insecure about the EE and RE technologies, they tend to prioritise clients with high credit rating. Small and medium sized enetrprises with average credit rating and installed capacity less than 1 MW has for the moment little possibility of getting financial support. Another new feature in the energy sector is the targeted support for the development of the ESCO-market, which is perceived as an efficient tool to speed up the process of renewable energy project development and implementation. The electricity buy-back obligation is a novel and basically efficient supportive measure. However, there could be room for improvement, as the tariff support element is not fixed in terms of a stable, simple and transparent pricing mechanism (at the moment the feed-in tariff depends on EGAT production cost, plus an element related to the fuels used). The only tax-related / fiscal measure that has been introduced relates to the import tax of RE technology equipment. The Import Tax on these technologies has been reduced to 5% since 1992. The effect of this measure has over a period of 4 years been estimated at a total tax reduction of 110-120 million Baht. The new Energy Strategy also encourages use of measures such as provision of tax credit, and subsidies from the ENCON Fund to provide incentives for purchase of RE based electricity [COWI 2006]. The main financing tools are

- ENCON Fund
- Revolving Fund Programme (RFP) under ENCON fund
- Environmental Fund EF
- ESCO Development Support Programme (under ENCON fund)
- Power purchase obligation from SPP
- Power purchase obligation from very small renewable energy power producers
- Import tax
- Global Environment Facility (GEF)
- Incentives from Thailand board of Investment

An overview about funding and financing possibilities is provided in the appendix.

4 Solar Energy specific Data in Lao PDR

In order to understand the solar energy basic conditions of the Lao PDR a quick and thorough look at the countries basic geographical and economical data is necessary. Please see 2.1.1.

PV power which other to biomass energy generation is not attributed to work and additional energy input can set aside time and effort for enhanced education and income generation. The extension studying hours due to lighting or water pumping or the possibility of income generation by the operation of small equipment or enhanced communication prospects due to mobile communication or even internet access are such effects.

PV Power and the Millennium Development Goals (MDG) by the UN

The MDGs and some of the roles for PV as a general contributor are according to the IEA:

1. Eradicate extreme poverty and hunger – PV based lighting allows increased income generation and reliable electricity encourages enterprise development, energy for water supplies for cooking and drinking and water for irrigation increases food production.

2. Achieve universal primary education – PV based electricity enables access to educational media and communications, energy helps create a more child-friendly environment and reduces school drop-out rates and lighting in schools allows evening classes and helps retain teachers.

3. Promote gender equality and empower women - Availability of modern energy by PV modules means that women do not have to carry out survival activities, good quality lighting permits home study and reliable energy services offer scope for women's enterprises to develop.

4. Reduce child mortality – PV based electricity for lighting can bring about less indoor air pollution, increased safety, free up more time to be spent on child care and provide pumped water and purification.

5. Improve maternal health – PV based energy services provide access to better medical facilities (vaccine refrigeration, equipment sterilization, operating theatres). Provision of cooked food and space-heating contribute to better health.

6. Combat HIV/AIDS, malaria and other diseases – PV based energy services provide better medical facilities, and energy can help produce and distribute sex education literature and contraceptives.

7. Ensure environmental sustainability - Traditional fuel use contributes to erosion, reduced soil fertility and desertification, PV based energy can be used to pump and purify clean ground water.

8. Develop a global partnership for development – PV based energy supply can contribute to the development of information and communication technologies in remote / rural areas.

4.1 PV Solar Application in Laos

The first PV systems have been introduced in Lao PDR since early 1980s by telecommunication companies and then international development programs, mainly to supply electricity for telecommunication systems, vaccine storage and lighting in remote or off-grid areas. Since then PV technology has become more and more popular in remote rural areas. In general, two main categories of PV systems users in Lao PDR are Telecommunication systems and off-grid electrification programs.

Since middle of 1980s, telecom companies have started to use PV systems for power supply to telecommunication devises, such as telecom substation or microwave repeaters. Usually, telecom systems voltage is 48 V or higher, with bank of deep cycle maintenance-free batteries and inverter. In some cases, inverter-combiner is used when PV systems are installed as stand-by power source for diesel gen-set. The panels usually are imported from China, while inverters/combiners are made in Europe.

First introduced into the country in the 1980s for telecommunications, PV solar is now a major component of the off-grid electrification programme and the most widely recognised RE technology – with 48% of surveyed business enterprises and 63% of households indicating they knew about PV solar. PV solar's current market growth of 30% per year is largely driven by government incentives resulting in significant cost reductions (Nanthavong 2005). Following the government's IPP policy there are two competing models for the extension of PV solar in the country: the pilot programme conducted through the Ministry of Industry and Handicraft (MIH) with funding from the World Bank (WB), and Sunlabob rural electrification systems, a private energy utility.

The present chapter will give an overview and detailed description of chosen demonstration projects in the PV Solar Sector. An overview of the PV applications and a detailed data sheet for each application are attached in Appendix 3: PV applications in Laos and Appendix 5: Data Sheets of selected PV plants.

4.1.1.1 TRI's solar PV demonstration projects (1997-2001)

Since 1997 the Technological Research Institute (TRI) has implemented several demonstration projects, including:

Since 1997, Technology research Institute under the Science, Technology and Environment Agency (TRI/STEA) has started several solar PV projects (TRI report, 2004). The objectives of the projects were to demonstrate viability and feasibility of PV technology application in Lao PDR.

Solar Battery Charging Station (BCS).

The project was to show viability of solar PV systems in Lao conditions; as well as to find out management scheme for village energy system and raise public awareness on renewable energy technologies. Two BCS - 1775Wp funded by the Lao-Canadian-Thai Trilateral Environment program (CTTE) and 1875 Wp funded by the Swedish International Development Agency (SIDA) were installed by TRI. Both systems are designed for 45 households. Each household (user) is equipped with house kit, including battery (80 Ah for the first BCS and 85 Ah for the second one), one or two Direct Current (DC) saving lamp and assigned a certain day for charging the battery. User pays monthly fee (about 1,5 US$ per household) for covering system's administration.

The equipment was installed by TRI technicians and then handed over to village authority. Village committee hereby was formed thereby to handle system's management and tariff collecting. Village technician was briefly trained on systems maintenance and troubleshooting.

Combined Solar Home-Battery Charging Station systems (SH-BC system).

This system was intermediate between solar home system and village battery charging station. Each SH-BC system consists of 240 Wp Solar panels and is designed for a group of 7 households, closely located:

- The house which attached panels and charge-controller is called **a Key House**.
- The other 6 houses called **a Satellite House**. Each satellite house is equipped with discharge controller, DC socket and some saving DC lamps.

The charge controller was specially designed so that it can charge 3 batteries at one time: one battery for use in the key house, the two others – are standby for satellite houses. To charge a battery, each satellite house needs to do only one trip: in a day assigned to him, he carries his battery to the key house and takes back home a standby one, which is already fully charged during previous days.

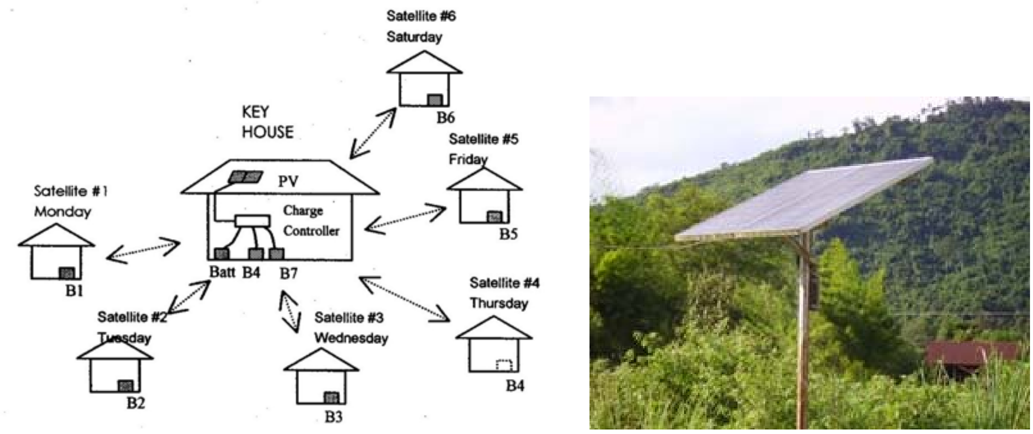


Figure 18: Principle of Solar Home – Battery Charging system

Per household capital cost of SH-BCS is lower than cost of SHS, but is higher than that of village BCS.

The main advantage of SH-BCS is users' convenience: closer to user house, flexible charging process, lower capital cost. But the main disadvantage of this system is probably its more complex management scheme: to have to deal with many key-house managers (15 in this pilot project) instead of one manager as in case of village BCS. So, it is difficultly to keep service standard as the same high as for all systems.

These SH-BC were in service only for less then two years and have been evacuated due to grid connection of the target area.

4.1.1.2 MIH-JICA solar PV pilot projects (1998-2001)

JICA has launched several pilot projects in Vientiane and Bolikhamxay provinces of Lao PDR. The overall objective of the projects is to formulate a master plan to promote rural electrification in Laos by using renewable energy resources such as photovoltaic power and small hydropower.

An emphasis is placed on the establishment of an appropriate management model for solar-based rural electrification. In particular, technical, financial and organizational aspects regarding the operation and maintenance of solar systems were intensively studied considering socio-economic conditions in rural Laos. Based on the results of the pilot projects, the feasibility of introducing solar systems into remote areas as a means of rural electrification, from technical, financial and organizational viewpoints was evaluated.

In order to promote solar-based rural electrification in the future, appropriate technologies, operation methods and institutional structures were analyzed. The following three points were focused on in the pilot project:

- Appropriate capacity and configuration of PV systems.
- Appropriate cost sharing by villagers (users)
- Management and maintenance by villagers

As a concluding suggestion, the JICA team drafted 10-year plan of promoting solar systems for rural electrification. The plan stresses the viability of solar systems in Laos and addresses a strategy to achieve the ultimate goal to electricity 90% of households by the year 2020. Potential of small-scale hydropower development in these two provinces was also studied and models of hydropower power plant were developed for two candidate sites.

Installed SHS and BCS Piloted systems

- SHS. There were total of 254 SHS installed by the pilot projects, with 55W-SHS and 110W-SHS sizes offered. Initial payment was US$15 per 55W-SHS and $20 per 110W-SHS. Repayment was counted for period of 20 years, with monthly repayment of about US$0.75 for 55W-SHS and $1.50 for 110W-SHS.
- BCS: Different sizes of BCS, from 1 kW to 3 kW, were installed in pilot villages. Utilization rate of BCS was about 80%. The fee of charges was set at $0.75 per month for member. Charge fee for non-member: US$0.13 for a 6 V battery, $0.26 for a 50-70 Ah battery, and $0.4 k for a 120 Ah battery, per charge. Installation works were carried out by JICA team, MIH engineers and EDL sub-constructor

Lessons learned from the pilot project in the Lao PDR:

The project has shown that people in rural Laos accepted the PV systems and demand is fairly high. Initial payment and monthly fees were affordable for villagers. In order to promote spread of PV it is necessary to set reasonable prices in consideration of the market prices of alternative energy sources, such as charging battery in electrified areas or kerosene.

Village electricity committee (VEC) plays a vital role in system management. Education level, technical background and position in the village are selection criteria for VEC members.

In Laos "Sustainable operation" is an important concept for rural electrification. In order to achieve this, the three most relevant keywords are (1) people's participation; (2) capacity building and (3) cost recovery.

Based on the results of the pilot project, the JICA team made proposal of suited for Laos PV system. The proposal consists of main components, as (1) standard system configuration; (2) points to be considered while selecting systems parts; (3) replacement of parts;

Some problems that JICA pilot project could challenge:

- Competency and incentive of local office of Industry and Handicraft to cope with systems' monitoring and support for long term
- Long repayment period (15-20 years). On one hand, it is desirable argument for making low repayment rate to users. On the other hand, usually such project needs full long-term subsidies in the form of grant that is not always available.

4.1.1.3 MIH/World Bank Rent-to-buy projects (1999-2004)

Since 1999, Ministry of Industry and Handicraft (MIH) has managed the soft-loan from the World Bank (WB) to finance solar home systems, village hydro and small gen-set by applying **rent-to-buy** mechanism. In case of solar home systems (SHS) the villagers are prospective owners of the systems. Villagers buy systems by monthly repayment with repayment period from 5 to 10 years. Systems installation and maintenance service are performed by trained village technicians. Newly formed or existing Local Electricity Service Company (ESCO) has responsibility to support village technician with their installation and maintenance service. The Village Electricity Advisory Committee (VEAM) is formed in each target village and to play advisory role to village electrification strategy and implementation.

Figure 19: Rent-to-buy solar home systems

The rent-to-buy SHS system consist of solar kit (solar panels, outdoor wiring, mounting pole and charge controller) and house kits (indoor wiring, saving lamps, car battery and battery box).

Figure 20: Application of SHS (Lighting for handicraft production, education and entertainment)

Over five years, a team of Lao experts has been training small companies to become village service specialists, to work in areas not due for electricity grid connection. The key challenge has been to make sure the stand-alone electricity installations operate reliably for many years. The solution has been to develop a "Rent-to-buy" mechanism, as following:

- In the case of SHS, villagers buy the equipment by monthly payments over a period of several years. The solar panels become an important economic asset to poor families, since it retains high re-sale value. They choose village manager to provide technical support.
- In the case of village hydro and engine generating-sets, village manager rents-to-buy the equipment personally, using it to run a small business by selling electricity.

In the target areas, during the pilot stage 6 small energy service companies (ESCOs) have been registered as electricity installation companies. The concession agreement, signed with the Off-grid Promotion and Support (OPS) office gives these ESCOs an additional license to implement off-grid program in a particular area, either a group of districts or the whole province. ESCO's specific services are participative planning for off-grid entrepreneurs, supporting the villages in the long-term management, maintenance and financing of their equipment.

Most villages have chosen SHS, but for the electrification of cloudy and hilly areas, more villagers there are choosing village-scale hydro systems. The repayment rates for SHS customers are the core equipment cost price divided by 120 months, which implies that they are relieved of the financing cost of the initial capital investment, as well as of administrative and delivery costs- as their hidden subsidy.

The user of SHS makes down payment (approximately 10% of solar kit's cost) and pays for their house kit. Monthly payments for solar kit ranging $2 – 5 for 5-year and $1 – 2.5 for 10-year repayment period, depending on the size of system used. The user is also responsible for replacing house kit's components, which was estimated to last between $6-14 per year depending on whether the system is used carefully or not.

In Village Hydro (VH) and Generating-Set (GS) schemes, households pay for consumed electricity not to buy hardware. Due to the limitation of generated power, village Electricity Manager (VEM) sells electricity in Units rather than by metering kWhs. Each household signs a contract with the VEM specifying the number of units he chooses. The customer can reduce or upgrade at any time, but within limits of total power produced by the station. The electric current limiter is used to prevent overload of the VH or GS.

The program delivers a complete management system, to make reliable off-grid electricity possible for rapidly expanding numbers of people. Various techniques, such day and night units, standardized ESCO-VEM, VEM-Consumer contracts, regulation by a village electricity committee **(VEAC)**, etc, are all designed to make widespread access to electricity a realistic proposition.

The main mechanism of the program is designed to create reliability by using financial incentive:

- First, the SHS user is buying the equipment and is motivated to take care of it so as to not lose his investment. In case of VH/GS, VEM makes a significant private investment and looks forward to increased income at the end of the hire-purchase period, so he is motivated to keep the equipment in good working condition.
- Second, VEM, VEAC and ESCO are receiving a portion of each user's monthly payment (called "operational rebates"), only if the users' payment is actually made. So VEM, VEAC and ESCO all have strong incentive to maintain the equipment in good working order, as they lose income if villagers withhold payments for any reason.
- Third, OPS does not approve plans for installation in new villages, if the ESCO is not matching an average repayment rate of above 95% from all his villages. If the ESCO allows reliability to slip, repayments will slip and his business will fail. Also each ESCO is in competition with other ESCOs, who would expand their business in his area.

The strong points of the rent-to-buy scheme:

- Smart hardware subsidy (up to about 50%), soft loan support with long repayment term make repayment affordable for majority of rural population.
- Well-designed financial mechanism, applying financial incentives as management tools

The weak point of this approach, perhaps included in the following:

- Systems installation and maintenance are performed by village technicians, whose skills and capacity may not yet be mastered during short training and practice. Quality of their service may not as high as required for PV system and, therefore, long-term sustainability and reliability of the systems are still doubtful.
- Incentives are not strong enough to involve private sector investment into this business, where, for example, long term investment versus low profitability.

The largest state electricity utility-Electricity du Laos was involved into project for the beginning stage (1999-2001), then since 2001, the project was transferred to the Off-grid Promotion and Support Office (OPS) under authority of Department of Electricity (MIH).

To date, over 5200 solar home systems have been installed or being purchasing by this scheme.

4.1.1.4 Sunlabob-InWent's pilot projects on Renting PV systems (since 2003)

Objectives: to explore and develop a viable rental system to tackle another way of using PV systems for rural electrification in Lao PDR.

What is rented PV system? "Rented system" is a solar PV unit, which is installed on household base. The household pays for the electricity on a regular basis, while the installed equipment remains the property of the provider.

Favorable targets for rental systems are un-electrified areas along national road, national borderline and densely populated areas, where normally people have relatively high income and may belong to future grid extension.

Public-Private Partnership in running rental rural power systems

- Government authorities are concerned with rural electrification policy by using of renewable energy resources and implementing ESCO activities in remote areas
- Funding agency supports the rural development program of government, such as rural electrification, income generation, etc
- Rental Company is responsible for launching and managing rental systems
- Hardware Company provides, installs and maintains equipment
- Training company (or training provider) is to provide training of village committee and village technician on technical skills and business administration
- Village committee (VEC) is responsible for the management routine of rented systems; facilitating equipment installation and user training; collects the rent from end-users and hands the agreed fee over to the rental company and manages village fund, that is accumulated from portion of collected rents

Procedures of Renting Solar PV systems

- Village authorities approach the rental company for a program to launch a rental system in their village.
- The rental company dispatches a team of a fund manager and a person of the hardware company to assess the situation and reach an agreement with the village authorities.
- The hardware company plans and installs the systems. Simultaneously the training company trains the village committee on financial management, the village technician in use and first level maintenance.
- The rental company pays the hardware company for installing the equipment and the training company for the initial trainings.
- The rental company makes a service contract with the hardware company, and pays a fixed sum per year per system for maintenance.
- The village authorities collect rents from the various systems, and pay the collective rent to the rental company. The difference of the rents is for managing at the village level.
- The rental company reinvests the rents into new equipment, etc. The aim is to maximize the number of rents that are operating.

- The rental company pays interests on the investment to the fund.
- The rental company also pays back the initial loan. The public investor can decide whether to reinvest the interests/loan-money in the fund or not.

Achievement so far:

The pilot project on rental systems was launched in cooperation between Sunlabob Co. LTD and InWent-Capacity building International (Germany), with consulting support by Viltec (Switzerland). The pilot project was to prove rental mechanism.

Negotiations with the Triodos Bank (the Netherlands) have now resulted in a first loan for the rental operations from the recently launched Triodos Renewable Energy for Development Fund. This loan is for launching 300 rental SHS at several targeted villages.

4.1.1.5 Sunlabob Solar PV systems (2002-present)

Sunlabob rural electrification systems Co. LTD is the only registered private company in Laos, which is specialized wholly on rural electrification by using renewable energy resources. Installation and sale of community solar PV systems, solar fridge for vaccine storage, solar home systems, etc, are among business service of Sunlabob. Two typical systems offered by Sunlabob are **Community system** and **Rented Solar home systems**.

Figure 21: Community solar system: Ban Kuay health post

Figure 22: Possible appliance of community PV system

To date, Sunlabob has sold / installed around 948 community systems, with total installed capacity about 60 kWp and sized from 10 Wp up to several kWp (these information are courtesy by Sunlabob Co.). Usually, these systems are installed as a component of various rural development projects, funded by in Lao PDR accredited international organizations.

Sunlabob installed Community systems for such purposes as health post vaccine storage and lighting, community water pumping systems, telecommunication, etc

Since 2003, Sunlabob has started piloting rented PV systems. The objective of the project was to pilot another approach of off-grid rural electrification, by renting power systems. Rural people do not have to make any significant initial investment, but just pay for used electricity on regular basis, while systems remain property of the electricity service company. The service company also do installation and after installation (maintenance & repair) service.

The strong point of this approach: all works, such as installation, regular maintenance service are performed by electricity Service Company through its network of well-trained skilled franchisees, so that high satisfaction of service is always guaranteed. Also, in order to achieve long-term sustainability and reliability, usually high-quality equipment is installed, and that more reliable service provides.

The weak point of rental systems is that relatively high monthly rent, which may limit market of rented PV systems within wealthy portion of rural people only (approximately 10% of rural population).

Figure 23: Rental Solar Home systems

Figure 24: Installation and maintenance service are performed by well trained technicians, operating systems as franchisees of Sunlabob Co.

So far about 925 solar home systems with total capacity of 24,610 Wp have been already rented in different parts of the country. Prospective targets for grid extension and more prosperous rural areas are among favourable areas for renting power system.

4.1.1.6 Summary of available PV Solar Technologies

Solar PV for telecommunication systems

Up to year 2003, communication companies have installed more than 122.000 Wp of solar systems (MIH, 2003), to supply electricity to telecom substations or repeaters in remote or off-grid areas.

TRI/STEA demonstration projects (1997-2000)

Since 1997, Technology research Institute under the Science, Technology and Environment Agency (TRI/STEA) has started several solar PV projects (TRI report, 2004). The objectives of the projects were to demonstrate viability and feasibility of PV technology application in Lao PDR.

Solar Battery Charging Station (BCS).

The project was to show viability of solar PV systems in Lao conditions; as well as to find out management scheme for village energy system and raise public awareness on renewable energy technologies. Two BCS - 1775Wp funded by the Lao-Canadian-Thai Trilateral Environment program (CTTE) and 1875 Wp funded by the Swedish International Development Agency (SIDA) were installed by TRI. Both systems are designed for 45 households. Each household (user) is equipped with house kit, including battery (80 Ah for the first BCS and 85 Ah for the second one), one or two Direct Current (DC) saving lamp and assigned a certain day for charging the battery. User pays monthly fee (about 1,5 US$ per household) for covering system’s administration.

The equipment was installed by TRI technicians and then handed over to village authority. Village committee hereby was formed thereby to handle system’s management and tariff collecting. Village technician was briefly trained on systems maintenance and troubleshooting.

Combined Solar Home-Battery Charging Station systems (SH-BC system).

This system was intermediate between solar home system and village battery charging station. Each SH-BC system consists of 240 Wp Solar panels and is designed for a group of 7 households, closely located. Per household capital cost of SH-BCS is lower than cost of SHS, but is higher than that of village BCS.

The main advantage of SH-BCS is users’ convenience: closer to user house, flexible charging process, lower capital cost. But the main disadvantage of this system is probably its more complex management scheme: to have to deal with many key-house managers (15 in this pilot project) instead of one manager as in case of village BCS. So, it is difficultly to keep service standard as the same high as for all systems. These SH-BC were in service only for less then two years and have been evacuated due to grid connection of the target area.

4.1.2 MIH-WB vs Sunlabob

From 1999 to 2004 the Ministry of Handicraft has managed a World Bank soft loan to finance solar home systems using a rent-to-buy model. As part of a wider Asia Alternative Energy Programme (AAEP) the World Bank has for a long time sought to overcome three hurdles to successful implementation of PV Solar in off-grid areas: 1. High capital cost associated with equipment; 2. high transaction costs due to limited supply, sales outlets and technicians and; 3. market distortions such as duties and tariffs that increase the price for PV solar (Cabraal et al. 1998). In response an extension model was developed to enroll developing Energy Service Companies that buy, install and maintain systems in close proximity to consumers, create revolving funds that can be used to finance leasing and hire purchase arrangements and help local banks create short-term financing arrangements for home systems (Martinot et al. 2001).

In Lao PDR the World Bank model enables households to purchase systems on credit with a repayment period of between 5-10 years. In response to the ongoing need for maintenance a key feature of the system is service provision by a network of ESCOs who in turn support village trained technicians who collect the monthly re-payments. Households benefit from the rent-to-buy scheme because of the affordable price, with an in-built hardware subsidy of 50%, as compared to outright purchase of the home systems.

Sunlabob started a rental service for PV home systems as an alternative to the MIH off-grid electrification programme. Households do not pay any initial installation costs, only paying for the electricity they use while the systems remain property of the company. Sunlabob also maintain the systems through a network of franchised service providers, much like the MIH system of ESCOs. A main advantage of the system is that the service providers are well trained with the incentive of ensuring long term use of the home systems. For households there is the added bonus of up or downgrading the systems to meet their consumption needs without any further charges on equipment. The World Bank system notes that solar panels become an important economic asset to poor families, since it retains high re-sale value and it is assumed that the significant private investment made by the household forces them to increase their income at the end of the hire-purchase period - with the added benefit of motivating them to keep the equipment in good working condition (Harvey 2004). While PV solar has the distinct advantage of being widely known and accepted RE technology in rural Lao communities there remain considerable concerns over its long term use as a solution for rural electrification.

Despite the promise of better management and planning by ESCOs, franchises and households alike, both systems face high default rates on repayment and farmers face difficulties in using the PV solar systems to invest in productive assets. The monthly repayments of the MIH-WB system is three times cheaper than the Sunlabob system (€3.20-3.55) - because of the 5-50% subsidy[4] - and boasts up to 95% on-time repayment of loans (Harvey 2004). The higher price of the Sunlabob system has limited its potential with only 10% of the current

[4] The subsidy is calculated on a sliding scale based on the size of the Solar Home System ranging from 50% for 10 W systems to 5% for 50W systems.

target off-grid population able to afford the PV system. If compared to battery systems Sunlabob is roughly twice as expensive, limiting adoption of the PV system to wealthier households. On the other hand, the Sunlabob rental system is more flexible allowing for payments to correspond with the seasonal rice harvest. The MIH-WB system is also constrained by the long waiting time for extension, dependent on the willingness of ESCOs to join the programme, the participative training with village electricity of committees and training of village technicians which can take from 1 to 2 years. In comparison Sunlabob provides quick installation through their franchises, not relying on the long service chain and reaction time between technicians, service providers and the MIH. With failure rates of the PV systems as high as 20% the efficiency of maintenance and service for these systems is an important determinant of the future adoption and the success of off-grid electrification programmes.

The long-term viability of RE in Laos depends on the ongoing competition within the sector. Public-private investment in development has become an increasingly important focus of the World Bank through their Development Marketplace award scheme, which Sunlabob received in 2005 in partnership with World Wide Fund for Nature Lao. Following the success of the first phase of the MIH-WB rural electrification project, the Bank subsequently put out a tender to manage the second phase which was won by the French company Innovation Energie Développement (IED). In this new phase, which runs until 2009, IED must maintain the existing network of ESCOs and the current 6000 installed units, while meeting the target of installing 10000 additional units. Although running in parallel to private sector, including Sunlabob, IDE will be working with a World Bank funded supply-side subsidy of up to 85% on PV solar equipment. While reducing the cost of equipment these subsidies also distort competition in the sector, leaving operators outside the MIH-WB scheme with little incentive and almost impossible market prices.

Stakeholders in the RE sector argue that the challenge for both the private and public sector alike is to find financing models that are competition neutral. Instead of reducing costs for one competitor, in this case ESCOs within the MIH system, public funds could go to capacity building and demand-side subsidies so they can afford services they require at commercially viable prices – which would support the Sunlabob model endorsed by the World Bank through their Development Marketplace. If the MIH-WB systems persists with their public-private investment model, giving a clear competitive advantage to their member ESCOs, the goals of rural electrification may be reached, but seemingly at the expense of the long-term viability of the RE sector.

4.1.3 Meteorological Solar Irradiation Data

In Germany the total sum of the yearly global irradiation is amounting to 1.000 kWh/m², is a rule of thumb. However in most countries the variation of the solar irradiation is much larger between different sites and geographical regions. In Spain for instance a difference between 1.300 kWh/m² in the north until 1.800 kWh/m² in the south occurs.

The solar irradiation in Asia however is completely different than the one in Europe. In the following sections the solar irradiation of key Cities in Laos are displayed according to the

Ground Site Data of the NASA Surface meteorology and Solar Energy division as to the publication from the World Radiation Data Centre (WRDC) of the National Renewable Energy Laboratory (NREL). For this study three different locations were chosen to give an average prediction of the expected solar irradiation available for the application of commercial technologies.

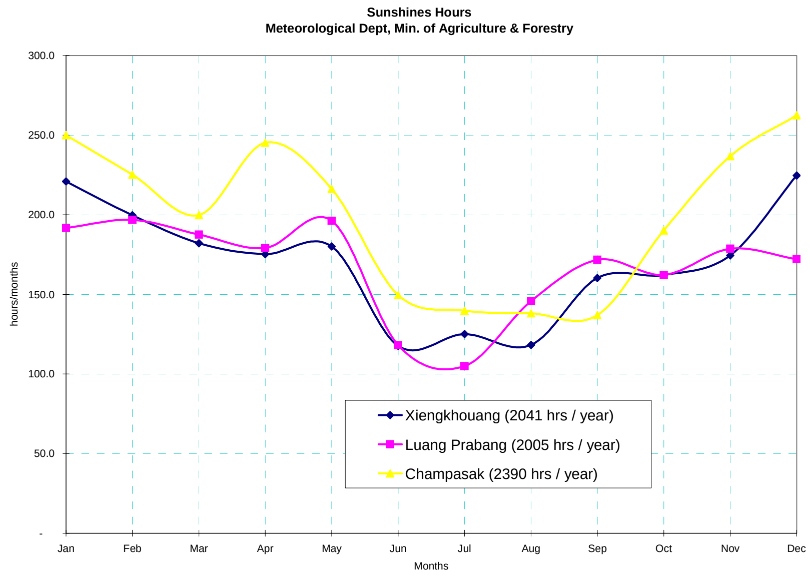


Figure 25: Sunshine hours in Lao PDR

The sunshine hours in Lao PDR differ from Champasak to Luang Prabang up to 20%. Generally however it can be said that Laos is offering a decent climate for PV solar applications all regions of the nation possess an above average radiation potential which leads to an enhanced commercial viablility and solar yield compared to more northern countries. This natural solar potential is readily available and few limitations due to locally occurring wheather conditions such as intense fog or ground mist are appearing. The overall radiation map for Laos also refects this trend.

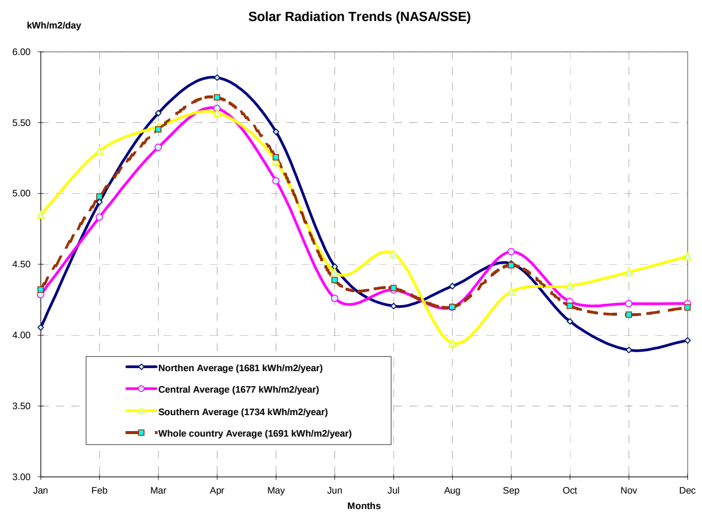


Figure 26: Solar Irradiation in Lao PDR

In Figure 26 it can clearly be seen that from January till June an above average solar radiation is recorded in the nation. Generally more than 1.600 kWh/m² and year are delivered which are usable for solar applications. In order to re-calculate this figure into kWh/kWpeak due to the warm climate approximatly 15% must be deducted so that an overall yield of 1.450 kWh/kWpeak in PV power installation can be expected.

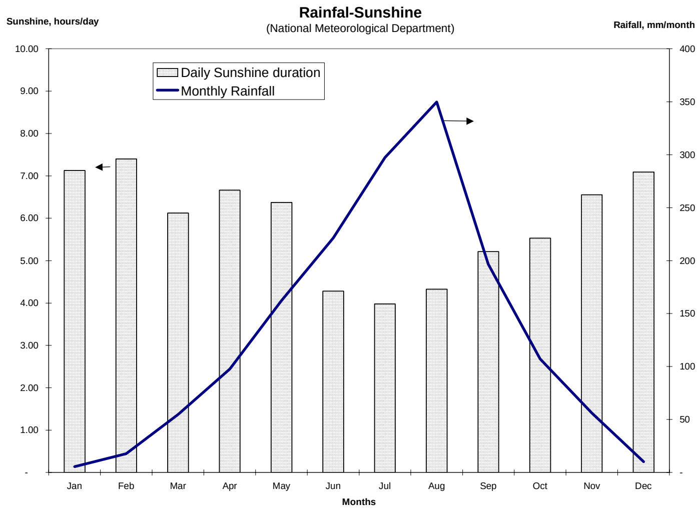


Figure 27: Combination chart: Rainfall-Sunshine duration

With such a radiation potential present Lao PDR has more than 60% more radiation available than northern Europe such as Germany. It equals the situation of southern Spain. This leads to the positive situation that equipment installed in Laos whill generate a higher yield by this factor. This way PV solar can offset higher investment costs to a point. Generally not only the solar availability is shaping the potential for a rural electrification but also the economic surroundings and cost structures for such elements such as diesel or the distance and extension costs of the grid.

4.1.4 Educational Demand for Operators and Applicants of the Technology

Photovoltaic power, although not a direct goal of the UN, drive can be delivering a real contribution towards achieving the Millennium Development Goals (MDGs). In most developing countries neither access to modern energy services in general, nor provision of electricity are recognised as specific goals in themselves. Nevertheless they play a central role in poverty alleviation, through impacts on education, health and local enterprise, as well as access to modern telecommunications and information technology resources. It is especially the generation of chances in education and communication which are the driver behind the special contribution of photovoltaic electricity for rural development and therefore poverty alleviation. As the director general from the United Nations Industrial Development Organisation UNIDO phrased it in the 2006 conference in Montevideo Uruguay on energy security in the Latin American Region:

"You can not erradicate poverty without generating wealth!"

K. Yumkella UNIDO secretary general

The generation of wealth and therefore a potent customer base for project developers however is the key element in the generation of a sustainable power supply program for rural electrification programmes. Although it is wishful that the poor can be supplied with electricity free of charge to enhance their development many failed programmes by donor agencies or governments have proven that long term subsidies for such costly enterprise will not be up kept and hence the chances generated quickly fade. Hence despite it being somewhat contradictory to the old fashioned donor policies and poverty eradication strategies of the national and international donor communities the elements of business, education for income generation and entrepreneurship must be embraced also in the rural development efforts. Especially the provision of modern energy services must be attached with a small but affordable price tag and paired with education and income generation opportunities.

Figure 28: Poverty cycle model simple (left) and advanced with education possibilities (right) (www.tripurafoundation.org)

The simple poverty cycle model from the Tripura foundation shows that education is the key behind breaking the poverty cycle for families and inhabitants of underdeveloped areas. This education is meant to break the low wages or income source element and hence create the chance for income opportunities. The advanced model includes education possibilities. The difference made by income generation opportunities from enhanced education can be seen clearly.

Majority of population in developing countries is rural based and dispersedly inhabited. Generally, rural population lacks of opportunities for income generation due to inadequate market mechanism, underdeveloped rural infrastructure, etc.

From all these points the lack of income opportunities is the most problematic aspect. Energy in all ways is coming at a cost. If no connection between energy generation and income opportunities is to be created the energy supply of such regions will lead to an export of capital and an improved drive for poverty. Energy generation must go hand in hand with joint income opportunity generation. For that education is the key. The main conses of the second Stakeholder Workshop of the APE project – PV solar and Biomass was, that

- The lack of education from children to graduate level is the main obstacle for RE implementation in Laos.

Education is needed in the following fields:

- Raising awareness on energy efficiency to change the habit on air condition use and understand the advantages of energy efficient devices.
- Training and raising awareness on EnergyFarming and feed-in possibilities
- Incorporate RE idea in school curricula.
- Awareness raising, training and education on RE.
- Dissemination of information on EnergyFarming.
- Raise awareness of Lao people to the quality of Lao products. Implement a campaign similar to the Thai campaign "**O**ne **T**ambon **O**ne **P**roduct"

It is important that people are clear of the chances, technology and education so they are ready for further development of RE.

4.1.5 Overall PV Solar Condition in Lao PDR

Lao PDR is a country whose conditions are generally favorable towards the utilization of photovoltaic power. The resaons behind this evaluation are generated from a multitude of factors:

Lack of national grid coverage

In 2002 the Lao PDR possesses a national electrical grid extending to only 38% of the nation, reaching only 30% of the rural population. Any extension of the grid comes at high investment costs and even higher maintainance costs which are to be transferred to a minimal amount of users and customers quickly leading to a deficit of this operation.

Need for de-central power generation in off grid areas

These off-grid areas are difficult to reach due to the sometimes verry rugged terrain in Lao PDR, hence is the extension of the national grid to such an area a costly enterprise. Due to the very minor amount of power consumption in these areas and the resulting low turnover of the grid-investment a re-financing perspective of such grid builduing efforts can not displayed effectively. Ultimately de-central power such as PV-solar is the smart choice for such areas.

General power consumption among rural consumers low

The rural areas of the Lao PDR generally possess a very weak contribution to the national GDP. Hence people living in this area will not be able to afford electric power without being enabled for a better income opportunity.

National rural electrification programmes

The Lao PDR possesses a commitment by the contries national utility Electricite de Laos (EDL) to extend electrical power throughout the nation. This programme althoug mainly operated as a grid extension programme is more often coming to terms with the situation that smart off-grid solutions are more cost effective than the limitless extension of the grid to political reasons.

International donor support for small scale power generation

The generation of small scale power is a key goal from all international donor organisations. Programms supporting such an off-grid development range from PV solar based initiatives to the errection of smal scale biogas plants by chineses development authorities or the Dutch organisation SNV.

In general it can be said due to the huge electification potential and the immense costs behind the central approach in such a nation with rugged and natural terrain off-grid solutions are becoming an ever lager focus by donors and investors. Laos posseses an receptive atmosphere towards such technologies and the responsible authorities show a general interest towards the subject. Criteria which are hindering the rapind expansion are the question of financing and loans as well as the payback operations in areas where little GDP is present and income generation efforts are sparse. A sustainable development of these activitites to full swing can only be expected when income opportuinites can be developed alongside the provision of energy services to the rural population.

A study conducted a survey among Laotian businesses and it showed that 48% of surveyed business enterprises and 63% of households indicating they already knew about PV solar. Moreover the actual growth rate of PV solar at 30% per year in Laos is largely driven by government incentives resulting in significant cost reductions (Nanthavong 2005).

Following the government’s IPP policy there are two competing models for the extension of PV solar in the country: the pilot programme conducted through the Ministry of Industry and Handicraft (MIH) with funding from the World Bank (WB), and Sunlabob rural electrification systems, a private energy utility.

Both programmes are operating on a competitive level which is leading to some irregularities on the martket often experienced when government or donor interaction takes place.

4.1.6 Policy review

Electrification is seen as a key component of the government's poverty eradication policy by raising the standard of living of the predominantly rural population, stimulating investment and providing opportunities to enter national and regional markets. Attention has focused mainly on the provision of grid electrification, but recent institutional reorganisation has increased the profile of RE within the Department of Energy. The government has focused on the providing finance through the off-grid promotion fund and the poverty reduction fund, set up through the Prime Ministers office to finance small-scale investment and services that contribute to village development including energy.

Policy and legislation for independent power producers (IPP) has been developed for hydropower but this experience has not been transferred over to the extension of off-grid electricity. If IPP legislation is linked to the government's reforms of decentralizing responsibilities in the administration and management of electricity activities, then further investment in market-based incentives within the private sector may assist in the promotion of off-grid extension to rural areas.

A major step in the development of a broad-based forum for research and development of RE is the recent formation Lao Institute for Renewable Energy (LIRE), combining a range of private, state and civil society. LIRE intends to develop research and development capacity within the country for RE ensuring technologies are commercially viable and affordable. An opportunity also exists to link LIRE with the renewable energy stakeholder network developed through this Asia Pro Eco project. How the institute intends to establish itself, and what its exact position is vis-à-vis policy, research and extension, remains to be seen.

4.1.7 PV Solar

There are two competing models for the extension of PV solar in the country: the rent-to-buy programme through the Ministry of Industry and Handicraft (MIH) with funding from the World Bank (WB), and the rental service through the private energy utility Sunlabob rural electrification systems. The WB-MIH provides a rent-to-buy scheme while Sunlabob runs a rental scheme. Both models address the main constraints to extending off-grid electrification to a diffuse and isolated population, by working through decentralized networks of entrepreneurial electricity service companies (ESCOs).

The long-term viability of RE in Laos depends on the ongoing competition within the sector. The ongoing investment by the World Bank project provides further subsidies for equipment, giving a clear competitive advantage to their member ESCOs. The goal of rural electrification may be reached in the short-term, but without financing models which are competition neutral, the subsidies will be at the expense of the long-term viability of the RE sector.

Ensuring successful adoption of PV solar by rural households requires the provision of energy services to increase the productive capacity of households, enabling them to meet monthly instalments and contributing to income security. There is little empirical evidence for the actual suitability of current income opportunities from lighting – such as silk weaving, head lamps for fishing, basket weavings and rice milling. PV solar may meet consumptive needs of households, but without further empirical understanding of how this energy contributes to household income there is no less reason to think that poverty alleviation will necessarily follow.

4.1.8 Biomass

Biomass energy appears to have enormous potential in Laos based on the availability of agricultural and forestry residues totalling some 18907 MWh or 1922 million l/ diesel fuel per year. However, to determine the actual potential of biomass in off-grid rural areas it is necessary to consider both the availability and accessibility of these residues to farming communities, especially as both agricultural and forestry resources are already under the increasing strain of food and income security. The acceptance of energy farming needs to be seen in the context of where production occurs relative to markets and support services, and the willingness of farmers to turn food crops over to energy production.

Shifting farmers to produce non-food crops for energy production from anaerobic digestion requires a considerable shift from the food production focus of farming communities, as well as challenging the food security, agricultural production policy of the government. Farmers currently have little experience with non-food crops, and even less with food crops that are used for non-food uses. The only example of a commercial non-food use of rice is for Beer Lao which farmers from around the country are contracted to produce Mallee rice in both wet and dry seasons. Careful consideration also needs to be given to the assumptions of organic fertilizer as a by product of biomass digestion. Although organic fertilizer and production shows potential in Lao PDR, a major shift is needed away from the use of chemical fertilizer for small-scale farming practices, and further attention is needed to promote organic farming as a niche sector in domestic and export markets.

4.1.9 Comparison of private sector extension models

Comparing the experiences of different extension and support systems for RE, from both private and public sector, provides insight into the possibilities for ensuring participation at the local level and possibilities for ensuring ongoing competition within the sector. A comparison of four extension services available in Laos are summarised in Table 44. This analysis of strengths and risks does not provide a definitive answer, but instead is designed to encourage further discussion over which mix of extension models are suitable for further development of PV Solar and energy farming.

Pilot Projects

The ‘traditional’ method of extension by the government is through setting up pilot or demonstration villages, based on a belief in rural Lao people’s preference for more practical application or ‘seeing and doing’. How successful these projects are outside the village is questionable given the institutionalised support from the government to these communities.

As seen in the Chinese biogas project the efficiency of service provision, passing through the various levels of bureaucracy can be a potential limiting factor.

Electricity Service Company

The ESCOs draw in the village level as a level of technical support, but have found that delays between ESCOs and low levels of training and capacity at the village level as hindered the successful adoption and maintain. Very remote off-grid areas may remain poorly serviced if ESCOs are unable or unwilling to travel long distances. Indeed, in some cases it may prove unprofitable to do so given the time and effort required. Although they rely on village technicians, there are potential delays in payment and in returning with spare or replacement parts. The systems and technology required for biomass, especially biomass, will require considerable start-up costs and ongoing training and maintenance. The profitability and sustainability of these technologies will occur over a long time period, the length of which may prohibit some investors from joining these networks. Like the ESCO system Sunlabob franchisees may find it difficult to travel to remote areas for maintenance and collection of tariffs. Also like ESCOs the poor profitability of making these trips may limit the extension of services to remote areas.

Biomass and energy farming include a complex combination of technical and farming extension. In off-grid areas, where access is limited and communities are dependent on semi-subsistence forms of production, considerable effort would be required to encourage the adoption and ongoing sustainability of energy production. The lessons leant from PV solar - to decentralize technical support to district or village level entrepreneurs - could prove useful, but it is unlikely these entrepreneurs will have the capacity to support production, distribution and consumption without the support from agriculture and forestry expertise. Furthermore, given the sensitive nature of forestry and the importance of agriculture, extension services need to foster sustainable production and use of biomass ensuring control and use of these resources do not compromise the rural livelihoods.

PV Franchising

The Lao company Sunlabob Ltd. started a rental service for PV home systems as an alternative to the MIH off-grid electrification programme. Households do not pay any initial installation costs, only paying for the electricity they use while the systems remain property of the company. Sunlabob also maintain the systems through a network of franchised service providers, much like the MIH system of ESCOs. A main advantage of the system is that the service providers are well trained with the incentive of ensuring long term use of the home systems. For households there is the added bonus of up or downgrading the systems to meet their consumption needs without any further charges on equipment.

Despite the promise of better management and planning by ESCOs, franchises and households alike, both systems face high default rates on repayment and farmers face difficulties in using the PV solar systems to invest in productive assets. The monthly repayments of the World Bank funded MIH off-grid electrification programme system is three times cheaper than the Sunlabob system (€3.20-3.55) - because of the 5-50% subsidy - and boasts up to 95% on-time repayment of loans (Harvey 2004). The higher price of the Sunlabob system has limited its potential with only 10% of the current target off-grid population able to afford the PV system. On the other hand, the Sunlabob rental system is more flexible allowing for payments to correspond with the seasonal rice harvest. The MIH system is also constrained by the long waiting time for extension, dependent on the willingness of ESCOs to join the programme, the participative training with village electricity of committees and training of village technicians which can take from one to two years. In comparison Sunlabob provides quick installation through their franchises, not relying on the long service chain and reaction time between technicians, service providers and the MIH.

Beer Lao Contract Farming

Contract farming of rice through the Beer Lao factory represents the only industrial level non food production of rice in the country and, as such, may provide useful insights into the difficulties and opportunities for biomass energy. While contracting provides benefits of systematizing agricultural production for energy needs it also holds some risk for farmers locked into production cycles. The experience of farmers supplying the Beer Lao factory appears to be positive: price agreements have always been honored, prices are higher than the food market value, and demand has continued to increase. Nevertheless, control over rice farming by actors outside the community could prove problematic if electricity demand fluctuates. Contract arrangements over 'non-food rice' could prove instructive for energy farming in Laos and further research over the risk and benefits of different farmer organization, and the support and protection that government legislation could provide should be further researched.

Table 44 Strengths and risks associated with extension models

Extension model	Strengths	Risk – Biomass	Risk – PV solar
Pilot village	• Encourages 'organic' extension through a working model	• Selection of village does not reflect conditions in different parts of the country • Possible high cost of investment and maintenance not addressed	• High cost of investment and maintenance not addressed
ESCOs	• Decentralises maintenance to village level • Encourages local private investment	• Increased external control over production by ESCOs • Lack of technical capacity for complex system management • High cost of micro grid requires external support	• Financial risk of failed equipment placed on community • long term sustainability not guaranteed • High costs, long period of return
Franchises	• Affordable technologies for households • Decentralised net-	• High costs, long period of return 2) Lack of technical capacity for complex	• Risk of failure on franchises • High costs of service provision

Extension model	Strengths	Risk – Biomass	Risk – PV solar
	worked maintenance 1) Encourages private investment	system management	• High costs, long period of return
Contracting	• Working private sector example through Beer Lao	• Indebtedness of farmers with failed crops • High costs, long period of return • Centralised control over agriculture	3) Not applicable

Improved extension systems could emerge from sharing the experiences of private and public sectors. In determining the most suitable mix of extension models for both PV solar and energy farming the government must ensure that competition continues to develop in the sector while also ensuring that remote rural areas are also serviced. The lessons learnt from PV solar and contract farming provides insights for the development of biomass use, including multiple sectors: energy, agriculture and forestry. As it is unlikely any one RE technology will provide a sustainable source of energy in either off or on-grid areas, it is necessary to develop hybrid systems across micro (village) grids, based on a mosaic of energy supply and also a mosaic of energy extension and support.

4.1.10 Summary and Conclusions

The two renewable technologies reviewed in the APE project – PV solar and Biomass - pose some interesting comparisons with respect to the social acceptance. PV solar is an established technology in Lao PDR with considerable effort having gone into its extension by both state and private sector actors. Nevertheless, problems remain. Despite the potential uses listed by the MIH World bank and Sunlabob it remains unclear as to the specific income generating activities that can be derived from PV solar. If these are not identified, or if extension services do not also offer different activities in parallel to the systems, then the long term viability of RE technologies, beyond a consumptive assets, also remains unclear. At the institutional level the long term viability of PV solar is under threat from public sector investment by the MIH World Bank project. The current subsidies provided through the this project has somewhat distorted competition between private sector competitors which may affect the choices that consumers have in the PV solar market in the future. To remedy this clearer state policy is needed to ensure that further subsidies promote rather than inhibit private sector investment in the sector by maintaining market competition.

The potential of biomass is predicated on either the transition of farmers to non-food crops or the use of forest resources. In a country that continues to struggle with food security and sustainable management of forest resources, the introduction of RE technologies that place further pressure on these production systems needs to be introduced with caution. This is not to say that biomass has no potential in Lao. At present about 62% of energy comes from fuel wood and there is a large potential for timber residues in timber mills and agricultural residues in farming communities. However, in developing the technology investors need to be careful what the implications further pressure on agricultural and forest resources will have for mainly semi-subsistence based producers. To minimise the impact from these energy sources it is necessary to align policy within the energy agriculture and forestry sectors ensuring that development and extension also support the responsible and sustainable use of natural resources by asking what claims exist over agricultural and forest resources and who benefits from greater exploitation of these resources for energy production.

Like PV solar and biomass little research has been done on the social acceptance of these RE technologies. Nevertheless, in combination these RE technologies may prove suitable if tailored to local conditions, meeting the income and livelihood needs of rural and urban populations. Like agricultural and forestry, biomass bamboo and improved woodstove technologies must be supported by policy which promotes suitable extension services and responsible use of these natural resources, ensuring compatibility with current resource access and tenure arrangements and local energy needs. Indeed, in a country with such diverse environments, income levels and market access as Lao, there is no one RE solution. Instead multiple technologies should be built into an energy mosaic of grid, micro grid and stand alone energy services that reflect the variety of income levels and environments. Supporting such a mosaic of energy supply requires integrated extension, service and support networks building on the experiences of existing ESCO, franchise networks and public systems across a range of energy, forestry and agricultural sectors. In this regard, further research should be carried out that in different parts of the country empirical studies should be carried out on what the specific are for successful adoption of RE in Laos. In doing so, policy needs to given greater credence to private sector competition and the development of alternative RE technologies, providing space for discussion and debate (such as through LIRE), ongoing financial support and improved multi-sector collaboration between agriculture, forestry and energy.

5 Solar Energy Specific Data in Thailand

5.1.1 Research and Development, Pilot Projects and Studies

This part of the report is about the development of pilot PV Solar System in Thailand. PV systems in Thailand have been promoted by many Government Organizations since 1990 particularly for off grid areas. The Department of Public Health was one of the first for which PV systems were installed for vaccine refrigeration at public health centres where electricity is not available. Further the Department of Public Works and town & country Planning which PV systems are used for battery charging and water pumping and the Department of Alternative Energy Development and Efficiency (DEDE) who is the majority in promoting PV system in Thailand. For DEDE; the PV systems are applied for battery charging for lighting in households, stand alone for public buildings (e.g. schools in off grid area).

In additional to the above; EGAT and PEA are government enterprises who applied PV Solar systems for both off grid and on grid application.

At present, Thai government has a strategy to increase Renewable Energy (RE) up to 8% within 2011.DEDE and those government organizations are working as committee to support the strategy. By 2011, target amount of wattage of energy produced by PV system shall be totally MW 250.

Promotion

To promote PV solar system dissemination, DEDE is working with other government organizations in three projects, those are:

- PV Solar system in off grid area; the system will be installed at public buildings in off grid area, for instance; primary schools, public learning centers, public health centers, water pumping systems, etc.
- Solar home system (SHS); this project is implemented by Provincial Electricity Authority (PEA). 289.000 sets of 120 Wp-PV solar system are being installed on households in offgrid area. The project will be completed by fiscal year of 2006.
- Incentives for Grid Connected System; DEDE in cooporation with other government organizatioins are working to analyze appropriated figures and methods to support PV Solar system dissemination, for instance; feed-in tarrif, soft loan, taxation, etc.

In additional, Renewable Portfolio Standard (RPS) is another factor to be applied to promote PV Solar and other Renewable Energy(RE). At present, New Electric Power Plants need to use RE (PV Solar system, Biomass, etc.) at least 3-5% of total amount of the plant output.

Barriers

However, there are several barriers encountered PV Solar dissemination, those are;

- High Cost of PV Solar Module - Eventhough Thailand has 4 local manufactures of PV Solar Module, but price of PV solar module is still rather high because most of raw materials need to be imported.

- Limited number of PV Solar experts in Thailand
- There is no PV Solar Data Center

  Data base of PV Solar system in the country are separated and kept inside each government organization and universities.

With reference to a report of research and study on daylight data base in Thailand made by Department of Physics, Silapakorn University in cooperation with and funded by DEDE, Ministry of Energy (MOE) in August 2004; it was found that most parts of the country have the highest global illuminace in April, when a monthly average of hourly values ranging between 80-100 klux.

44.1% of area of the whole country receive the yearly average of hourly illuminance in the range of 75-80 k lux while the regions which receive the highest global illuminance are in the middle part of the Central Region and the lower part of the South. The mountainous areas in the North which represent 1.7% of the area of the country receive a relatively low global illuminance ranging between 50-65 k lux.

The result indicates that Thailand has a relatively high day light potential.

5.1.2 PV Applications in Thailand

At present; there are approximately **39.906,881** kilowatt of electricity produced from Solar Cell. Most of them are installed in remote areas where electricity supply network are not available. The main application of those solar cells is for electricity generation. The applications shall be drawn as the table bellows:

Table 45: PV Solar Applications in Thailand

Item	Application	KW	%
1	Electricity generating sytem	36.271,596	91
2	Battery charging system	1.396,954	3.5
3	Telecommunication system	1.002,522	2.5
4	Co-generation system with elctricity transmission lines from hydro-electricity and wind power-electricity	898,738	2.2
5	Water pumping system	337,071	0.8
Total		**39.906,881**	**100**

Solar Energy is new and renewable energy which is under developing process consistently to be one of alternative energies for energy from fossil. Thai government have been working hard since many years through government's arm in Ministry of Energy which is Department of Alternative Energy Development and Efficiency (DEDE) who has been working in cooperation with other government organizations and private sector for energy conservation and development of renewable energy projects.

At present ; there are barriers of P.V. Solar system in Thailand , for instance; high investment cost (Baht/kw) and high generating cost (Baht/kwh) comparing to conventional energy cost.

Therefore; “incentives program” from the government needs to be introduced to stimulate domestic demand and production of P.V. Solar system, for instance;

- Attractive feed-in tariff/adder
- Taxation (eg: income tax exempt for investor for a certain period, etc.)
- Low interest Loan
- Etc.,

Manufacturers

There are local manufacturers for solar cell and solar system, those are:

- Bangkok Solar Company Limited
- EKARAT Group
- Solartron Public Company Limited
- Thai Agency Engineering Company Limited

Current installations of PV Systems in Thailand

PV Solar systems are disseminated and installed for generating electricity serving various applications as follows:

- Solar Home System
- EGAT’s Projects (Rooftop application)
- Green Building Project (Tesco Lotus)
- Military applications
- Others

The different applications are described briefly below. For every application a data sheet for one typical installation is attached in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

5.1.2.1 Solar Home Systems

First announced in 2003, Thailand is approaching completion of an ambitious program initiated by acting Prime Minister Thaksin Shinawatra for the installation of approximately 200,000 solar home systems (SHS).[5] The Thai Solar Home System program (known in Thai language as the “Krong Gan Fai Fa Euah Athorn” or “Electricity Handout Program”) adds about 22.7 MW of solar electricity to the total installed solar capacity in Thailand, which stood at just 6 MW in 2003. The program brings Thailand’s rural electrification rate[6] to nearly 100%, and provides valuable electricity to Thai villages that do not have access to grid electricity.

While it appears that the installations were quickly -- and in most cases, professionally -- done, considerable questions remain concerning the sustainability of these solar electric

[5] Hirshman, W. P. and D. Ruppik (2006). "Thai-ing up the votes?" Photon International: April. 62-64.

[6] “electrification rate” refers to the percentage of villages electrified, not households electrified.

systems in light of several factors: virtually no local knowledge on solar home system repair, lack of locally available replacement parts, and lack of information on the part of system users concerning the existence of the system's warranty. This study discusses results from a survey of the status of 405 Thai solar home systems in two districts in Tak province. The survey finds that out of the 405 systems, 22.5% were broken within the first year. Most of the equipment failures were faulty inverter/charge-controllers and fluorescent light ballasts. This study discusses the technical nature of these failures, and identifies important linkages among failures of different components.

Another key concern regarding the program is the ability of the project implementers to learn lessons from the field. The program appears to lack important linkages from the grassroots level back to decision-makers so that the existing program can be sustainable and future programs can improve. This paper discusses the administrative arrangements in the program, and describes efforts by one grass roots group to address information/knowledge gaps in the program.

With an initial target to provide electricity to the majority of Thailand's 290,716 off-grid households, the installation of solar home systems was planned in two phases over a period of two years, starting April, 2003 and finishing April, 2005. The first phase initially provided for the installation of 153,000 SHS; this figure has been reduced to 138,996 systems, all of which are now installed, with the balance of systems being shifted to the second phase. The second phase, currently underway, is to install the 15,242 remaining first phase systems and 34,757 additional SHS with a total of just under 50,000 total systems to be installed. This will bring the total SHS from both phases to 188,995, somewhat lower than the goal of over 200,000 systems. The following tables[7] and figures show the geographic distribution of SHS in Thailand:

Table 46: Geographic distribution of SHS in Thailand

Phase 1		
Region	**Total SHS**	**% of Phase**
North	66,210	48.0
North-east	21,815	15.8
Central	17,619	12.8
South	32,352	23.4
Total	137,996	

Phase 2		
Region	**Total SHS**	**% of Phase**
North	24,709	49.4
North-east	20,232	40.5
Central	0	0.0
South	5,058	10.1
Total	49,999	

Total (Both Phases)		
Region	**Total SHS**	**% of Phase**
North	90,919	48.4
Northeast	42,047	22.4
Central	17,619	9.4
South	37,410	19.9
Total	187,995	

[7] Data from the Bangkok office of the PEA

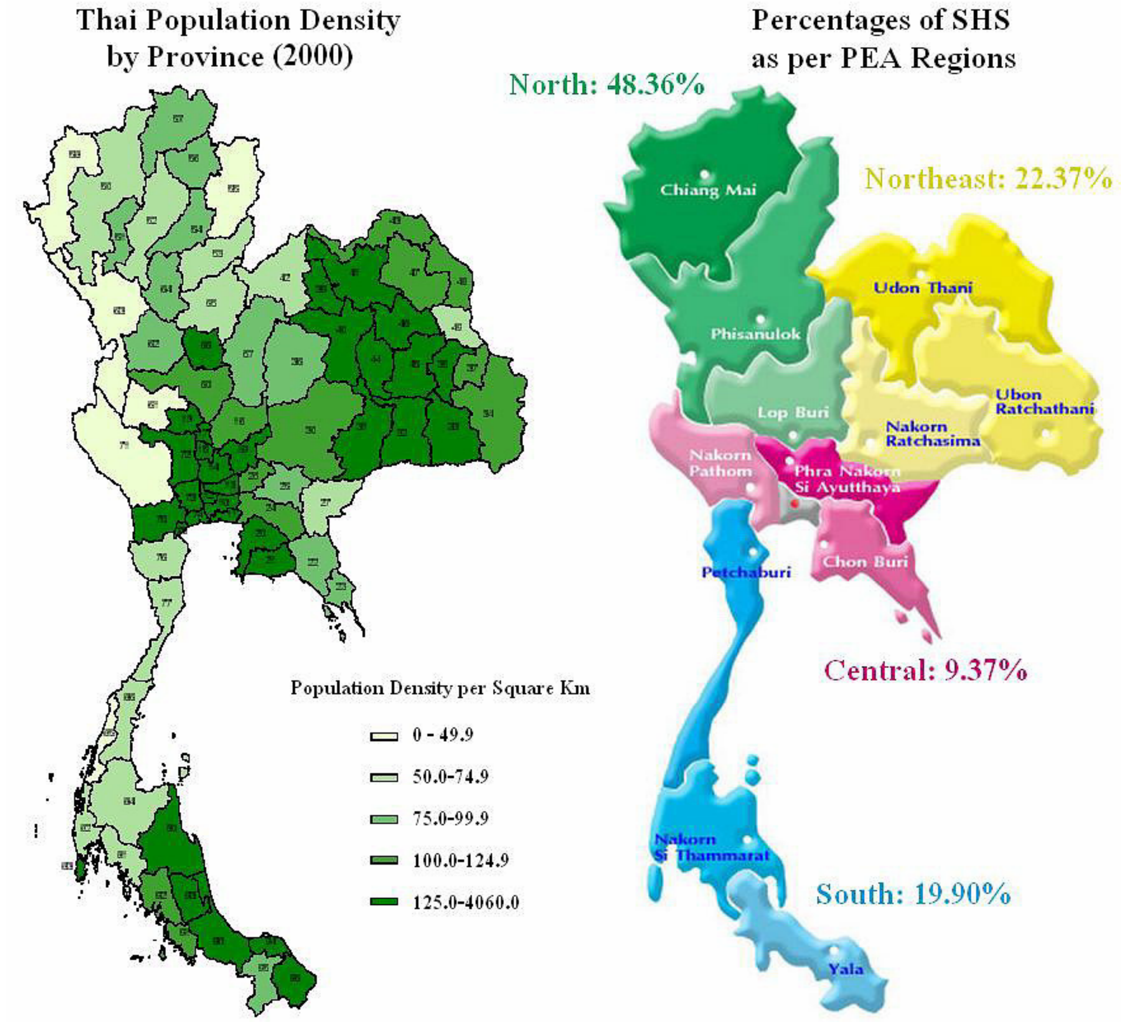


Figure 29: Population Density and SHS Distribution Maps (NSO, 2000; PEA, 2004)

Containing nearly half of all SHS installed, Northern Thailand has by far the most systems and more than twice as many as Northeast Thailand, the region with the next largest number of SHS. Southern Thailand, with just under twenty percent of Thai SHS, follows the North-east in system distribution, and last comes Central Thailand, with under ten percent of all SHS. This distribution makes sense, as Northern Thailand is the most rural and isolated re-gions in Thailand with the lowest average population density (please see Appendix A for attached maps comparing Thai population density and SHS distribution). While Northeast Thailand has many provinces with high population density, it is also a very large region and includes more rural provinces with very low population density. It correspondingly has a large but not dominant percentage of SHS to provide electricity to its isolated households. Similarly, while Southern Thailand has areas of high population density, much of it is very rural and it has almost as many SHS as Northeast Thailand. Central Thailand, however, is both the most densely populated and perhaps more importantly is in close proximity to the technological and political nerve centre of Thailand, Bangkok. Due to this, it contains under ten percent of Thailand's SHS, most of these probably in the sparsely populated western provinces.

5.1.2.2 EGAT Projects

EGAT have completed installed 10 sets PV Solar system (8x 2.25 kW single crystalline and 2x 2.88 kW amorphous) of the First Phase and 50 sets PV Solar system (approx. 3 kW per each set, combination of single crystalline and amorphous types). By 2007, EGAT is considering to start project implementation for installation of 10 MW PV Solar as according to RPS's condition.

5.1.2.3 Tesco Lotus System

However; there is a very good sample of energy conservation and development of P.V. Solar energy projects which are accomplished by cooperation efforts of DEDE and private in-house policy of TESCO Lotus a big Department Store Chain who have developed energy conservation program in Thailand since year 2002 through their branches in the country. They have invested Baht 284 million for the program since then while they can save Baht 336.5 million from decrease of energy consumption during the past 4 years, at the same time they have reduced carbon dioxide emission to the environment for 85,000 tons.

In 2004, TESCO Lotus have finished construction of "Green Store" at RAMA 1 Branch in Bangkok ; it is the most outstanding energy conservation project. It is the first Branch of them which has 60% of roof area covered by P.V. Solar Cells those generate energy (600.000 kWh per year) for 12.5% of energy consumption of the whole operation. The P.V. Solar system saves Baht 1 million a year for them. Beside installation of PV solar system, they can save another Baht 2.6 millions from energy conservations which are obtained from improvement of efficiency in water chiller system as well as minimization of loss in air-conditioning system and heat leakage in to the building.

In 2006, TESCO Lotus have planned to invest Baht 184 million more for 6 energy conservation projects, those include air-conditioning system, cold storage & refrigeration system, lighting system and ventilation system. They expect for Baht 56 million a year for energy saving.

5.1.2.4 Military applications

PV Solar system is considered as new technology product for Military operation in Thailand. However, due to essential required for telecommunication system, there are around 100 x 225 watts PV solar systems in Military bases and Frontier police stations in off grid area.

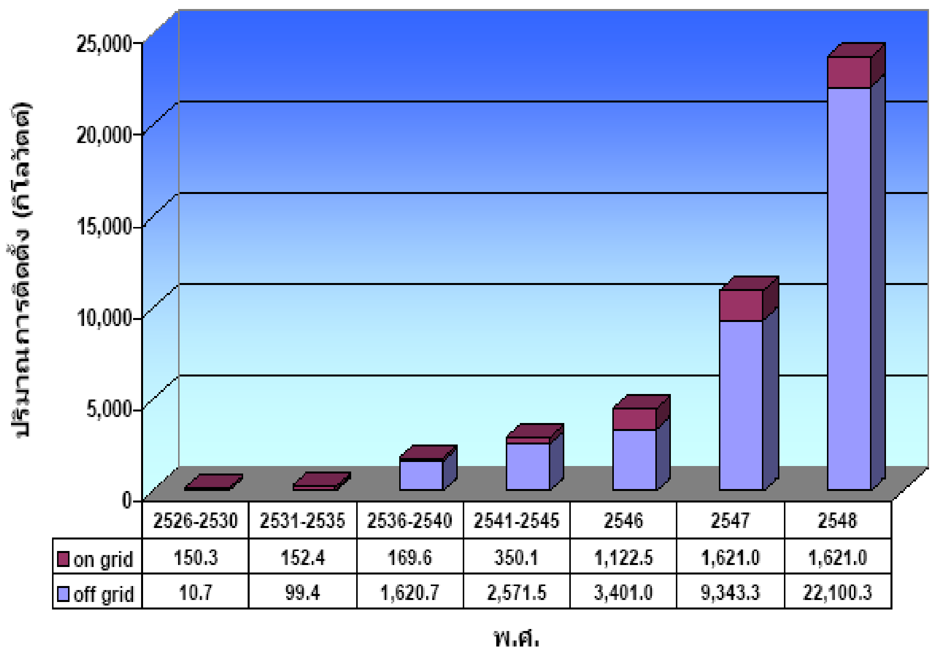
5.1.2.5 Others

Beside applications as above mentioned, PV solar systems have been installed for providing electricity to education centres/ schools, public health offices, national reserved forest government offices, etc. in off grid area.

We can anticipate for further development of P.V. Solar system and other renewable energies in Thailand in the near future at higher speed if the good cooperation between both government and private sectors is still exist and prolonged to work together to minimize the barriers and achieve the mutual goal together.

It shall be noted that most of PV Solar systems are installed in off grid area as per the graph here bellows which shows trend of growth of the PV Solar system in Thailand since the beginning. The record was made by an Office of Solar Energy Development of Department of Alternative Energy Development and Efficiency (DEDE) during 2526 B.E.-2548 B.E.(1983-2005)

สรุปสถานะการติดตั้งเซลล์แสงอาทิตย์ในประเทศไทยตั้งแต่อดีตถึงปี พ.ศ. 2548

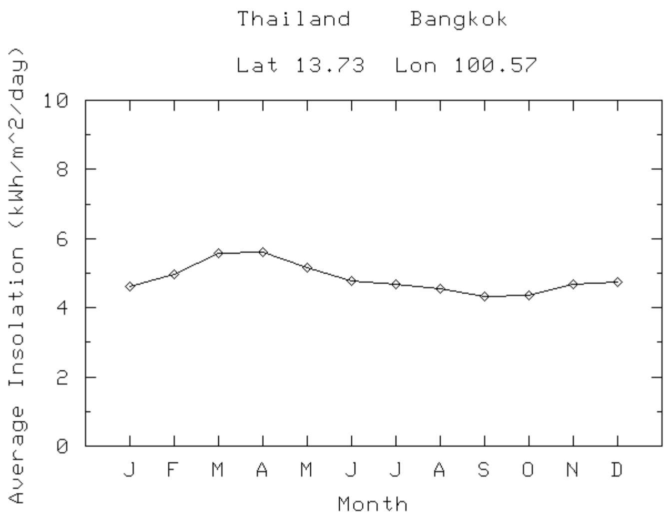


	2526-2530	2531-2535	2536-2540	2541-2545	2546	2547	2548
on grid	150.3	152.4	169.6	350.1	1,122.5	1,621.0	1,621.0
off grid	10.7	99.4	1,620.7	2,571.5	3,401.0	9,343.3	22,100.3

ที่มา : พพ. ยธ. กฟผ. กฟภ. กฟน. สวทช. สอท. กห. ศธ. มจธ. มน. มก. มท.
จัดทำโดย : สำนักพัฒนาพลังงานแสงอาทิตย์ กรมพัฒนาพลังงานทดแทนและอนุรักษ์พลังงาน เมื่อเดือนตุลาคม 2549

5.1.3 Meteorological solar irradiation data

From the World Radiation Data Centre (WRDC) some data sets for the nation of Thailand can be produced. These radiation curves can be found on the following pages:



Thailand Bangkok
Lat 13.73 Lon 100.57

Years Encompassed: 1966 - 1993

Monthly Average Insolation (kWh/m^2/day)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.60	4.96	5.58	5.60	5.16	4.78	4.67	4.54	4.31	4.35	4.66	4.73

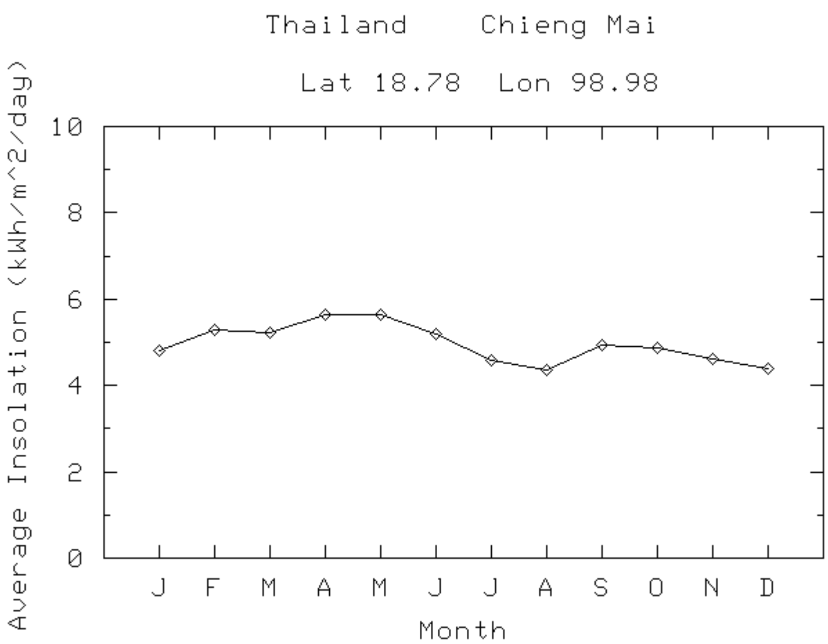
Number of months available for computing monthly average

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
27	27	25	27	26	26	27	27	27	28	28	28

Maximum number of days available in any given month for computing monthly average

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	29	31	30	31	30	31	31	30	31	30	31

The Monthly Average is a climatological monthly average derived from all available data for individual ground site stations.



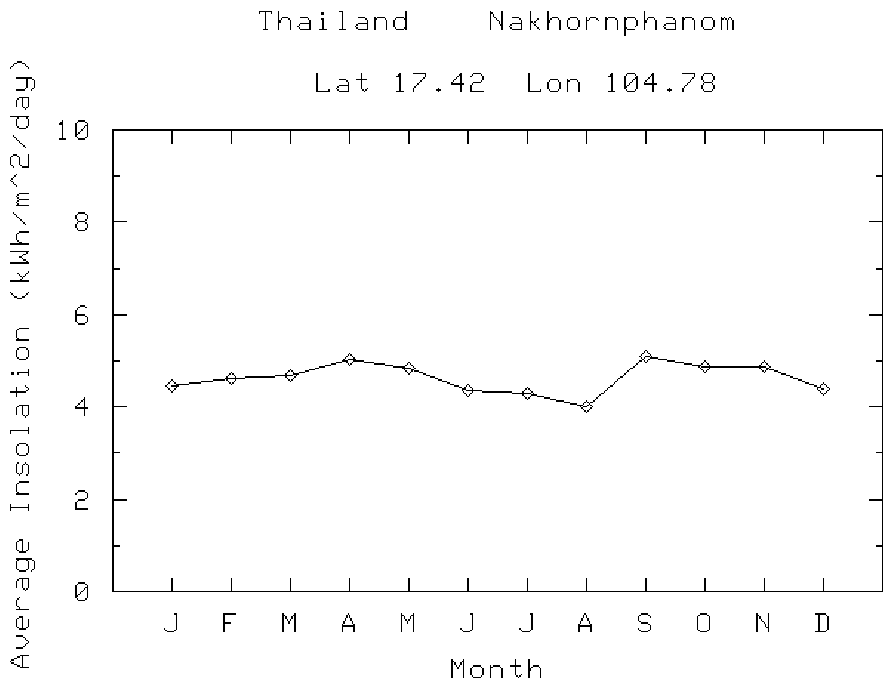
Thailand Chiang Mai
Lat 18.78 Lon 98.98

Years Encompassed: 1966 - 1973

Monthly Average Insolation (kWh/m^2/day)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.80	5.29	5.22	5.64	5.65	5.20	4.56	4.35	4.92	4.87	4.60	4.39

Number of months available for computing monthly average											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7	7	7	7	6	7	6	6	6	6	6	6

Maximum number of days available in any given month for computing monthly average											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
30	27	31	30	31	29	31	31	30	31	30	31



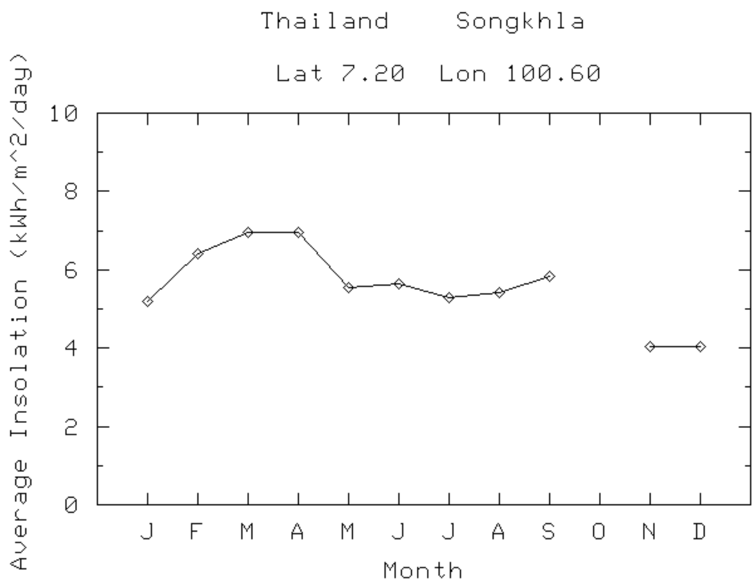
Thailand Nakhornphanom
Lat 17.42 Lon 104.78

Years Encompassed: 1966 - 1970

Monthly Average Insolation (kWh/m^2/day)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4.46	4.61	4.67	5.03	4.83	4.36	4.30	4.02	5.09	4.86	4.86	4.39

Number of months available for computing monthly average											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
4	4	4	4	4	4	3	3	2	2	2	2

Maximum number of days available in any given month for computing monthly average											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
31	28	31	30	31	30	31	31	30	31	30	30



Thailand Songkhla
Lat 7.20 Lon 100.60

Years Encompassed: 1966 - 1967

Monthly Average Insolation (kWh/m^2/day)											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5.18	6.42	6.94	6.94	5.55	5.65	5.30	5.40	5.81	n/a	4.03	4.04

Number of months available for computing monthly average											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2	2	2	2	2	1	1	1	1	0	1	1

Maximum number of days available in any given month for computing monthly average											
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
29	26	30	30	30	27	31	22	13	0	15	29

The Monthly Average is a climatological monthly average derived from all available data for individual ground site stations.

5.1.4 Available Technologies

5.1.4.1 Thai grid connected system description

When using grid-connected systems solar photovoltaic electricity is fed into the grid. As the electricity generated by a PV module is in the form of direct current (d.c.) the electricity needs to be converted to alternating current (a.c.) for which an inverter is required.

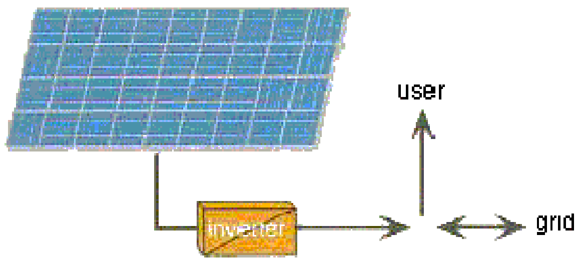


Figure 30: Principle of grid connected PV systems

We distinguish two types of grid-connected PV systems. Small utility interactive PV-systems can be used by private owners for their own consumption. Energy surplus will be fed into the grid, while in times of shortage (e.g. at night) energy will be consumed from the grid. The other option is utility scale, central station PV fields, managed by the utilities in the same way as other electric power plants. All d.c.-output of the PV field, which are generally of megawatt range, is converted to a.c. and then fed into the central utility grid after which it is distributed to the customers.

In a grid-connected power system the grid acts like a battery with an unlimited storage capacity. Therefore the total efficiency of a grid-connected PV system will be better than the efficiency of a stand-alone system: as there is virtually no limit to the storage capacity, the generated electricity can always be stored, whereas in stand-alone applications the batteries of the PV system will be sometimes fully loaded, and therefore the generated electricity needs to be "thrown away".

In Thailand the concpt is based on a grid meteting system where the energy is disposed and taken from the grid. Howerver as explained in the study a feed in tariff is in the planning. Both systems do not have different inverters it is just that the placement of a second meter is necessary with the feed-in tariff system.

5.1.4.2 Thai solar home system description

Compared to many solar home system designs, which have a single solar module of 35 to 75 watts peak, Thailand's solar home systems are large. Each system comprises a 120 watt peak panel[8], a 150 watt inverter/charge controller, a 125-Ah 12-volt battery, and two 10-watt fluorescent lights (Figure 31). This is sufficient to provide electricity for several hours of light-

[8] About 75% of the solar modules are single crystalline silicon, and the remainder are amorphous silicon.

ing (two 10-watt bulbs) and an hour or so of TV and/or VCD video per night. Total energy production from the solar panel is about 350 to 450 watt-hours/day. Maximum continuous power output is limited by the inverter's capacity to about 150 watts.

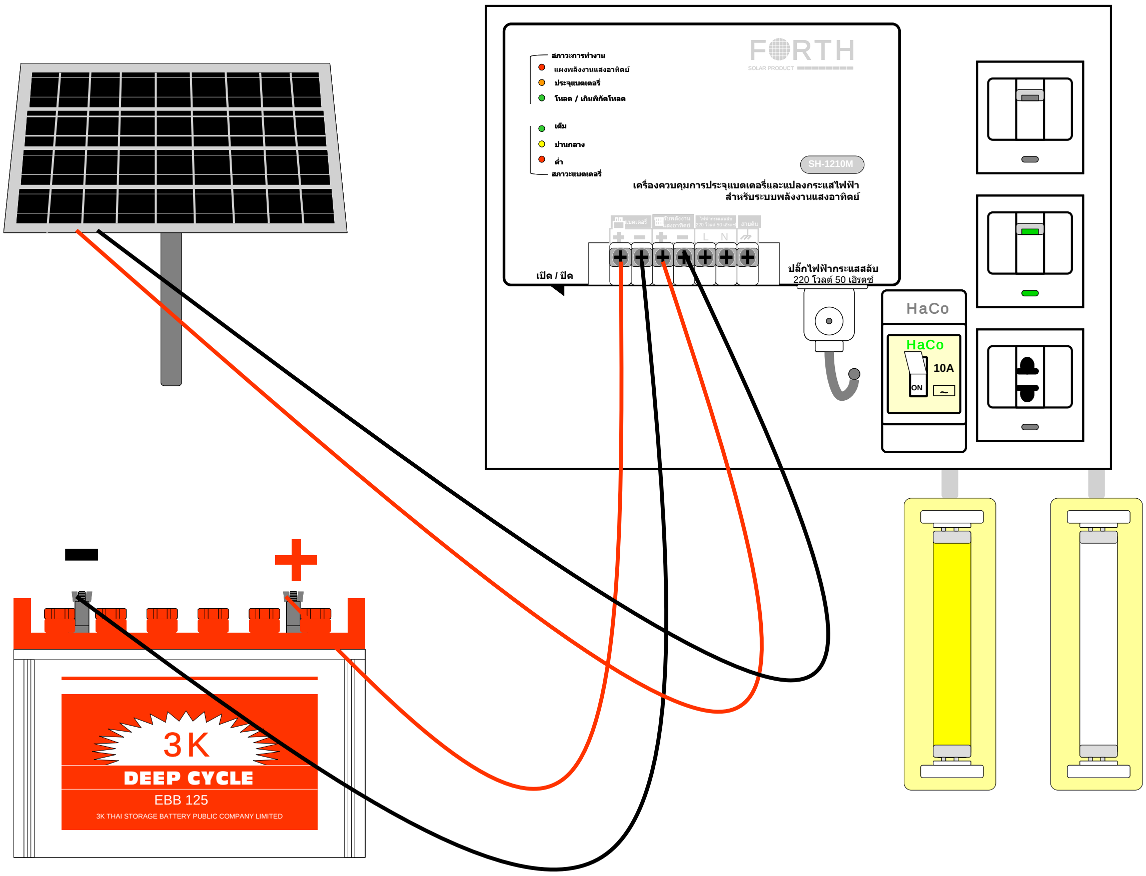


Figure 31: **Solar home systems comprise a 120 watt solar module, a 125-Ah 12-volt battery, and a combination inverter/charge controller. Maximum power output from the system is 150 watts. The system shown is the type installed by Solartron in Tak province.**

5.1.5 Educational Demand for Operators and Applicants of the Technology

Photovoltaic power, although not a direct goal of the UN, drive can be delivering a real contribution towards achieving the Millennium Development Goals (MDGs). In most developing countries neither access to modern energy services in general, nor provision of electricity are recognised as specific goals in themselves. Nevertheless they play a central role in poverty alleviation, through impacts on education, health and local enterprise, as well as access to modern telecommunications and information technology resources. It is especially the generation of chances in education and communication which are the driver behind the special contribution of photovoltaic electricity for rural development and therefore poverty alleviation. As the director general from the United Nations Industrial Development Organisation UNIDO phrased it in the 2006 conference in Montevideo Uruguay on energy security in the Latin American Region:

"You can not erradicate poverty without generating wealth!"

K. Yumkella UNIDO secretary general

The generation of wealth and therefore a potent customer base for project developers however is the key element in the generation of a sustainable power supply program for rural electrification programmes. Although it is wishful that the poor can be supplied with electricity free of charge to enhance their development many failed programmes by donor agencies or governments have proven that long term subsidies for such costly enterprise will not be up kept and hence the chances generated quickly fade. Hence despite it being somewhat contradictory to the old fashioned donor policies and poverty eradication strategies of the national and international donor communities the elements of business, education for income generation and entrepreneurship must be embraced also in the rural development efforts. Especially the provision of modern energy services must be attached with a small but affordable price tag and paired with education and income generation opportunities.

Figure 32: Poverty cycle model simple (left) and advanced with education possibilities (right) (www.tripurafoundation.org)

The simple poverty cycle model from the Tripura foundation shows that education is the key behind breaking the poverty cycle for families and inhabitants of underdeveloped areas. This education is meant to break the low wages or income source element and hence create the chance for income opportunities. The advanced model includes education possibilities. The difference made by income generation opportunities from enhanced education can be seen clearly.

Majority of population in developing countries is rural based and dispersedly inhabited. Generally, rural population lacks of opportunities for income generation due to inadequate market mechanism, underdeveloped rural infrastructure, etc.

From all these points the lack of income opportunities is the most problematic aspect. Energy in all ways is coming at a cost. If no connection between energy generation and income opportunities is to be created the energy supply of such regions will lead to an export of capital and an improved drive for poverty. Energy generation must go hand in hand with joint income opportunity generation. Even Thailand as an emerging country is still faces poverty problems in its remote areas. The problems of those areas are similar to those of poorer countries.

For more than one decade, Thailand has been trying to increase the renewable energy production with programmes like the Small Power Producer (SSP) programme and the Energy Conservation Promotion ENCON fund. But so far only a marginal part of the energy has been produced by renewable resources. The main obstacle of the implementation of renewable energy projects is the missing education. There are no local experts available, who are able to decide on appropriate projects, technologies and to maintain existing plants. Renewable energy plants often have to shut down due to missing maintenance and/or use of inappropriate foreign technologies. Only the human resource development can strengthen the renewable energy sector and increase the implementation and operation of renewable energy plants.

Education is needed in the following fields:

- Public awareness raising on energy efficiency an renewable energies
- Training and raising awareness on EnergyFarming and feed-in possibilities
- Incorporate RE idea in curricula from primary school to universities
- Dissemination of information on EnergyFarming.
- Installation and maintenance provision for the SHS programme

The Thai governments want and need to strengthen their renewable energy sector though face a severe lack of adequately trained human resources required to develop renewable energy concepts, to design, construct, operate and maintain renewable energy plants and to evaluate technologies and concepts offered from abroad. Both countries are in need of local engineers with practical knowledge. These engineers must be competent to develop renewable energy concepts, to understand the technique(s) of the plants. Thus, they can adapt, repair and maintain renewable energy plants. So far, the available higher education programmes in Thailand in environmental science do not focus on renewable energy. Thus, higher education programmes in the RE sector are strongly needed.

6 SWOT Analysis

6.1 PV Solar Systems

6.1.1 PV Based energy Generation Possibilites

An important driver for PV solar extension within the funding models studies in Laos is that PV solar will increase the productive capacity of households and therefor the income generation efforts in off-grid rural areas. By this it is supposed to enable the families them to pay their monthly instalments in addition to contributing to their overall income security. However it must be said that this connection in most cases is a fragile one and the direct connections between modern energy services and incomen generation remain questionable since a lot of the services aquired by the villagers tend to lean towards the entertainment side. Examples are Radio, TV, Karaoke Station and DVD players which are powered by the systems.

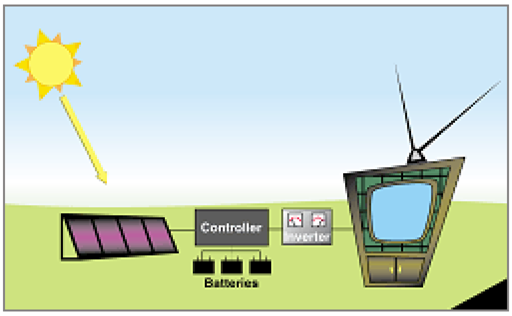


Figure 33: Sketch of solar home system (www.eere.energy.gov)

In detail the project has found the following situation in Laos. Two major projects are promoting PV solar in Laos. The Ministry of Industry and Handicraft – World Bank (MIH-WB) project promotes solar energy as a means of providing productive opportunities to households investing in a solar home system. Here basic energy services are provided and these are supposed to enhance productivity through traditional income opportunities. Such activities include weaving traditional *sinh* or silk weavings, charging batteries for head lamps used in night time fishing activities, basket weavings for tourists and extended hours for rice milling (Harvey 2004). While all these examples are taken from responses from households that have already adopted home systems further analysis is necessary to see how widespread this adoption is beyond individuals, and somewhat anecdotal evidence.

Sunlabob the second private competitor in the Lao PV industry argues that rural communities can utilise PV solar for productive purposes if they choose activities that “leverage the advantages of rural production” and don’t compete directly with grid powered activities (Sunlabob 2003). By leverage they mean the increased in income above what would normally earn from existing rural activities if electricity was not available. Like the World Bank Sunlabob suggests that lighting in the evening allows for more time during daylight hours for existing activities. Extending the day with lighting therefore increases the potential earning of the household through more efficient use of time. Sunlabob also argues that direct income is also through the local village economy by powering karaoke, TV, and small refrigeration or on the open market economy through handicrafts, solar pumps for growing vegetables, lighting tourist lodges, food processing, with the higher cost of energy being off-set by the lower cost of labour.

Figure 34: Solar home systems in a Lao village (www.iea-pvps.org)

Although not investigated systematically evidence from the APE project – PV solar and Biomass suggests that different systems both are not capable of directly providing adequate income generation effects. The connection between modern energy services and income generation seems to a point fabricated if these energy services are on low voltage basis and hence are prohibiting access to modern professional tool and applicances which would be able to offer productiveness on an on-grid level.

It is this on grid parity of electrical quality which would allow access to modern communication possibilities auch as Internet and Computers as well as small tools and operations which would in return be able to generate the adequate income opportunities needed to a change in the village financing structures. The solar home systems currently employed are not capable of providing this on a systematic basis. This default has nothing to do whith bad implementation or faulty products which add a different threat to villagers in financing structures where these products are under their ownership. Renting models are less affected since the installer of these systems is bearing the risks and it can be better mitigated on his side.

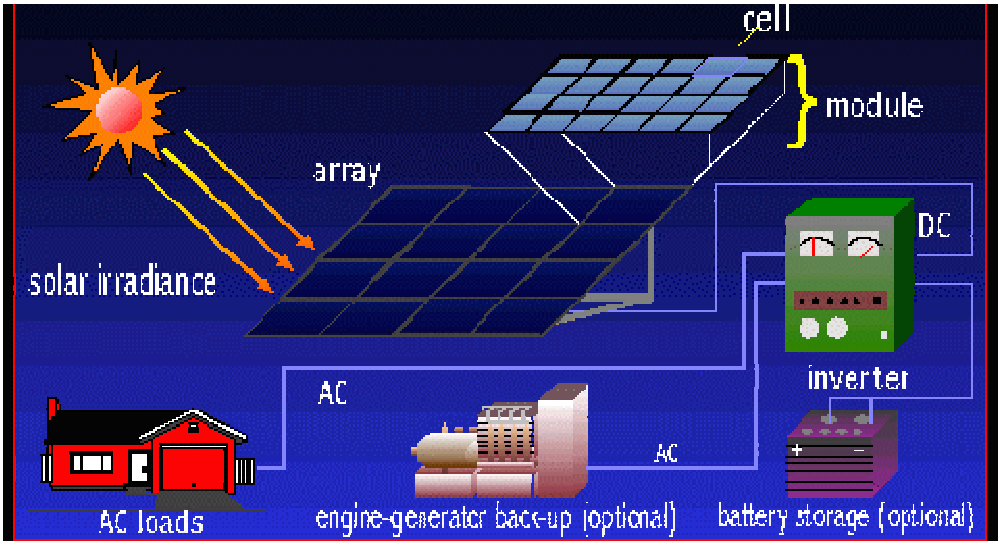


Figure 35: Sketch of a PV based hybrid system (www.nsenergy.org)

Most of the appliances used in both systems are for entertainment purposes – including television, household lighting and radio. While these may increase the consumption of those households there is less reason to think that income generation, pay for both the monthly instalments and increase overall income security will necessarily follow. Notably, the problem is more of a limitation of the technology itself rather than its poor application by either MIH-WB or Sunlabob. Both organisations have information on the income and expenses of their target population and have set their tariffs to meet the largely poor, rural consumer base.

If there is no direct return on investment to households in off-grid rural areas a slow draining of the low financial capacities occurrs. Then collective financing arrangements rather than individual may be more appropriate. Sunlabob has extensive experience with specialised PV solar systems for powering remote area vaccine fridges and powering bore water pumps, financed either by development projects, or collectively by communities. The more productive applications of PV systems an hybrid grids on a collective basis may in fact be a more effective means of promoting PV Solar as a productive form of RE rather than at the household level, where the investment capacity and therefore size of PV solar installations are limited.

6.1.2 SWOT Analysis

For the SWOT analysis a detailed study of the local demonstration and commercial PV energy projects was undertaken. During this study the strong points and weaknesses was compiled and summarized.

Findings

- Solar Energy is a big technical driver in rural electrification
- Education of Installers key to successful plants
- Technical standards vital for consumer protection
- Donor programmes must be carefully selected to fit the market initiatives

- Stakeholder participation and benefit essential in project success

The results of the group discussions conducted in the stakeholder workshop is a big feed-back for the SWOT analysis.

Key Points:

- Participants of the dialogue agree that solar energy is needed in Laos as an alternative energy source. However, solar energy potential in off-grid areas is not fully realized by politics and markets.
- The education level experienced in the market is not adequate.
- The technical level for installation of equipment has not met the expectations of consumers.
- There are general policies and legislatures for the overall energy governance. However, a more detailed legislature is still needed, especially on RE.

Key problems and challenges:

- Import of technical equipment and knowledge
- There is no sufficient knowledge on solar energy as the level of understanding on this topic is still limited.
- People are curious about basic information of how to afford the high cost, how to maintain the equipment, and how the system works in general.
- Previously, there has been no promotion or wide acceptance of solar energy.
- Stakeholders, such as villagers and farmers, cannot fully participate due to their lack of access to information and resources based on limited funding sources.
- Import tax for solar energy equipment is very expensive.
- Insufficient legal framework.
- No clear, precise policy
- No RE law
- No incentives for the RE sector,
- Limited engagement of local entrepreneurs.
- PV equipment is imported 100 %.

Proposed Solutions:

- Awareness
    - Raise awareness by the implementation of information and promotion campaigns using especially newsletter, radio, TV and books.
    - Raise capacity for technical staff to obtain necessary skills and knowledge on the technology of solar energy, and how to produce and use the equipment.
    - Raise awareness of local entrepreneurs and create the legal environment for them to make the PV business more attractive.
    - Educate students starting from primary school level on RE; begin with introduction through environmental factors and weaving the topic into physics, chemistry, biology, etc.

- Policy
  - Clear policy on cost reduction for the PV sector is needed. Possible ways could be tax exemptions, e.g. reduced or even no import taxes for PV equipment and/or tax incentives. It is important that a law regulates precisely when and who gets which exemptions and/or incentives, like 40 % tax reduction if….
  - Tax incentives could be bounded on Module quality.
  - Clear investment policy which gives the private sector the needed ground for investment.
- General
  - Technical development in the country, e.g. production of spare parts or storage devices in Laos.
  - Include all stakeholders.
  - Establishment of a co-ordinating agency for stakeholder involvement.
  - Create provisions for communities to earn income to pay for the RE equipment.

Resources Need to Achieve Solutions:

- There is high demand for funding, expertise, equipment, knowledge and relevant information on RE.
- Mechanisms and policies for governance
- Investors and Funds
- Technical support
- Transparent and inclusive law on RE.
- Clear and sacred law of guarantee and protection for the investors and users of RE.

Responsibilities:

- • The government should be responsible for educating the people because private sectors cannot afford mass media and to create country-wide awareness. OR
- • Both public and private sectors can be responsible for educating the people. The government can promote awareness while private sectors can promote and build capacity.

Many problems discussed are similar to developed countries. The human factors in politics, private sector, NGO, etc., are very important. Despite this, there are real chances for Lao P.D.R. and other nations in South East Asia to use renewable energies. Most importantly, Lao P.D.R can pull ahead from because the country has lots of sunshine, biomass, and the people; if there are correct management and if good solutions are found on the ground level.

All this talk is not about energy, but about money. This means that problems of income generation must be solved to have rural RE. Thus far, development concepts and experiences from many NGOs have demonstrated which try to demonstrate that income generation issue is not a direct link to project development. But our meeting shows those strong connections and electricity generation are linked. However a big shadow of doubt remains. The meeting has shown that the dependence is only there if proper value generation efforts can be provided. This means in return that quality energy services are necessary which go beyond the pure provision of lighting for reading and prolonged weaving activities.

A good idea can get very far in Laos. Many people have mobile phones because people want to have them. If we can find a good link between income generation and electrification, then there will be a success. It is important that people are clear of the chances, technology and education so they are ready for further development of RE. Government and mass media, NGOs, NPOs, must work together. This means for us, there are many chances where our goals and objectives are put into place.

Rural development is not giving gifts to people, but giving them economic opportunity. Management of electrification programs should and could be changed. Electrification should be more flexible. People and villages who want it must have access to it. They should be more favorable because of their geography.

All sectors should work together to provide electricity and effectively manage funding.

6.1.3 SWOT Matrix

Summary of the Findings if the SWOT analysis for the PV Solar Systems:

Table 47: PV Solar SWOT Matrix

Strength	Weakness
• PV Solar is universally applicable • No special requirements for the location • Electricity available at remote locations • Reliable technology, no moving parts	• Price of investment for solar systems • Warranty issues can often not be resolved locally • Coupling with battery system can lead frequent breakdowns
Opportunity	**Threats**
• Easy to install systems • Little knowledge of operators necessary • Basis for access to modern information technology	• Electricity price in the nation too low • No direct coupling between energy and income generation • Lack of investment support can lead to an underperformance of such a programme

6.2 PV Solar

The SWOT Analysis for PV Solar in Thailand shows the following aspects:

With reference to the result of project meeting during July 25-26, 2006 participated by concerned parties in solar energy development area from government organizations, manufacturers and private companies, SWOT analysis shall be listed as follows:

S	**Strength:** • High Daylight potential • Local Solar Cell Panel Manufacturers • Local Institute working on R&D for producing solar cell • Clean energy
W	**Weakness:**

	• Political Support • No clear implementation plan from government • Very few experts and scientists in field of PV Solar energy are available • Users have very limited knowledge to operate and maintain the system
O	**Opportunities:** • High oil price • Environmental concerned
T	**Threats:** • High investment cost • Economic situation of Thailand

The followings are Strategies for future work in promoting PV Solar are suggested;

- SUPPORTS from concerned organizations are essentially required. Those are:
    - Policy Maker: Ministry of Energy
    - Producers: Manufacturer
    - Investors
    - Energy Buyer: PEA

At present, the government has policy to promote development of Renewable Energy focusing in area of bio-gas and bio-mass. Promotion plan from government for development of PV Solar energy is still unidentified. There are few prospects for PV Solar market in the foreseen future.

There is under discussion by an authorized committee for introduction of Feed-in tariff to be applied for buying electricity produced by solar energy around Baht 8 plus Baht 2,50. However, there is no certainty that this tariff shall be approved and applied in the near future.

Local manufacturers need to explore more export market for survival.

It might be advisable for concerned authorities to study from successful development of Renewable Energy in Europe like Germany where the government set reasonable price level that main electricity generating companies have to buy electricity produced by renewable energy producers. The price is high enough to generate good profit for producer and firmed for about 20 years which make the investment project bankable.

Government support shall be the main factor to promote PV Solar energy in Thailand.

- SUPPORTS for Research and Development
    - Research for applications and development of owned technology are needed for appropriated effectiveness and obtaining lower cost of PV Solar system. At present, local manufacturers are working on R&D by cooperating with government organization, university, local companies and foreigners. However, it requires a lot of money input to carry on R&D which creates much difficulty for manufacturers and partners particularly in tough market situation, they still need more funding to support. The situation of R&D project shall be improved if the government extends financial support.

- Strong features
    - Relatively big PV module – 120 watts (compared to SHS in other countries)
    - PV modules & battery work well
    - Systems are generally installed well
    - Provide useful services, appreciated
- Weak features / challenges
    - Failure-prone inverter/controller, ballast Insufficient local capacity for O&M, repair
    - Insufficient user knowledge about system limitations, basic care, warranty
    - Villages often very remote – hard to get to (especially in rainy season)
    - Language barriers in remote areas (few speak/read/write Thai)
- Opportunities
    - Installed solar panels represent huge investment (25,000 baht x 200,000)
    - Relatively small additional investment to make good use
- Threats
    - Widespread SHS failures unless coordinated effort to address sustainability

6.3 Biomass

Biomass comes in a number of different forms among them energy crops, harvest residues or organic waste. And also its conversion goes via different chains depending on the source of biomass as well as on the output that is aimed at. The figure below shows the several conversion chains of the different biomass energy materials.

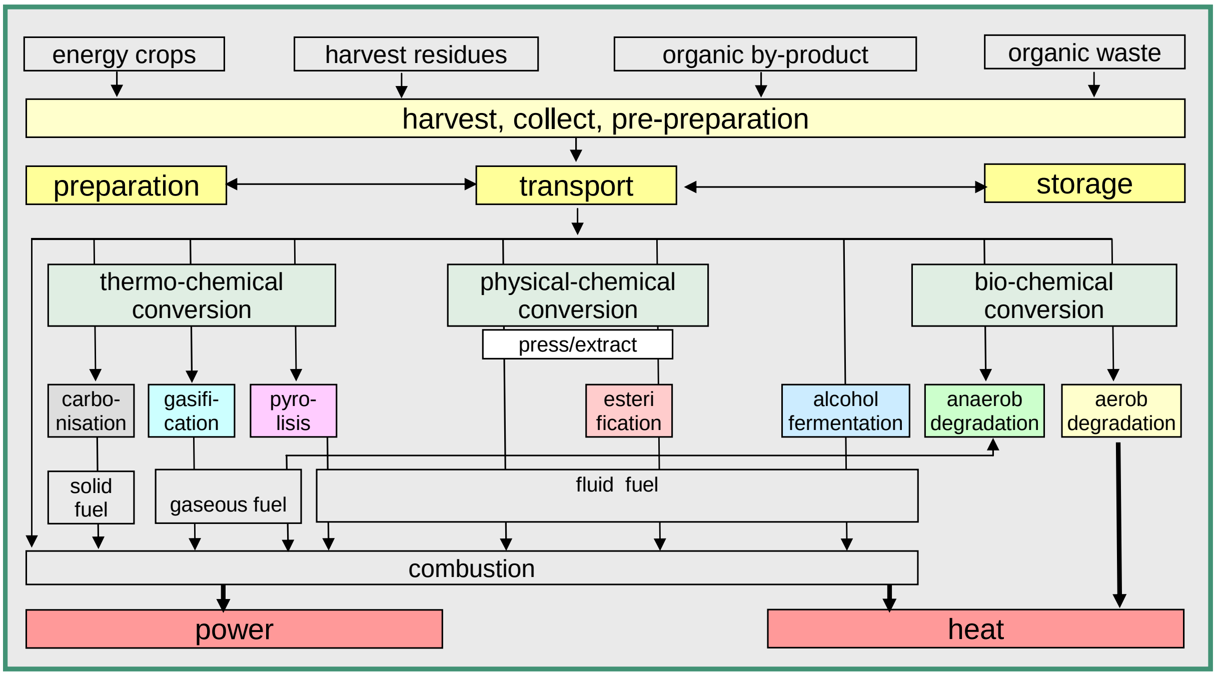


Figure 36: Conversion chains of the different biomass energy materials

The study focuses on the anaerob degradation as this is the conversion chain which is the easiest to implement. Therefore there is a SWOT-analysis for biomass to energy and as a sub-component there is a SWOT-analysis for biogas application in Laos.

6.3.1 Biomass to Energy

Strength	**Weakness**
• Good availability of biomass and arable land due to for example climate conditions and agrarian-oriented structure • At the moment there is a trade off between food and energy supply, however when using the biomass more effectively this trade off can be offset	• Though biomass is available at a good quantity, the soil in Laos lacks humus • Until now Biomass to Energy has not been a topic of awareness in Laos which results in a lot of information work when implementing biomass to energy systems and technologies • Though there are already a few systems in Laos, there is no reliable data and information on the local energy crops
Opportunity	**Threats**
• EnergyFarming is a new and effective way for Laotian farmers to create an additional source of income • The Laotian farmers already know about the advantages organic fertilizer as for example that it is much more cost-effective • EnergyFarming provides an opportunity of a crop rotation potential of over 12 month	• There is a strong renewable energy alternative in form of wood and hydropower • The Laotian farmers lack of interest in the production of non-food crops, however this is mainly due to the lack of awareness as stated in the weaknesses • Until now the Laotian government has no clear policy regarding renewable energies

6.3.2 Biogas Application in Laos

Strength	**Weakness**
• There are already existing applications for biogas in Laos • SNV already did a survey on the biogas market and its opportunities and is just developing a biogas market based on the results	• Though there are feasible applications existent, they had to be shut down because of being oversized • Plant owners were not trained and therefore had not the necessary knowledge about essential areas like the biology • There is no support system existent • In the minds of the Laotians biogas is still only associated with manure • There is a lack of information on the opportunities renewable energies and especially energy crops can bring
Opportunity	**Threats**
• When taking the service provision of solar applications as a model there can be learned a lot for the implementation of biogas applications • The guidelines compiled by the SNV should be institutionalized • There are special micro credit programmes which promote renewable energies • The failed projects give a great opportunity to learn and avoid failures	• As wood as source of energy is available quite well throughout Laos, consumers do not think about alternatives like biogas • Though micro credit programs are offered, there is a negative image as farmers often do not pay back their micro credits • The existing saving committee funds do not provide loans for renewable energy applications • In addition high interest rates prevail in Laos

6.4 Legislation

<table>
<tr><th>Strength</th><th>Weakness</th></tr>
<tr><td>

Article 4, Agriculture Law is specifically targeting the promotion of agricultural products to domestic and foreign markets. It allows provision for alternative agricultural crops including energy crops for use in biomass digestion.
Article 1, Agriculture Law states that the government also wishes to create favorable conditions for building and expanding agro-industrial processing that will contribute to national economic growth while ensuring the protection of the environment.

</td><td>

Existing regulations lack implementation.
Lao institution involved in agriculture, have no idea about the EnergyFarming concept. They only know that biogas can be produced from manure.
Policy on human resource development need amendments on RE considering awareness raising of the public and including of RE in school curricula
Lack of RE master plan. The Off-grid master plan does not meet all RE requirements.
Lack of financial mechanisms like credits and funds for RE implementation put also for research and development projects.

</td></tr>
<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>

Micro hydro power is expensive if you look at the kWh price. PV and biomass may offer better benefits than micro hydropower.
30-40% of households in the central and south provinces use car batteries systems for electrification. These expensive systems harm the environment due to improper disposal after the one one-year usage period.
Power sector reform stands just on its beginning, thus new approaches still can be included in the overall strategy.

</td><td>

The agricultural law defines five land categories including agricultural (suitable for plantation of crops and raising livestock) and industrial (factories, water filtering industrial waste sites as well as land used for energy resources and electricity transmission lines). Allocation of land is done by different ministries. Thus, special permissions will be required for biogas plants.
Food security remains a central objective of government policy. Land use conversion including the changes to food crops must not jeopardise food production
Electricity enterprise with production capacity above 2 MW face difficult licensing approval (2 to 50 MW approval by the government, above 50 MW licensing application be filed with the government, who shall submit it to the National Assembly for approval)
Maximum duration of license shall not exceed 30 years (plus 10 yeas extension). Afterwards all rights shall be transferred to the government without compensation.
The government off-grid electrification programmes focus on grid extension only 100.000 households shall be off-grid electrifies in a long-term.
Interest rates for rural programmes are to high

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7 Strategies for the implementation of Solar and Biomass Energy

Rural electrification marks one of the remarkable achievements in the socio-economic development of Lao PDR with the connection rate increasing from approximately 120.000 households in 1995 to about 420.000 households by the end of 2005, as stated before. However, as electrification moves to increasingly remote areas, grid connection becomes less viable. Thus grid extension projects in remote areas do not proceed smoothly. Most un-electrified villages would not be connected to grid for more than 20 years. Rather, it would be more realistic to develop off-grid electrification systems on the base of locally available energy sources, to meet basic electricity needs of the rural people. The off-grid model currently being undertaken by the Ministry of Industry and Handicraft (MIH) is still in its infancy and up until now lacks a firm regulatory and sustainability foundation and technology and planning basis. Thus, it will be a big challenge for MIH to increase rate of off-grid connection from current about 6.3% of electrified households to 20% in 15 years.

The connection of rural development with renewable energies in particular PV solar

The country is endowed with several renewable energy resources, such as hydropower, solar energy, biomass and some potential of wind power. Poor socio-economic conditions mean low power demand in rural areas. Low power demand, associated with dispersed settlement, underdeveloped infrastructure and difficult geographical conditions would make grid extension to some remote rural areas costly and financially not viable.

In this situation, as shown by the experiences of other developing countries, off-grid electrification, using locally available renewable energy resources or improved diesel generator would be an alternative for remote rural areas of Laos. The main reason behind this is the extensive and unappropriate costs induced by an extension of the national grid to remote areas. Secondly the resource draining import of fossil fuels to the rural region is wasteful and unsustainable for the financially strained rural population. This is the reason why small diesel generator-set is used in some remote areas, but usage hours are limited because of rising fuel costs and supply shortage. Hence, leading to a bad economic performance of this power generations efforts. Large-scale combustive renewable & waste electricity is widely competitive with wholesale electricity prices and technology has already been well developed in industrialized country. But at present, this technology may be still sophisticated for least developed country, as Laos. Furthermore such large technologies bear the problem of distribution in remote areas. Thus, by not near future, probably only Solar PV and small-scale hydropower (Micro-Pico rang) would be the most suitable options for electricity supply in rural areas of Laos. In some high land locals, small wind power generator may also be the option.

7.1 Suitable Technologies

7.1.1 PV

TYPES OF PV SYSTEMS suitable for Lao PDR:

1.) OFF-GRID PV Systems

Completely independent of the grid, the system is connected to a battery via a charge controller, which stores the electricity generated and acts as the main power supply. An inverter can be used to provide AC power, enabling the use of normal appliances without mains power. Typical off-grid applications are industrial applications such as repeater stations for mobile phones or rural electrification. Rural electrification means either small solar home systems (SHS) covering basic electricity needs or solar mini grids, which are larger solar electricity systems providing electricity for several households.

2.) GRID CONNECTED PV Systems

This is the most popular type of solar PV system for homes and businesses in the developed world. Connection to the local electricity network allows any excess power produced to be sold to the utility. Electricity is then imported from the network outside daylight hours. An inverter is used to convert the DC power produced by the system to AC power for running normal electrical equipment.

In countries with a premium feed-in tariff, this is considerably higher that the usual tariff paid by the customer to the utility, so usually all electricity produced is fed into the public grid and sold to the utility. This is the situation in countries such as Germany or Spain.

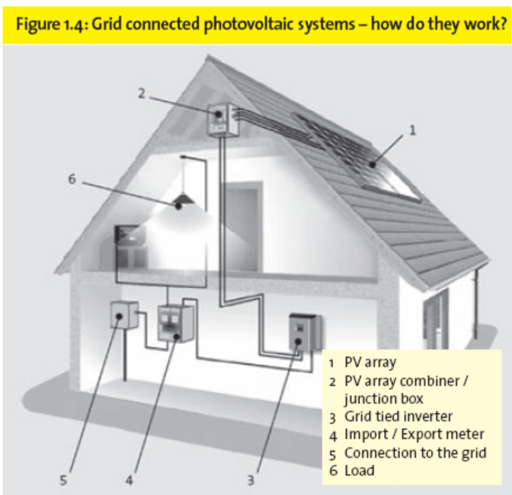


Figure 37: Grid connected PV systems

The electricity (direct current) generated by the solar cells in the PV modules is transported via normal cables to an inverter. This electrical tool, which is often installed somewhere close to the house's connection point to the public grid, transforms the direct current into alternating current in order to make it compatible with the electricity in the house and the public grid. Then there are two options:

1. In countries with an attractive feed-in tariff for solar electricity (see Feed-in tariffs) all electricity generated will be fed after the inverter directly into the grid. The electricity is thereby sold to the utility. The amount of electricity fed into the grid will be measured by a meter in order to get the correct payment from the utility.

2. In countries without an attractive feed in tariff for solar electricity (e.g. a feed-in tariff below the usual consumer prices for electricity) the electricity is in the first place used to cover the electricity demand in the house. By this the electricity bill can be reduced. Only if there is no or not enough demand within the house, the surplus electricity will be fed into the grid.

3.) HYBRID PV SYSTEMS

A solar system can be combined with another source of power - a biomass generator, a wind turbine or diesel generator – to ensure a consistent supply of electricity. A hybrid system can be grid connected, stand alone or grid support.

For the least electrified areas in Laos the option 1 and 3 are the most likely option. Since electrity prices are low in Lao PDR for the forseeable future a grid connection is the unlikely commercial option for operators.

7.1.2 Biomass

The chapter 3.2. shows the biogas applications in Laos. All these technologies are based on manure from husbandry, either for pigs or for cattles. These technologies are suitable for single households and for farms with enough pigs or cattles. The most of the farms in Laos don't breed cattles or pigs. They need another technology solution. They could have plenty of biomass either as agricultural waste or as energy crops. But for these types of feedstock the existing manure biogas plants don't work.

The requirements for a biogas solution are

- Suitable for fibrous biomass as feedstock
- Capacity to run duel fuel gensets for electricity production

The executed technology overview for biogas in Europe shows, that no suitable technology for the Laos conditions is available.

These technologies

- Are too expensive in investment and operation
- Are too big for the demand of villages or small towns
- Need experts for operation and maintenance

A biogas technology, which can use agricultural waste or energy crops has to be developed. This research and development must be based on the European experiences in biogas production from energy crops. The experiences from the pig manure biogas plants in Laos are useless, because these technologies can never utilize the cellulosis, which is part of the biomass. They have no devices to control the heat in the digester. Inlet and outlet aren't suitable for grass and other fibrous material. Fibrous feedstock needs a stirring system to avoid floating layers. These are only a few aspects, which explain, why the local biogas plants are not suitable for energy crops and agricultural waste.

The conclusion is, that no biogas technology can be recommended to use the agricultural waste or energy crops.

7.2 Energy Plants – Cultivation and Harvesting

Energy farming as a strategy for electricity supply is only relevant in remote areas without connection to the national electricity grid. The electricity from the big hydro power plants is so cheap, that the electricity from the energy crops can't compete.

All the tested crops are suitable for energy farming. For the selection of energy crops the biogas test results are less important than the cultivation experience of the farmers in the project region.

The criteria for energy crops in Laos are

- The farmers are familiar with the cultivation
- The harvesting and chopping technology exists already or is affordable for the farmers

Details of the existing and suitable cultivation and harvest technology can be found in the Report "Cultivation and Harvest Technology" which is attached as Appendix 4.

7.3 Calculation of Profitability

7.3.1 PV Solar Calculation of Profitability for South East Asia

PV Solar has to be considered an investment into power generation. The systems provided on the market have the advantage that generally they can be considered reliable and lasting. Experience has shown that PV modules can last as long as 20 years without long term maintainance costs. Furthermore there is one striking advantage of PV Solar over other types of energy generation such as bioenergy or fossil fuels. There is no cost for the fuel, the sun does not issue a bill and the solar energy provided is free. This is why for calculations of the economic profitability of PV solar systems are mainly base on the investment costs that need to be written off.

In the following pages a calculation with the PV investment costs software PV-Profit has been undertaken for three different lifetime scenarios. The first being a 20 year lifespan of the module and system, the second a 15 year lifespan of the module and systems and the third a 10 year life span. The software PV profit enables the user to generate power generation cost out of an investment. The the cases present here an interest rate for the investment of 4% was envisioned. Alternatively the 4% could also be viewed as a degradation. On this basis the software made the connection between investment costs and the conversion rate of the system (kWh/kWpeak) which is depending on the system itseld and the surrounding available radiation potential. In all the cases presented in the study graphs a capital value of 0,00 € was searched over the energy generation costs.

This interative action lead to the following graphs:

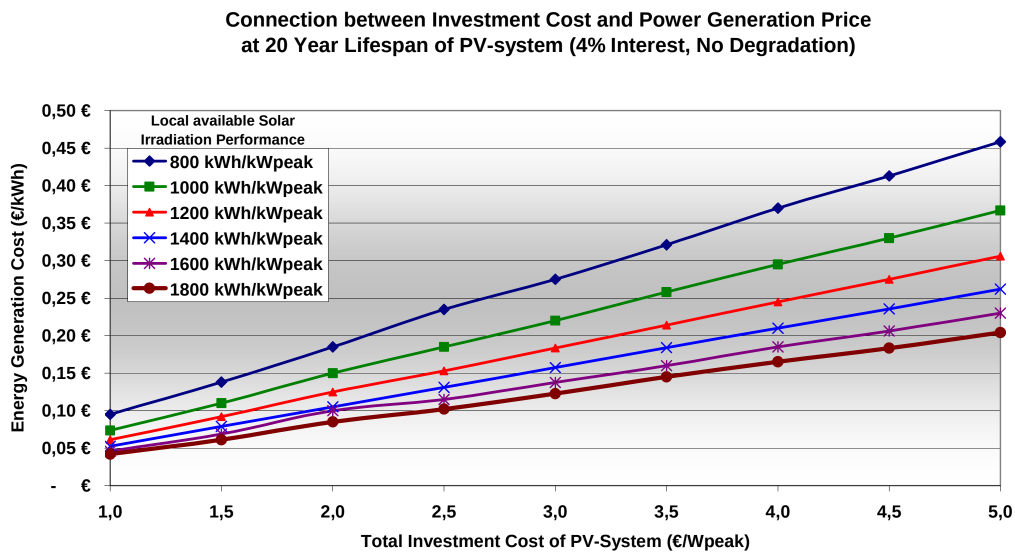


Figure 38: Connection between investment costs and power generation prices at 20 year lifespan

For the conditions in Lao PDR power conversion rates between 1.400 and 1.600 kWh/kWpeak seem realistic. Hence the maroon and puple curves are the ones to be watched for a prediction of the power generation price. Currently the market of PV Systems will average prices per Wpeak of 4 to 5 €. This will lead to a basis of the generation costs between 17 and 23 €ct / kWh at the 20 year lifetime. For the 15 year lifespan the following graph is valid:

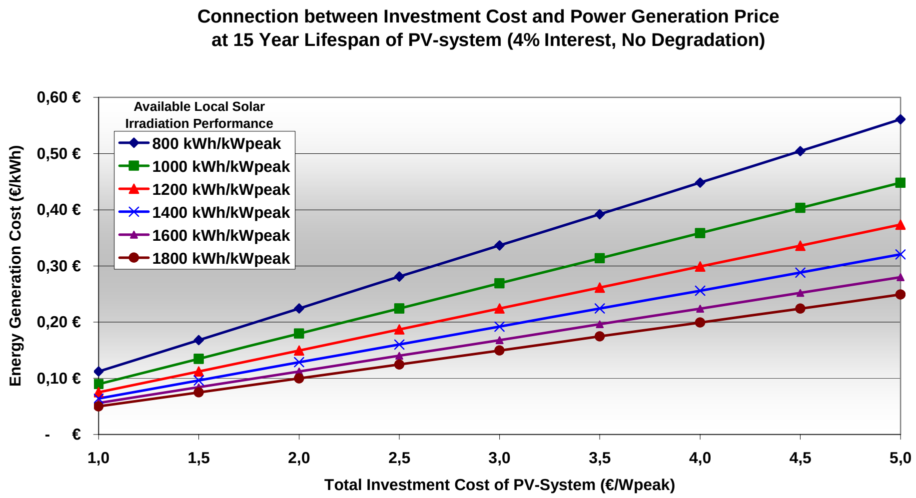


Figure 39: Connection between investment costs and power generation prices at 15 year lifespan

At the 15 year lifetime of the system generation costs of the electricity between 20 and 28 €ct / kWh are resulting. For the 10 year lifespan the following graph is valid:

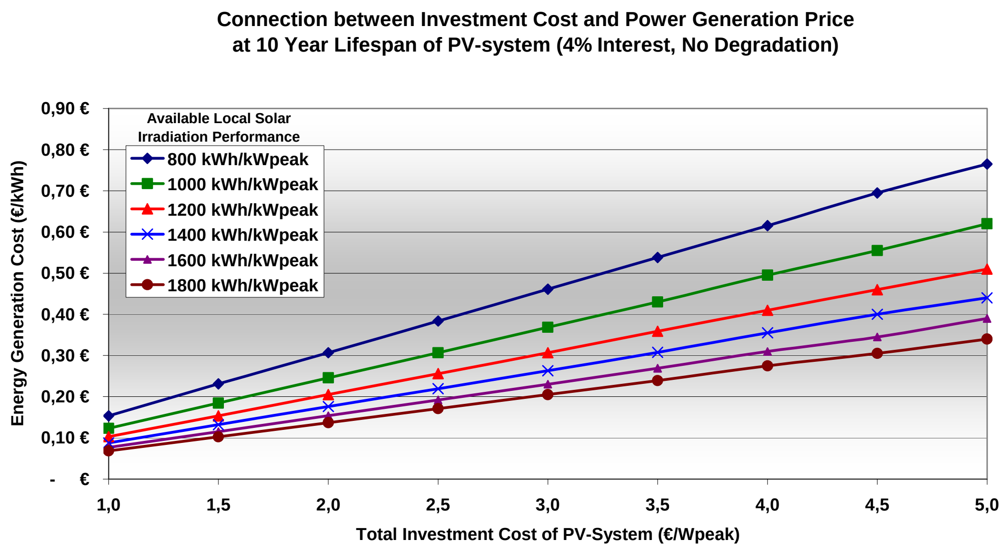


Figure 40: Connection between investment costs and power generation prices at 10 year lifespan

At the 10 year lifetime of the system generation costs of the electricity between 27 and 49€ct / kWh are resulting for the situation in the Lao PDR.

The purpose of these graphs is to generate a feeling of the economics of PV for investors. It also shows the influence of quality where reduced lifetimes lead to and intense increase of the costs. Generally it can be said that at a 20 year lifespan the costs of PV in these high radiation zones are competitive compared to fossil fuel based genset in remote areas with high diesel prices.

7.3.2 Affordability Price for SHS and BCS

From the date calculated with the presened study the affordability prices can be described as followes. The initial payment is almost equal to $ 15-$ 20 US dollars and the monthly payment is about $ 0,75 US dollars (12000 Kip for 55W-SHS and 17000 Kip for 110W-SHS) and the battery charging fee is set at 0,27-0,4 US dollars (2000 Kip -3000 Kip/charge fee) with exchange rate $1US =10 800 Kip as of December 2005.

Table 48: Affordability SHS and BCS Price

Payment	SHS-50W	SHS-110W	BCS
Initial Payment	100 000 Kip	150 000 Kip	-
Monthly payment	7000 Kip	12000 Kip	2000- 3000 Kip/charge

Villagers can pay cost of PV systems and battery charging. However, payment and collection of fee were done without problem and their capacity of payment was confirmed. The question whether easy payment and financial productivtiy are going hand in hand was however not questioned at this point.

World Bank Model

From 1999 to 2004 the Ministry of Handicraft has managed a World Bank soft loan to finance solar home systems using a rent-to-buy model. As part of a wider Asia Alternative Energy Programme (AAEP) the World Bank has for a long time sought to overcome three hurdles to successful implementation of PV Solar in off-grid areas:

1. High capital cost associated with equipment;

2. high transaction costs due to limited supply, sales outlets and technicians

3. market distortions such as duties and tariffs that increase the price for PV solar (Cabraal et al. 1998).

In response an extension model was developed to enroll developing Energy Service Companies (ESCO) that buy, install and maintain systems in close proximity to consumers, create revolving funds that can be used to finance leasing and hire purchase arrangements and help local banks create short-term financing arrangements for home systems (Martinot et al. 2001).

In Lao PDR the World Bank model enables households to purchase systems on credit with a repayment period of between 5-10 years.

A model for such a payback timing can be seen from the Thailand off-grid programme:

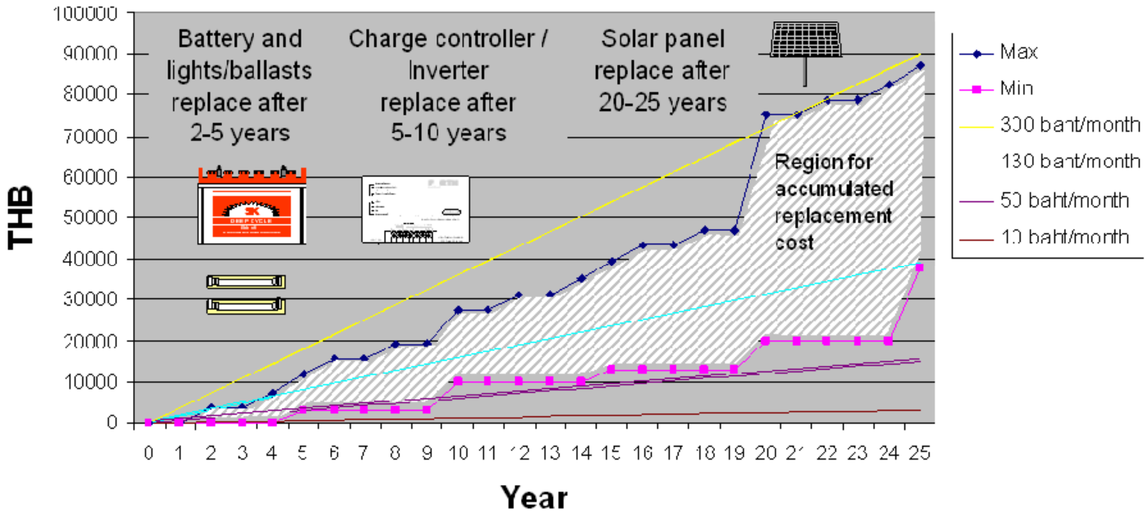


Figure 41: Off-grid SHS Payback time model from Thailand

The graphic shows the ideal operation of such a PV solar home system where all components are functioning to the ideal lifetime of their performance. Indirectly one can infer from the grafic however the danger behind such a financing model. The system will collapse immediately when the equipment invested will seize functioning or an unplanned service occurrs. Especially when PV power systems are to be financed by poor great care in purchasing of components is to be exercised.

The World Bank system notes that solar panels become an important economic asset to poor families, since it retains high re-sale value and it is assumed that the significant private investment made by the household forces them to increase their income at the end of the hire-purchase period - with the added benefit of motivating them to keep the equipment in good working condition (Harvey 2004).

This assumption however places a big responsibility on the manufacturers and suppliers of such equipment. Recent product re-calls of companies such as the Dec. 2006 re-call by BP solar Germany with 140.000 modules show that a much larger emphasis must be placed on the setting and enforcement of industry standards for the core system asset PV module.

Sunlabob System

Sunlabob started a rental service for PV home systems as an alternative to the MIH off-grid electrification programme. In this rental scheme households do not pay any initial installation costs. They are only paying for the electricity they use while the systems remain property of the company. It is the responsibility of Sunlabob to maintain the systems through a network of franchised service providers, much like the MIH system of ESCOs. Renters only pay for the electricity used or the energy service provided. A great advantage over investment, since the risk of operation lies with the providing company Sunlabob and not the poor investors.

A main advantage of the Sunlabob system is that the service providers are well trained and that the incentive of ensuring long term use of the home systems is dominant. For households there is the added bonus of up or downgrading the systems to meet their consumption needs without any further charges on equipment. The exchangability of systems mean for the rural population that they will receive energy services similar to living within an on-grid area where it is up to the user to determin the amount of energy consumed.

Table 49: Cost and potential usage of available solar systems (Source: Sunlabob)

Solar system and unit	Retail price (€)	Examples of appliance use	Hours/day
10 W home system	131	2 x 5W lamps	2
		1 x 5W lamp	4
20 W home system	179	3 x 5W lamps	3
		2 x 5W lamps + radio-tape	2+2
30 W home system	234	3 x 5W lamps	3
		2 x 5W lamps + radio/tape	2+3
40 W home system	300	3x5W lamps + radio/tape	3+2
		35W TV (B/W 14") + 1x5W lamp	2+2
50 W home system	351	Lamps 4x5W + Radio/Tape	3+3
		35W TV (B/W 14")	3
		55W TV (colour 14"DC)	2
75 W home system	448	Lamps 4x4W + radio/Tape	4+4
		35W TV (B/W 14")	4
		55W TV (colour 14"DC)	3
100 W home system	704	4 x 5 W lamps + radio/tape + TV B/W 2	4+4+2
		55W TV (colour 14" DC)	4
150 W home system	986	1 x14" TV (colour 14" DC) + 15W VCD	4
Vaccine refrigerator	2172	Fridge + 4 x 5W	24+3
Water pump system	1474	2400 L/ day; total head 20 m	

Notes: B/W – Black and White

7.3.3 Biomass

A calculation of profitability of energy farming from biogas is not relevant and not possible for Laos. As no technology to use energy crops in biogas plants is available for Laos, no calculation data are available.

And for the actual situation in the villages the price or the production costs of the electricity is not relevant. For many development purposes electricity is necessary at any price. The most expensive electricity is the electricity, which is not available.

7.4 Location Requirements

7.4.1 Special location requirements for PV Solar Systems

The key advantage of PV Systems is the lack of surroundings required for the operation. PV Systems can be installed anywhere where direct solar radiation can be gathered. This means any open spaces. This is a major difference towards fossil fuel systems which need to permanently be supplied with fuels. Even Biomass energy systems need fuel and have a huge impact on the logistics side of the supply. Even wind power plants have a special location requirement, areas where a certain average wind speed is to be found.

PV Solar systems in Laos PDR do not possess any special requirements concerning the location. However it must be clearly stated that a possible site must be fully without shading. The solar panels on the market are very sensitive towards the influence of shading and hence the only requirement of the location is a shade free environment.

7.4.2 Biomass

To help parties interested in biomass projects to decide which kind of technology is suitable for specific applications, a catalogue with location requirements for different sized plants was developed. This catalogue is based on the minimum criteria of feasibility of biogas projects set by the calculation of profitability.

Below the catalogue is shown.

Figure 42: Catalogue for planning and financing of a biogas plant

1 Applicant	
	Nominating of the applicant (with proof of the legal form respectively certificate of registration)
2 Site	
	Local subdistrict, where the biogas plant is to be built
	If necessary street address
	Postcode and location
	owner
3 Preliminary work	
	How often is the plant, which you want to build, constructed and operated in this size and with the substrates you want to use? Please name address.
	Which trainings are finished concerning supervision of a biogas plant? (seminary, visits of biogas plants, trainings, etc.)

	Is there any exposure of smell in the neighbouring area of any other business (independently if it is of another biogas plant or not)?
	How do you guarantee that there is not any annoyance of smell in the neighbourhood of the biogas plant?
	Is the biogas plant built in town or out of town?
	How far is the nearest residential building located?
	Do you intend to give up your stock breeding? If yes, when?
	Which kind of plant do you want to build? (kind of fermenter, brand of the BHKW)
	Add results of the planning (site plan, construction plan, plan of the wires, sequence plan of the plant including the sorage of the substrates, technical concept, etc.).
	Add authorization.
	Plan costs projection – including personal contribution.
	Add plan of building time.
	Naming of the planning office.
	Naming of the executive firm.
	Add offer(s) for the plant.
	If applicable add gratuity decree of a public assistance of the plant.
	Statement of the common carrier about the connection of the plant to the power grid: add the calculation of the net, if applicable connection and injecting contract.
	If usage of heat – please add proof (precontract respectively contract)
	Add written statements of the insurance about the insurability of the biogas plant, if applicable add insurance agreement.
4 Substrates	
	Add and create the substrate plan as follows (see Table 50):
	(1) Add proof (e.g. about own fields, lease agreements, contracts or precontracts about delivery of energy crops)
	(2) If applicable add written results
5 Operating of the plant	
	Who is supposed to operate the plant? (applicant, non-applicant, name, qualification, if applicable relevant work experience)
	Calculated working time for operating the plant.
	If the operator is applicant and farmer at once – declaration of the necessary working time for the previous agriculture.
6 Output of the substrate	
	How do you bring out your liquid manure so far?
	How are the remains of the fermentation supposed to be brought out e.g. own output, manure community?
	Balance of nutrients of the agricultural bureau for the planned biogas plant with the abovementioned substrates
	If there are used alien fields respectively alien grassland for the output of the remains of the fermentation, add contract for the acceptance of the remains of the fermentation
7 Finance – finance plan	
	Costs for planning (if applicable already paid)
	Costs for authorization (if applicable already paid)
	Costs for mains connection (electricity)
	Investment costs constructional facilities
	Investment costs BHKW (including engine)

	- including – investment costs for combustion engine
	Investment costs remaining technology
	If applicable costs for site/ rental / legacy rental
	Costs for local public infrastructure
	Miscellaneous costs
	Amount of own capital (amount and type of own capital)
	Amount of the expected personal contributions (incl. validation of the own working time)
	Financing of the construction and warm-up phase (warm-up phase up to 6 months)
	Balances, income tax decree, income tax statement of the previous agricul-tural business (data of the last 2 years)
	Proof of the previous excluding agricultural income
	Financial statement and array of debts
	(Amount of yearly services for the existing loans plus present account bal-ance of these loans)
	Forecast result calculation for the first 2 years after finishing (assistance see below)
	Only if there is prescribed a renaturation in the authorization decree: costs for renaturation after closing of the plant
8 Calculated income	
	Sale of electricity
	Sale of heat (labour costs, basic costs, costs for connection)
	Income of recycling
	Compensation for arable crops
	Energy crops award
	If applicable marketing of the remains of the fermentation
	Negative costs for usage when cultivating on closedown areas (e.g. savings basic greening)
	…
9 Calculated expenses	
	Specify the time for write-off
	Costs for substrate
	If applicable estimation price increase/decrease of the substrate costs
	Water
	Transport costs for manure delivery
	If applicable oil for igniter
	Own power consumption for the plant
	Labour costs
	Insurance
	Upkeep building
	Upkeep BHKW
	Upkeep remaining technology
	Costs for output for remains of the fermentation
	If applicable costs quality assurance for remains of the fermentation
	Management of the plant
	If applicable costs for accounting
	Costs for electricity meter
	…

10 Advice for key figures		
Key figures	Advice	Customer value
Area for silo for energy crops	10 m²/kW_{el}	
Stirrer technology - investment	Ca. 30 – 50 T€	
Yield/ha energy crops	9.500 m³ biogas/ha (possible up to 13.000 m³	
Proportion fermenter capacity/ BHKW-capacity (volumetric loading 3 kg oTS / d / m³-FM)	100 m³ corresponds ca. 15 kW; converse 150 kW = 1.000 m³	
Storage capacity of the remains of the fermentation	> 6 months over the winter	
Calculated yearly BHKW-operating time	> 7.000; < 8.000 h/a	
Transport for remains of the fermen-tation (not for liquid manure)	1.50 up to 2.50 €/m³	
Own power consumption of the plant	5 %	
Amount of oil for diesel engine	>= 10 %	
Write-off building	20 years	
Write-off combustion engine	5 years	
Write-off remaining technology	12 years	
Upkeep building	1 % of the building investment	
Upkeep BHKW	1 – 2 CENT per produced kWh_{el}	
Upkeep remaining technology	5 % of the technology-remaining-investment	
Average dwell	30- 40 days	
Yield/ha for arable crops	http://www.stmlf-design2.bayern.de/lba/db/	
Liquid manure	50 litre / d / GV	
Density of the substrate Only in the fermenter because of the stirring – source Uni Hohenheim	1.00 t/m³	
Max. TS-amount for pumping ability (only of to pump)	12 – 15 %	
Max. volumetric loading (depending on the fermenter system)	< ca. 4 (kg oTS) / (d * m³)	
BHKW-efficiency, electrical, Gas-Otto *)	=0,0309*LN (efficiency in kW) +0,1687	
BHKW-efficiency, electrical, ignition jet engine	=0,0351*LN (efficiency in kW) +0,186	
Costs maize or grass silage	http://www.lfl.bayern.de/ilb/pflanze/05722/	

*) Source: Interpolation und Extrapolation C.A.R.M.E.N. e.V. according to Mitterleitner, H. Electricity-Heat-Machines. Page 31-36. Bayerisches Landwirtschaftliches Wochenblatt 15/ 14.4.2001

Table 50: Substrate plan

Type	TS in weight %	oTS in wei-ght - %	Particular bio-gas yield in m^3_N/t oTS	CH_4 in Vol.-%	How did you find out the values?: - literature - laboratory - existent plant	Source of supply e.g. - cattle - own cultiva-tion - purchase - etc.	Expected fre-quency in the current year (e.g.:constantly , fortnightly intervals, once a year, …)
e.g. liquid manure							
e.g. maize silage							
e.g content of the fat seperator							
etc.							

TS: dry matter, oTS: organic dry matter, weight-%: weight per cent in t/t, CH_4: amount of methane of the biogas, Vol.-%: volume per cent in m^3_N/m^3_N, m^3_N: standard cubic meter at an air pressure: 1,013 bar air pressure and 0° C, dry

(Possible contents of subtrate delivery contracts can be downloaded for free: http://www.carmen-ev.de)

7.5 Urban Energy Supply

7.5.1 PV Concepts for Urban Areas

City Residential Homes

Recent years have seen rapid growth in the number of installations of PV on to buildings that are connected to the electricity grid. This area of demand has been stimulated in part by government subsidy programmes (especially Japan and Germany) and by green pricing policies of utilities or electricity service providers (e.g. in Switzerland and the USA). The central driving force though comes from the desire of individuals or companies to obtain their electricity from a clean, non-polluting, renewable source for which they are prepared to pay a small premium.

In these grid-connected systems, a PV System supplies electricity to the building and any day-time excess may be exported to the grid. Batteries are not required because the grid supplies any extra demand. However, if you want to be independent of the grid supply you will need battery storage to provide power outside daylight hours.

Solar PV modules can be retrofitted on to a pitched roof above the existing roof-tiles, or the tiles replaced by specially designed PV roof-tiles or roof-tiling systems. If you are planning to put a PV system on to a building and have it connected to the grid supply there are likely to be local regulations that need to be met, and permission required from your utility or electricity service provider. The level of credit for any exported electricity will vary depending on local schemes in place.

Solar based Central Power Stations

Central Power applications use solar energy in the same configuration that a Utility would utilize a major power station. This is distinctly different from the other applications on this page, which are known as "distributed power" or power distributed in small aggregate amounts of power, usually close to the point of use of the electricity.

Central solar power generation plants have been installed in Italy, US and Spain, for example. However, all these plants are "pilot" in nature. Central solar plants may be attractive under certain conditions, but they do not capitalize on the competitive strengths of solar PV in terms of its flexibility of location (i.e. being located close to the customer) and its ability to be installed incrementally.

Commercial buildings

On an office building, atria can be covered with glass/glass PV modules, which can be semi-transparent to provide shaded light. On a factory, large roof areas have been the best location for solar modules. If they are flat, then arrays can be mounted using techniques that do not breach the weatherproof roof membrane. Also, skylights can be covered partially with PV.

The vertical walls of office buildings provide several opportunities for PV incorporation. The first is as a "curtain wall system" that constitutes the weather barrier of the building. The second, as a "rainscreen overcladding system" where there is an underlying weather barrier that provides the insulation and sealing of the building.

The third option is to create sunshades or balconies incorporating a PV System. Sunshades may have the PV System mounted externally to the building or have PV cells specially mounted between glass sheets comprising the window.

Urban Solar Potential for the Lao PDR

As stated in Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.** there are two types of building operators which might supply a potentially interesting source for urban solar power. The first category are commercial roofs and the second category is private house-holds among these only 6 % of the roof of the surveyed from companies are flat roofs. Thus the total roof surface of the surveyed companies accounts to 2.395 m² flat and 39.380 m² not flat roofs. Assuming the same situation for the total 1785 companies in Vientiane Capital the total surface of flat roofs would account to 54.951 m² and of not flat roofs of 903.492 m². This would make a PV solar potential in the capital of the Lao PDR of roughly 90 MWpeak since the non-flat roofs of large companies are typically angled with 15° and of small and medium companies at 10°.

Single households in Vientiane capital comprise of 86.9% of total households (NSC, 2005). Non-flat (tilted) roofing is dominant in private housing, with tilt angle of about 30-45° and areas of 140% comparing to flat cross area. About 67,30% of Vientiane's population lives in the urban areas, of which ~11% lives in multifamily housing. Multifamily housing includes students' dormitories, state employees' dormitories, commercial buildings, etc. From our survey trips we found that typical multifamily housing is commercial 3 or 4-storeyed buildings dominant in central part of Vientiane capital. Usually a one collective household occupies whole 3-4 floors. So, the roof can be counted as for one single house. Roof of multifamily housing is tilted by angle of 15°, or equal to 104% of the flat living area (70 m2/ household). Normally, wealthy merchants are living in these buildings. One family occupies up to 3-4 room, of which up – to 3 rooms are with air conditioners. The total not flat roof area with roof pitch of 15 to 45° accounts to about 11 km². Over all it can be stated that a PV Solar poten-tial for these buldings of 400-500 MWpeak could be derived if all the roofs could be hosting solar power plants.

Overall if a decent solar feed-in strategy is to be implemented in the Lao PDR it can be esti-mated that a generation of PV modules on 20% of the potential solar roofing area would be considered a perfect success. In that case a solar power capacity of 100 MW peak could result. Such an installation in the area would be yielding a 160 MWh in solar electricity a year. Considering the low energy prices in the Lao PDR this currently is not viable due to the low energy prices such a concept has to compete with. However if PV solar will be able to generate much lower prices and a dual use structure (roofing and energy production) would become available such a scenario could edge much closer to reality. Within the Lao PDR however there is not much that can be done to improve the situation, the lowering of cost must come from developments from other markets.

7.5.2 Biomass Concepts for Urban Areas

EnergyFarming today is not the right solution for the Lao electrification, as stated before. Anyway in a long term it could be especially interesting for urban areas, as those areas in laos have avery peri-urban, rural structure. More than 90% of the area of Vientiane Capital e.g. is not construced land as acricultural land, wood area and free land, see Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**. Thus in long term EnergyFarming for urban areas could be one suitable source for urban energy supply in urban areas. The needed frame conditions for EnergyFarming in urban areas and the nessecary legal basis, which especially have to allow electricity feed-in, the selling of the EDL electricity to real prices and the accessibility of the metioned not constructed areas of the the cities.

7.6 Energy Supply in Lao off-grid Areas

7.6.1 PV off-grid Concepts

7.6.1.1 Comparisom of the Main applies Systems MIH-WB and Sunlabob

If one wants to undertake a comparism of best practises on rural electrification in the Lao PDR the two best running prorgammes must be analysed. The Two most interesting systems currently running in Lao PDR are the MIH off-grid program “Rent-to-Buy” and Sunlabob’s “Rental systems”.

Both schemes have applied financial incentive as thier main management mechanism:

- Rent-to-buy scheme: if systems properly work, users pay monthly payment and then VEM can make repayment to ESCO and get operational rebates. ESCO then is able to transfer money to OPS and can receive operational rebates.
- Rental scheme: if systems properly work, users pay monthly rent, VEC/VT are able to transfer tariffs to rental company and then receive margins. Rental company receives money to pay for loan + interests and receives its business income.

Users Incentives

There are different tools used to create users incentive in each of schemes:

- Rent-to-buy scheme applies prospective ownership as user incentive: user is buying equipment by monthly repayment and is motivated to take care of system in order not to lose his investment. In the case of VHGS, the VEM makes a significant private investment and looks forward to increased income at the end of the hire-purchase period, so he is motivated to keep the equipment in good condition.
- Rental scheme applies users’ benefit as incentive: if users properly used and regularly paid tariffs, they would receive best service by rental company. Otherwise the rental company might confiscate evacuate the systems and users would lose their benefits such as using electricity, convenience, income generating opportunities, etc. Traditional customs, people’s pride or psychology may also support this idea, as in Lao rural areas people usually follow each other to act for any thing, and always have high respects to village authority and elderly.

Advantages

- Rent-to-buy scheme:
    - The main advantage of rent-to-buy scheme is an affordable price of delivered systems, compared to rental systems or in-cash purchase.
    - Well-designed financial incentives for planning, delivery, training and operational rebates and prospective ownership are available due to Soft Loan support. Thus reliability may be assured because not to lose income and all parties are motivated to keep equipment in working order.
- Rental systems:

  - Main advantage of rental scheme is its reliable servicing franchises network and high quality equipment installed to ensure reliability. Systems are installed and maintained by hardware company's skilled technicians. In order not to lose income and invested money, ESCO has strong incentive to keep systems in good working conditions,
  - Flexibility: (1) users don't have to do maintenance work and spare part replacement, which are usually too complicated and out of the ability of people with low illiterate level; (2) changing size, up or down grading, up to zero size (return to rental company) without any charges on equipment.

Challenges

Although both schemes are well though out, clear and simple in theory, but may not easy in practical implementation, especially in Lao reality, with still the lack of support mechanisms and lots of uncertainties.

Both schemes by different reasons may have the risk of long-term sustainability and reliability.

Rent To Buy scheme may have the risk of high rate of systems failures due to such reasons:

- High quality installation may not be assured, because VEMs install equipment by themselves under supervision of ESCOs. It is impossible for a villager with low illiterate ability, as a stranger to "high tech" such as solar PV techniques, to obtain necessary skills during several days training. So, VEM cannot do proper installation and maintenance of equipment, especially at the beginning stage of their business. Though SHS are simple in installation and use, but even small carelessness, such as some loose connection or wrong wiring size or length, etc, may lead to system failures.
- Prospective ownership of SHS as user's incentive may not work in rural Laos.
  - *Product quality*: to achieve affordable price, it is usually likely to comprise systems of low quality non-standard components, which have short lifetime.
  - *Installation quality*: performed by unskilled village electricity manager.
  - *Maintenance quality*: How illiterate villagers could properly take care of their equipment if they absolutely have no ideas about it? Even VEM may not able to do proper systems maintenance.
  - *What are users to do with the owned strongly degraded panel*? Probably as "monkey with coconut". Panels with lower value might be sold out with nearly "no price" and therefore destroy price market (from our own experiences: used modules illegal brought in to country from neighboring Thailand and sold with very low price have seriously destroyed market price in central Laos)
  - *Spare parts stocking:* it may not be easy to find good solar components retailer in local areas in Laos. Thus, many users cannot replace fault components, or will probably do it with unreliable spare parts found in the local markets, that will strongly affect system reliability, and shorten the lifetime of systems hardware.

  - *So, the systems equipment might have valueless at the end of long repayment period (5-10 years). Actually, prospective hardware ownership may not be the best ways for Lao users to save money.*
- In case of VH/GS, it is too risky for VEM to buy hardware:
  - VEM makes significant investment risk to buy hardware by his own resource, even by monthly payment;
  - It is not easy in Lao rural areas to find villagers who would be capable to run village systems properly, even though he will be preliminarily trained;
  - Experiences have shown that small-scale rural energy systems are very sensitive to management skills and many rural energy supply schemes launched in Laos failed due to these reasons.
- Lack of incentive to attract private sector participation into this business: ESCOs will receive only start up rebates (for first five villages) and operational rebates, which may not strong enough to attract private investors.
- The lack of the capacity of OPS staff and local ESCOs to cope with such high implementing rate as 6,000-10,000 connections per year or 500-900 connections per month, if without private involvement. As many common practices have shown in Laos that, while running for quantity, usually quality is forgotten and projects often ended with failures.
- Availability of funding source for long run. The establishment of Rural Electrification Fund (REF) is a good idea, but the problems lie in the ability of Lao governance to consistently and transparently cope with funding management.

Table 51: Table of Comparisons between Rent-to-buy and Rental Systems

Description	Rent-to-buy scheme	Rental scheme
Delivery scheme	SHS: User buy the equipment by monthly payments (SHS) VH/GS: User pay for electricity, VEM rents-to-buy the hardware	Users pay for electricity only, equipment remain property of Rental Company
Management scheme	OPS←→local ESCO ←→ VEM ←→Users	RCO (e.g., Sunlabob)←→Local Franchise←→ VEC VEC/VT ←→ Users VEC sub-rents the systems to users and get margin from collected tariff. VT overlooks systems' use and maintenance
Equipment Ownership	When repayment period is complete, equipment ownership will be transferred to user (SHS) and VEM (VH/GS)	Equipment remain the properties of rental company
Management mechanism	- Financial incentive for all parties - User's Prospective ownership incentive	- Financial incentive for all parties - User's benefit incentive
Equipment Installation	By Village Manager ESCO plays support role VEAC: facilitate negotiation and installation VEM has been preliminarily trained on equipment installation	By Hardware Company's + Franchise's technicians (currently Sunlabob plays this role) VEC/VT – facilitate negotiation, contracting and installation VT participates the installation, obtaining basic skills and knowledge
Maintenance	VH/GS by VEM with ESCO support SHS by Users with VEM support	Preliminary level maintenance and troubleshooting: by VT Higher level maintenance and troubleshooting: by Hardware company

Description	Rent-to-buy scheme	Rental scheme
Spare parts Replacement	Spare parts procurement: by users Replacement: By users with VEM support	Spare parts Procurement: by Rental company Replacement: by Hardware company
Contracting period	Two terms: 5-year, 10-year period	Not fixed, but should not shorter than 6 month
Technical Training	By OPS's staff and assigned international consultants Oversea training (in Vietnam)	By Training provider (company) Master Trainers (MT) with support by Faculty of Engineering (NUOL), MT were preliminarily trained by invited International Experts
Business administration Training	By OPS's staff and assigned international consultants	By Business enterprise
User Payment	- Initial down payment, non refundable - Monthly repayment - Buy ancillary equipment and spare parts	– Connection fee, non refundable – Monthly rent – Deposit (keep in a bank, to be refunded with interests)
User advantages	- Affordable repayment rate for majority of poor families - No payment while system is fault - Changing consumption (in case of VH/GS) within limits system capacity - Money saving by becoming prospective owner of hardware (in case of SHS).	– High quality equipment used to ensure reliable operation – Installation and Regular maintenance by skilled technicians – Flexibility: no need to wait for grant or credit support, returnable systems, changing systems size (up or down grading) – No rental payments when technical failures
Challenges	– Ensure fast and reliable up-scaling – Retain quality of service – Assist poverty alleviation – Build successful public-Private Partnership – Develop a self-sustaining program	– Ensure fast and liable technical control and servicing of the widely isolated rented systems – Ensure fast and efficient collection and forwarding of rents – Ensure sufficient long–term capital investments for purchasing the equipment

7.6.1.2 Future of photovoltaic electricity in Laos

While PV solar has the distinct advantage of being widely known and accepted RE technology in rural Lao communities considerable concerns over its long term use as a solution for rural electrification remains. The core reasons behind this doubt is the general approach over solar home systems which in comparism with on-grid efforts only provide marginal energy services. As displayed in the table above mostly lighting and entertainment are featured in the usuable assets generated.

These services however are all of a non-productive nature. This means that the families receiving these services will have to foot out money which will not be earned through theses services. It is striking that the lack of connections between the integration and enhancement of rural energy services and the methods for income generation have not been solved. It is up to entrepreneurial type rural development programmes to bridge this obvious and important gap. Furthermore systems must be employed which deliver power at a level which can easily be utilized also for semi-industrial production methods such as power tools to generate proper income opportunities for the population.

The long-term viability of RE in Laos depends on the ongoing competition within the energy provition sector. The conflict of public and private initiatives must be highlighted and a situation of unfair competition which already exsits must be reduced.

Public-private investment in development has become an increasingly important focus of the World Bank through their Development Marketplace award scheme, which Sunlabob received in 2005 in partnership with World Wide Fund for Nature Lao. Following the success of the first phase of the MIH-WB rural electrification project, the Bank subsequently put out a tender to manage the second phase which was won by the French company Innovation Energie Développement (IED). In this new phase, which runs until 2009, IED must maintain the existing network of ESCOs and the current 6000 installed units, while meeting the target of installing 10000 additional units.

Although running in parallel to private sector, including Sunlabob, IDE will be working with a World Bank funded supply-side subsidy of up to 85% on PV solar equipment. Stakeholders in the RE sector argue that the challenge for both the private and public sector alike is to find financing models that are competition neutral. Instead of reducing costs for one competitor, in this case ESCOs within the MIH system, public funds could go to capacity building and demand-side subsidies so they can afford services they require at commercially viable prices – which would support the Sunlabob model endorsed by the World Bank through their Development Marketplace. If the MIH-WB systems persists with their public-private investment model, giving a clear competitive advantage to their member ESCOs, the goals of rural electrification may be reached, but seemingly at the expense of the long-term viability of the RE sector.

In response to the ongoing need for maintenance a key feature of the system is service provision by a network of electricity service ESCOs who in turn support village trained technicians who collect the monthly re-payments. Households benefit from the rent-to-buy scheme because of the affordable price, with an in-built hardware subsidy of 50%, as compared to outright purchase of the home systems.

Despite the promise of better management and planning by ESCOs, franchises and households alike, both systems face high default rates on repayment and farmers face difficulties in using the PV solar systems to invest in productive assets. The monthly repayments of the MIH-WB system is three times cheaper than the Sunlabob system (€3.20-3.55) - because of the 5-50% subsidy9 - and boasts up to 95% on-time repayment of loans (Harvey 2004).

The higher price of the Sunlabob system has limited its potential with only 10% of the current target off-grid population able to afford the PV system. If compared to battery systems Sunlabob is roughly twice as expensive, limiting adoption of the PV system to wealthier households. On the other hand, the Sunlabob rental system is more flexible allowing for

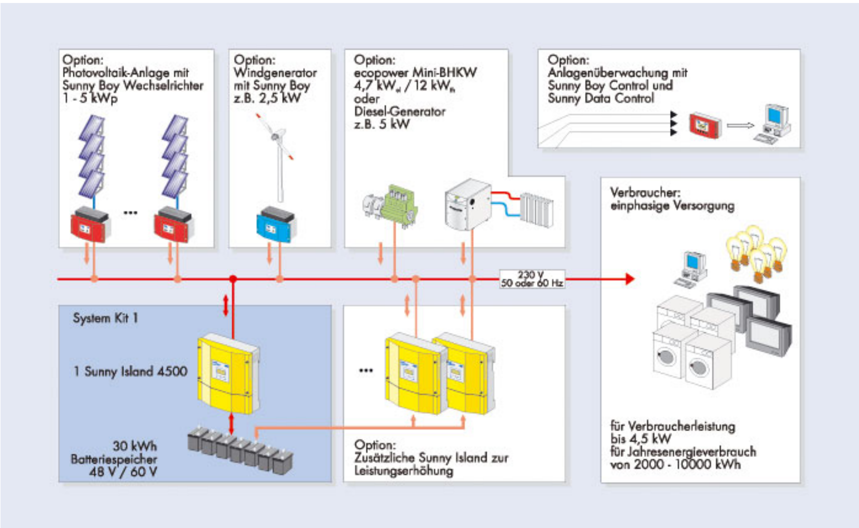
[9] The subsidy is calculated on a sliding scale based on the size of the Solar Home System ranging from 50% for 10 W systems to 5% for 50W systems.

payments to correspond with the seasonal rice harvest. The MIH-WB system is also constrained by the long waiting time for extension, dependent on the willingness of ESCOs to join the programme, the participative training with village electricity of committees and training of village technicians which can take from 1 to 2 years.

In comparison Sunlabob provides quick installation through their franchises, not relying on the long service chain and reaction time between technicians, service providers and the MIH. With failure rates of the PV systems as high as 20% the efficiency of maintenance and service for these systems is an important determinant of the future adoption and the success of off-grid electrification programmes.

While reducing the cost of equipment these subsidies also distort competition in the sector, leaving operators outside the MIH-WB scheme with little incentive and almost impossible market prices. The same applies to a tax reduction for imports applied to the MIH-WB programme which is favorable over the other providers which have to bear full tax on their equipment. These elements of donor driven market distortions must essentially be put into perspective of further developments by international donor actions. If sustainable functioning private initiatives are marginalized by the presence of non-sustainable donor actions these efforts must be questioned publicly and essentially re-directed.

Another aspect next to the above is the overall generation of value adding jobs. Such jobs can only be generated by the creation of high quality electricity grids which in return possess three phases. One of the grid possibilities is the utilization of an island based concept such as the one offered by SMA, Gemany. The Sunny Island inverter is capable of generating a mini-hybrid grid which will allow the users to have a decentral power gereration of full quality.



7.6.2 Biomass Off-grid Concepts

In Laos two main parallel concepts are suitable for the electricity supply in the country. Big hydro power systems can supply affordable electricity to cities, towns and villages near to the main grid. Remote areas can be connected to the national grid, but the huge investment in the power lines and the low consumption of electricity in the villages makes it not viable. The way to charge more for each kWh in the village leads to lower consumption and lower revenues and makes it even less profitable. To charge the regular price means, that the government has to subsidize the price and has to cover the losses of the national utility. Another way is the village solution, a standalone electricity system for one single village – a village grid.

Table 52: Possible supply strategy for Laos

	Parallel Supply Strategy	
Source of the electricity	Hydro power	Decentralized electricity production units in the village
Transmission and distribution	National grid	Village grid
Consumers	Cities, towns, villages near the national grid	Villages in remote areas

Requirements for a village grid

- Robust technology with a long lifetime
- Electricity for productive use to run milling system, grinders, etc.
- 24/7 electricity supply
- Value adding remains in the village
- Local fuel supply

PV solar systems, which are used already in many villages in the shape of low power solar home systems, are limited to lighting and battery charging, nearly no productive use is possible. Minihydro power systems need enough water during the whole year and are quite expensive. So minihydro power is limited to certain areas with sufficient waterflow. A basic strategy has to cover the main areas of Laos.

Biomass is plenty available around the year in the whole country and can be the fuel for energy production. The following scheme is under implementation in Africa and on an Indian island. It can be adopted for Laos conditions.

Table 53: Comparison of the various electricity production units for villages

Requirements	SVO (straight vegetable oil) genset	PV solar	Mini hydro power	Diesel genset
24/7 operation	Yes	Battery storage is necessary	No electricity during dry seasons	Yes
Fuel price	Local production costs	No fuel costs	No fuel costs	High
Value adding remains in the	Yes, locally produced fuel	Yes	Yes	Fuel must be bought from out-

village				side
Investment	Low 800 €/ kW	High 10.000 €/kW	High 2.000-10.000 €/kW	Very low 100 €/kW
Suitable for productive use	Yes	No	Yes	Yes

The comparison shows, that only the SVO genset fulfills the objectives for a selfsustainable village grid. Diesel gensets, the most common application causes drainage of money from the rural area due to the high fuel costs. The price of the SVO doesn't really affect the economy and the development of a village, because the whole money for the fuel remains in the village.

PV solar and mini hydro power systems do not provide continous power. In the dry season no or less water is available for the hydro power system. PV solar need battery storage systems to supply electricity in the night time. The batteries are the weak point in the system. Without proper operation and maintenance they are out of order within one year. The batteries cover 50-60 % of the investment. And the replacement by cheap car batteries is no long-term solution. A basic obstacle is the high price for the installation of PV solar and mini hydro power systems.

Figure 43: Damaged batteries for PV solar after 9 months of operation on Bitra, India

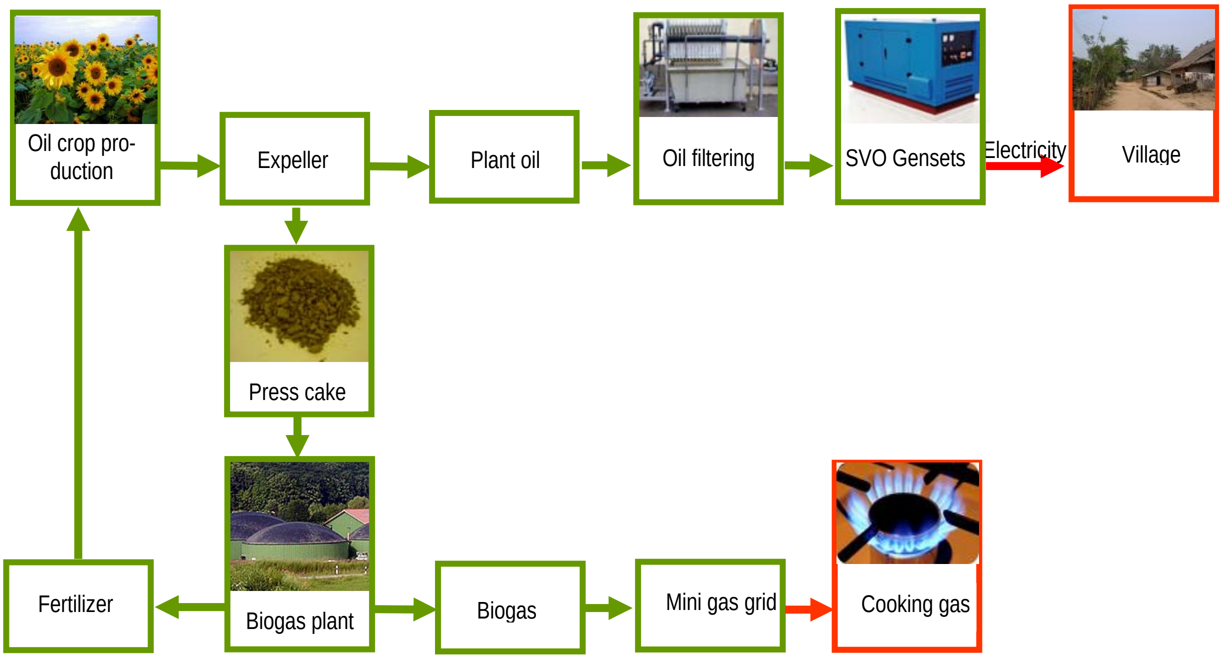


Figure 44: Flowchart of a selfsustainable, standalone energy production system from biomass in a village

Electricity production with a SVO genset

Diesel gensets are widely used in Laos to produce electricity in areas which are not connected to the national grid. This is at the moment the quickest, easiest and for the investment the cheapest way to produce electricity in remote villages. But the operators of such diesel gensets are faced with the rising diesel prices. The electricity price gen-set systems range from 0,04 to 0,11 US$/Watt. The initial payment is fixed with 15 US$. These costs do not include any system costs. This is much higher as the average costs for electricity in Europe. An economic problem is the massive money drainage from the remote areas to the financial centres by the diesel purchase. SVO (straight vegetable oil) is pressed and filtered plant oil from oil palm, sunflower, jatropha and others. This SVO can replace the diesel in the gensets. No esterification to biodiesel is required. With SVO the fuel for the electricity production can be grown around the villages.

Timeframe for the implementation

Within 4 month sunflower oil is available even in remote areas, because it can be grown everywhere. The various sunflower varieties are available all over the world. The farmers have experience with the sunflower plant in cultivation and harvesting.

With a small scale expelling unit the oil as fuel for the genset can be produced locally. After filtering the oil is ready for the consumption in a SVO genset to produce electricity. The press cake is a residue of the pressing and can be used as cattle fodder or for the bigas production in a biogas plant.

Jatropha and other oil plants need several years until they are under full yield. These plants are an essential part of a midterm biofuel supply strategy.

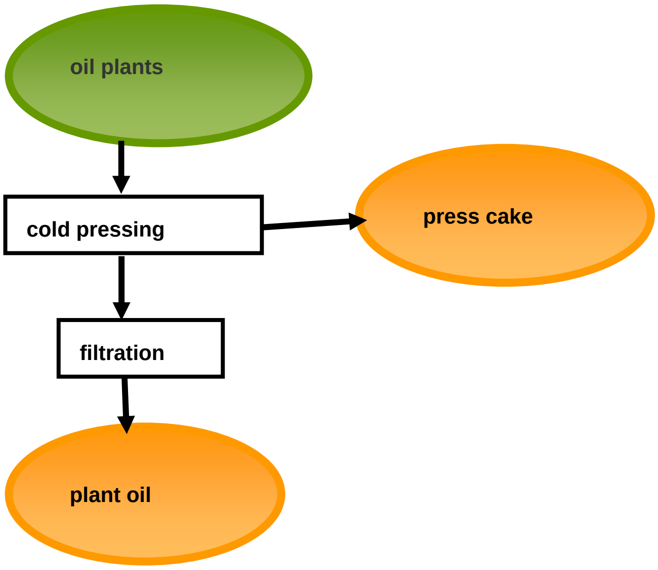


Figure 45: Production scheme for the oil crop expelling

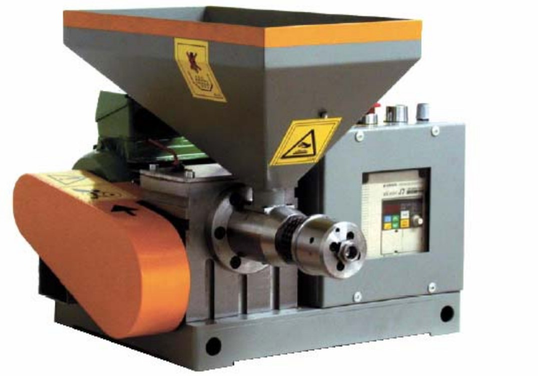


Figure 46: Oilseed expeller for cold pressing in a village size

Figure 47: SVO genset modified for the operation in developing countries in tropical areas

Food security and SVO production

One major issue in the discussions about fuel production by farming is always the food security in competition with the fuel production. In fact it depends on the local situation. In many areas of Laos plenty of arable land is available but not used. It has to be determined for each village how much land is used for oil production.

A common agricultural practice is to grow crops only every 3 years. Two out of three years the land is idle. In these years it is possible to grow oil crops. If leguminose as oil crops are used the advantage is, that the soil will be enriched with nitrogen. Instead of exhausting the soil by only rice growing, the soil can be made more fertile by a good crop rotation.

Table 54: Example for a crop rotation within a village electricity system

Year	**1**	**2**	**3**	**4 as year 1**
Common agricultural practice	Rice	Idle	Idle	Rice
Suggestion for oilcropping	Rice or vegetable	Oil crop as leguminose	Oil crop as leguminose	Rice or vegetable
Result	Food	Energy and soil recovery	Energy and soil recovery	Food

Biogas Plant for Cooking Gas Production from Oil Seed Cake

The total SVO yield of oil crops is around 25-35 % depending on the quality of the expeller technology. 65-75 % of the seed is left as oil presscake. The press cake is a very good energy fodder especially for dairy farms. But due to the demand of biofuel in a village the presscake production is higher than the fodder demand.

The best way to use the presscake is the anaerobic digestion in a biogas plant. This presscake can’t be used in the normal household biogas systems, which run with pig or cattle manure. The energy content of the oily press cake is too high and the biological process is spoiled within one day.

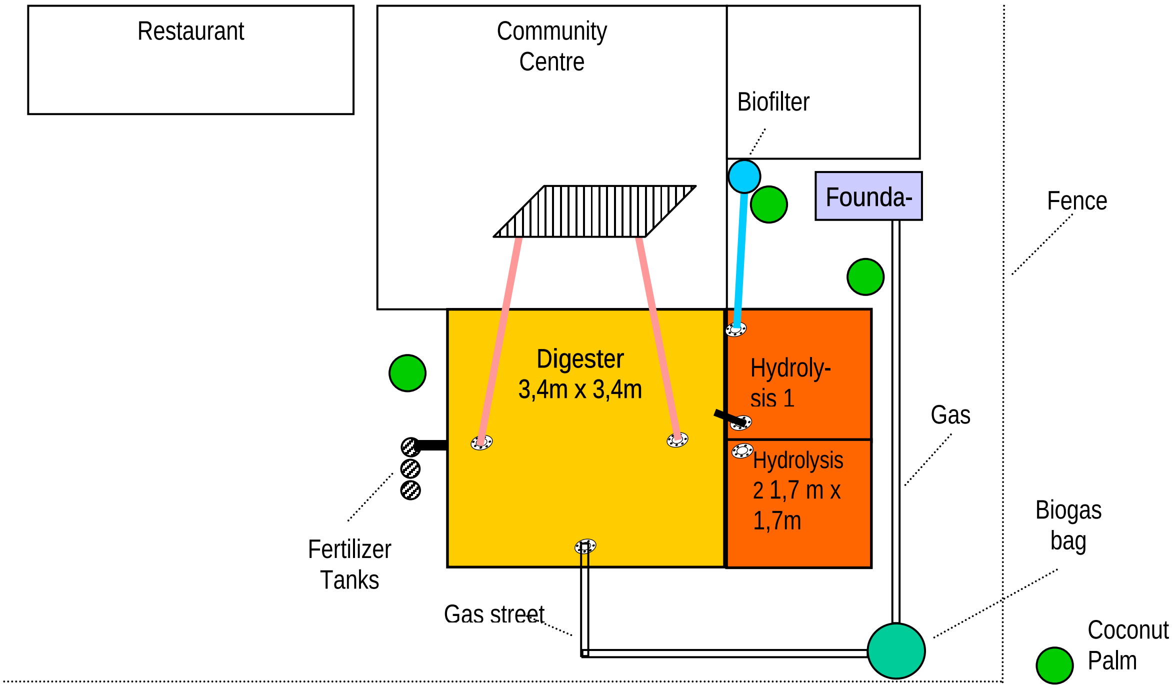


Figure 48: Scheme of a 2-stage biogas plant for the electricity supply for a community centre on Kavaratti island, India

For the utilisation of this high energy presscake or other residues a new type of a 2-stage biogas system is required. In the first step – the hydrolysis – the bacteria produce the fatty acids and in the second step – the methanisation – the methane bacteria produce the biogas. This biogas system is designed for a high performance operation to meet the cooking gas demand of a whole village.

Investment for a complete village electricity production and supply system

Table 55: Investment calculation for a village with 50 households

Oil production equipment	5.000 €
SVO genset 8 kW_{el}	5.000 €
Electricity grid	10.000 €
High performance biogas plant	12.000 €
Mini gasgrid	3.000 €
Engineering	2.000 €
Various	5.000 €
Total	**42.000 €**

The total investment for a village with 50 household for the electricity and cooking gas production is around 42.000 €. To install only PV solar systems to produce 8 kW_{el} an investment of 80.000 US$ is necessary. The installation of a mini hydropower system of 10 kW needs an investment of 40.000 – 60.000 US$ plus the transmission lines to the village. To connect a village in a hilly area to the main grid causes an investment of more than 10.000 US$ per km. The comparison of the investment shows, that a village grid based on biomass to electricity is economically viable.

7.7 Development of Suitable Financing Procedures

7.7.1 Recommendations for the Improvement of rural electrification programmes

High rental tariffs may limit business of Rental Company only within wealthy villagers of rural population. There will be further limitation for ESCO 's business, when transport and service costs for very few customers in scattered locations are take into account.

- If rental company cannot find support with long–term capital investment, it will not be able to offer affordable prices to larger portion of customers.
- To achieve significant service costs difficulties, rental company may hand in maintenance and installation tasks to village technicians; or by installing high quality equipment that requires less maintenance, e.g., maintenance free and long life sealed deep cycle battery (good point) but costly, or by installing lower quality equipment. All these measures are disadvantages for Rental Company.

7.7.1.1 Proposed new delivery scheme: Rent-to-buy by ESCO

Background of the idea

- Rent-to-buy delivery scheme receives good financial support that makes systems price affordable for the poor portion of rural population. But the scheme may face challenges of systems and service reliability, especially when systems will be spread to more and more provinces
- Rental scheme may have reliable franchises network and a tendency of installing high quality equipment. But, monthly rents of this scheme are relatively high, not widely affordable for majority of rural population.
- The dilemma: how to provide reliable and sustainable electricity supply by using costly technologies, but with price affordable to large portion of poor people in rural areas?
- Successful experiences of other countries have shown variety of applied approaches and tools. But, the most important for long-term sustainability and reliability are (1) private sector involvement, (2) consistent and appropriate support mechanism.
- For long-term sustainability and reliability of delivery system in rural electrification, Funding Agency or Organization are motivated to support involvement of private sector into this business. If such supports are available for rental ESCO, it can provide reliable service by affordable tariffs to larger portion of rural users, widens ESCO's market. This is an encouragement for ESCO to be involved into rural electrification business.
- So, the idea is to propose a Rent-to-buy by ESCO scheme, by considering the advantages and disadvantages of Rent-to-buy and Commercial Rental Schemes.

Objectives of the proposed Rent-to-buy by ESCO scheme is

- To provide long-term reliable and sustainable delivery system of Remote Rural Electrification by affordable tariffs to larger portion of rural population in Lao PDR.
- To increase stronger incentives for attracting private sector into off-grid rural electrification business.

- To increase flexibility of delivery scheme

The Core ideas of this scheme:

- ESCO(s) buys core systems' equipment by monthly repayments and then hires systems to users via Village Committee. Here ESCO may have some freedom in price setting within regulating policy of funding agency or programs
- ESCO and Franchise's technicians will do equipment installation (some time with skilled village technicians also) and further maintenance
- VEC facilitates installation and is responsible for management routine of delivered systems, collect tariffs and transfer to ESCO
- Village technician supports VEC with primary maintenance and trouble shooting

Why Rent-to-buy by ESCOs scheme?

With Rent-to-buy by ESCO(s) <u>more delivery reliability</u> will be achieved. The arguments for this are as following:

- <u>Stronger incentives</u> for ESCOs to be involved into off-grid business and to keep delivered systems always in good working conditions, because ESCO receives:
    - Start up subsidies and operational rebates,
    - Prospective ownership that motivates ESCO to use high quality equipment, provide proper installation and maintenance,
    - Some freedom on prices setting that allows ESCO get higher margins but maintain tariffs at affordable level for majority users,
    - Possibility of capital investment with long repayment period or low interests may allow ESCO provide service with affordable price, therefore, widen ESCO market.
- <u>Stakeholders' benefit by reliability and sustainability of delivery scheme</u>. Thus, all stakeholders are motivated to make stronger support of the delivery scheme, and in turn, ESCO business gets stronger and broader support.
    - <u>GoL</u>. Stronger Participation of private sector in to business with rural electrification may fulfill insufficiency in capacity and budget of government offices; rural electrification may speedily and reliably be spread to remote areas of country. Therefore, more assured with mission accomplishment to provide electricity to about 150,000 rural households in 15 years.
    - <u>Funding agency/Programme</u> benefit by long-term reliability and the self-sustainability of delivery systems through stronger involvement of private sector
    - <u>VEC</u> shall receive more convenience because the more reliable systems installed, the stronger support by ESCO and the more margins for village fund.
    - <u>VEM or VT</u> is not at risks, because he shall not have to do large own investment for hardware purchase (in case of VH/GS) or spare parts stocking. Also their skills will significantly be improved by more proper training.

  - Users. Thought they will have to pay slightly more than rent-to-buy rate, but they shall get more convenience, because the shall not have to buy hardware and spare parts; not to do maintenance by them selves.
- Other organizations, such as Rural Development Committee, Lao Women's Union, Youth organization, some International organizations, may get benefits by reliable and sustainable rural electrification in running their rural development projects. When living standard or rural population will be raised, they will have more purchasing power that in turn will be the advantage for ESCO business.

Sustainability.

The scheme's sustainability may be secured due to following factors:

- The scheme is based on all advantages of the best delivery practices in Laos,
- Progressive improvement of ESCOs business by getting more and more support from all concerned parties,
- Strong desire of rural people for reliable electricity to improve their living standard,
- Strong desire of Lao Government to develop country and move up out of poverty

Challenges.

- The ability of ESCO to create effective management axis: ESCO - Franchise - VEC - VEM - Users
- The capacity of ESCO/Franchises to timely and efficiently support VEC/VEM, in more remote areas.
- The availability of appropriate funding support that allows create affordable tariffs, thereby expand ESCO market
- If government institutions concerned can support ESCOs business for long-run by creating flexible and reliable mechanism, such as hardware standard, supplier standards. Are there incentives strong enough to involve private into doing business with rural electrification by renewables?
- Will Lao government's relevant institutions, such as rural electrification division be ready to welcome private sector involvement in to this business?
- How far will other rural development projects be involved in creating favorable background for rural electrification business, particular in such aspects of rural development as income generation, improvement living standards, etc.

Further studies

There may be a need to carry out further studies in order to identify feasibility of the proposed scheme, such as:

- investigating existing delivery schemes in order to identify its real advantages and facing problems, and then identify feasible approach.
- carrying out further works on the details of the scheme, such as pricing policy, ownership statement, reciprocal relation between stakeholders, networking and franchising policies, etc
- launching pilot project by using the detailed scheme to see its viability and make necessary correction.

Broad base support for ESCO business in Lao PDR

In order to strengthen ESCOs business in Lao PDR, there may be a need to establish Central or Parent ESCO(s), which will manage network of local franchises or smaller ESCOs in dealing with rural electrification projects.

- **Parent ESCO** is responsible mainly for funding support; Investment on hardware, ancillary and spare parts; Search for new technologies; Support member ESCO(s) with training, systems installation and troubleshooting; monitor and evaluate job of member ESCOs, VEC, VT; Carry promotional projects, such as public awareness campaign; Funding research, development and demonstration projects, etc
- **Local ESCOs** may act as franchises of parent ESCO and are responsible for project planning; equipment installation, systems managements, spare parts stocking (forwarded by parent ESCO); Support VEM and VT with systems and financial management; Support users with their financial arrangement; Support Training or assistance with Income opportunities to users, village organizations.

Further strengthening of ESCOs mechanism would be achieved by the creation of a non-government professional association, for example: "**Lao ESCO Association**", by grouping several parent ESCOs together with local independent ESCOs.

Public awareness campaign is necessary to be carried out in order to get broader public support of renewable energies use in Lao PDR

7.7.2 Micro-financing

The exisiting micro-financing tools are not suitable for RE, the interest rates are to high and the loan period to short, thus suitable mircro financing tool have to be developed. Financing Procedures for biogas dissemination projects are developed in India, Nepal and other countries, which could be used as example or even guideline to develop similar tools for Laos.

The most successfull introduction of biogas plants took place and is still running in Nepal. The financing schemes are well documented by WINROCK International. This is a US based development agency. The financing of biogas plants is embedded in a complete programm with micro-finance structures, training and capacity building.

Detail see in Financing Biogas – A reference manual for Microfinance Institutions in Nepal; www.winrock.org and Financing Biogas through Microfinance in Nepal in the Appendix 12.

7.8 Necessary Policy Adjustments

With the ongoing reform of energy sector policy and legislation in Lao PDR an opportunity exists to contribute to the more effective, long-term development of renewable energy. A key objective of the reforms thus far has been to create more favourable conditions for both domestic and foreign investment, as well as ensuring the needs of socially and environmentally responsible management within the energy sector. Further clarification is still needed to determine what the specific needs for renewable energy are with respect to both rural electrification and increased energy efficiency. The following policy recommendations are divided into five key areas:

1) The development of more specific targets and guidelines for renewable energy sector;
2) Further development of the IPP program for domestic investment in RE sector;
3) Better promotion of environmental benefits of renewable energy;
4) The development of more realistic policy on the social benefits of renewable energy in both on and off grid areas; and
5) The further investment in research.

Specific Targets and Guidelines

Existing policy and legislation indicates the needs for future development of RE in Lao PDR, but further of clarification is needed on sector specific targets and guidelines. In order to meet the government's main policy objectives of 90% electrification by 2020 a range of renewable energy alternatives must be rapidly developed. To achieve this, further clarification is needed on the specific needs of renewable energy within the institutions and legislation of both the private and public sectors. The following recommendations should be considered:

- Support should be given to promote further discussion and deliberation over RE development, including private and public sector actors at local, provincial and national levels. Support should be given to the newly formed Lao Institute for Renewable Energy LIRE as one such platform that could be used for such dialogues.
- Given the experiences of existing private sector actors, incentives should be given to private sector for RE research and development of RE. Again this could be co-ordinated under the newly formed LIRE.
- Greater transparency in rules, laws and regulations as well as information on electrification is needed across both public and private sectors, to support greater investment by local, national and international investors in the energy sector.
- Extension should focus on the provision of more holistic approach renewable energy through the promotion of 'energy services': focusing on technology transfer and also additional support programmes to promote income generating activities within rural communities.
- Specific targets should be developed for the establishment of integrated extension, service and support networks building on the experiences of existing ESCO, franchise networks and public systems. Given the range of resources used in biomass energy tech-

nologies, financial support and improved multi-sector collaboration between key organisations working in agriculture, forestry and energy.

Development of IPP Pogram

The current institutional arrangements of the government support the ongoing development of the energy sector, with provision made for the promotion of investment, technical support, environmental protection, and policy. Furthermore, the government's aim of improving the commercial viability of EDL may be further strengthened through renewable energy technologies. The promotion of market-based approaches to rural electrification, as exemplified through the government's support of ESCOs and the emergence of SUNLABOB, may prove an area that EDL may choose to support in the future. Further recommended changes to policy include the following:

- Attention should be given to balancing the current subsidies provided through the MIH World Bank PV project with the promotion of private sector. A clear policy statement on improved competition in the sector will encourage further investment, reduce current distortions in competition between private and public sector competitors and increase consumer's choice in the PV solar market.
- Greater incentive should be provided to private sector for the development of a range of alternative RE technologies, including pico and micro-hydro, biomass and PV solar. To ensure greater ownership of these technologies by the domestic private sector, the state should facilitate discussion and debate.
- Given the high levels of investment over long periods of return required for many RE technologies, government policy should support the provision of realistic subsidies for incentives for investors. However, it should be ensured that such subsidies do not remove competition within the RE sector.

Promote Environmental Performance and Benefits

The complex technical, legal and financial challenges faced by large energy projects, as well as their potential social and environmental impacts, have created a definite need to deliver a range of alternative, renewable energy sources. To attract financing for off-grid electrification, state policy needs to focus on the environmental performance and benefits of renewable energy. Specific policy recommendations are as follows:

- Attention should be given to furthering the process of decentralizing administrative and management responsibilities in energy sector, ensuring the continued, affordable expansion of electricity to off-grid areas.
- Given the diverse environmental conditions across the country, there is no one set of technologies that can fulfill the energy needs of the Lao population. Policy should continue to focus on promoting the development of multiple technologies, built into an energy mosaic of grid, micro grid and stand alone energy services that can be used under a variety of environmental conditions.
- Steps should be taken to ensure that legislation does not inhibit the use of agricultural and forest products for alternative activities such as energy production; however, due care should be given in ensuring that food security and responsible land and forest use is supported.

Promote Realistic Social Benefits

Few barriers to biomass energy production exist within the agricultural and forestry policy and legislation, yet food security remains a central objective of the government's poverty reduction strategy to 2020. Land use conversion, needs to balance between the imperative of ensuring a high enough level of food production while also providing adequate incentive to diversify into non-food crops for energy production. Further recommendations are as follows:

- Support should be given to better understanding the specific income generating potential of RE technologies for on and off-grid users. If these are not identified, or if extension services do not also offer different activities in parallel to the systems then the long term viability of technology, beyond a consumptive asset, is unclear.
- To minimise the impact from these energy sources it is necessary to align policy within the energy agriculture and forestry sectors, ensuring that development and extension also support the responsible and sustainable use of natural resources.
- Due to the cross-sectoral nature of biomass energy links should be made between different policy sectors, ensuring RE is combined with the concerns of agriculture extension and development, natural resources management and social welfare.
- Attention should be given to developing education programmes for different RE technologies, focusing on electrification and income generating activities and energy efficiency.
- Small-scale financing arrangements should be set up to provide rural and remote villages with ready access to funds for household electrification. Building on the ESCO model, management of these funds, as well as extension and support, should be developed through organisations at the village level.

Research and Information Needs

To develop better targeted policy, further research needs to be conducted to generate the necessary information and knowledge for LIRE. The following is recommended:

- Further research is needed into the specific trade-offs between food security and biomass use. Specific attentions should be given to understanding whether biomass can be used as an energy source in remote food insecure or forest dependent communities. Local studies should be commissioned to examine the specific circumstances of communities in remote, rural, peri-urban and urban areas.
- Further research is needed to investigate the potential conflicts over the use of different biomass sources, including forests and agriculture. Attention should be given to understanding what the potential threats to forest land if further claims are made over these resources as energy sources.
- Because of the variety of social and environmental conditions in Lao PDR further research should be completed throughout the country in a variety of different social and environmental conditions. These studies should include: detailed energy budgets in rural and urban areas to determine the efficiency of biomass form of energy *vis-à-vis* other forms of energy; consumption surveys outlining the consumptive and productive capacity of households.

- The ongoing integration of social and technical research should be further promoted, focusing on suitable extension methods, marketing strategies, integration into the rural economy and assessment of potential positive and negative impacts from RE development.

8 General Conclusions

- Off-grid electrification using locally available renewable energies is the best alternative for the majority of poor and dispersedly inhabited rural population in developing countries. Decentralized solar photovoltaic and small-scale hydropower are example of renewable energy technologies, which have been successfully implemented in many developing countries. But in general, renewable energy projects in developing countries are aid oriented and still heavily rely on subsidies. This must be changed with market oriented approaches.
- Rural electrification is a priority in the Rural Development policy of Lao Government and has been promoted mainly by grid extension. But when electrification moves to increasingly remote areas, grid connection becomes less viable. Most un-electrified villages would not be connected to grid for more than 20 years. Rather, it would be more realistic to develop off-grid electrification systems on the base of locally available renewable energy sources, to meet basic electricity needs of the rural people. These PV based concepts offer technologies capable of meeting local requirements already today.
- Though lacks conventional energy resources, Lao PDR fortunately, is endowed with several renewable energy resources such as solar energy, hydropower, biomass and some wind power. As learned by experiences of other developing countries, solar photovoltaic systems and small-scale hydropower are the most suitable renewable energy technologies that could be at present applied for decentralized electricity supply in Lao PDR.
- Several national and international organizations have been involved into renewable energy technologies promotion in Lao PDR, by launching pilot projects for a purpose to demonstrate market viability or verify a certain delivery mechanism. Overall observation has shown that almost launched projects are challenged with long-term reliability and sustainability; heavily relied on subsidies and failed as soon as subsidy support finished; Relevant government institutions are lack of planning and coordinating capacity; lack of private sector involvement, etc.
- Most interesting delivery schemes in off-grid rural electrification programs in Laos are (1) Rent-to-Buy delivery scheme, offered by rural electrification divisions (MIH) with Soft Loan support by World Bank; and (2) Rental power systems scheme - a pure commercial initiative offered by Sunlabob rural electrification Co.
- In terms of offered technology solutions, most suitable for Lao rural areas are Solar Home Systems, Pico Hydro Generator, Battery Charging Station and possibly also combined Solar Home-Battery Charging Systems. Further higher level, more reliable technology solutions in Lao PDR in the future probably will be (i) Village Mini Grid with Small-scale Hydro, or improved generating–set or even solar photovoltaic systems; (ii) Hybrid

Systems, combining several local energy resources, such as solar energy, small hydropower or wind power, with or without diesel generating-set back up.

- Practices in rural electrification by off-grid programs have shown that financial incentive might be the powerful tools in securing reliability of delivery systems. Furthermore, appropriate financial incentives may help attracting private sector in to rural electrification business.
- Off-grid programs have been targeted for difficultly accessible remote areas, where is low economic potential, low power demand and lack of income generating opportunities, and therefore users lack purchasing power. Normally subsidies or dole- out are provided to make price affordable to majority of poor rural customers. But, any subsidy has two-fold consequence:
    - Subsidy allows affordability for majority of users
    - Subsidy destroys market by offering lower prices, so that it may not be attractive for private sector.
- Proposed delivery scheme considers advantages and disadvantages of recently implementing delivery systems, specific conditions of Lao rural society in order to achieve long-term reliability and self-sustainability in off-grid rural electrification.
- For ensuring long-term support and further strengthening off-grid electricity service in remote rural areas of Lao PDR, there is a need to carry out some studies, for instance, (1) investigation of all implemented in Lao PDR delivery systems, (2) creating National Strategy and Master Plan for Renewable energies promotion, including potential assessment and sites identification; (3) establishment of some parent energy service companies; up to creating Lao Professional ESCO association in the future; (4) strengthen human resources development, in particular, training of technicians and engineers in the field of renewable energy technologies and energy planning, etc

8.1 Conclusions for Solar Energy projects

Solar energy projects are different to bioenergy in one major component. They do not need biomass to be fed manually or technically and hence a well planned, well built and well maintained system will deliver energy without any further involvement

- Lawmakers should take the focus of the proposed legislation for renewable energies serious that renewable energies can only become a sustainable lasting power source if systems implemented can posses a decent base quality.
- A clear focus on education for installers, operators, planners and administrative staff is required to set the intellectual basis for success. However sufficient education is only one side of the coin for the successful sustainable delivery of power to the regions desired.
- Legally binding basic standards which will protect the investment of the government, the operators and/or the customers from miss-investment due to faulty equipment. Here the government needs to utilize its consumer protection powers.

- Solar technology is supposed to be a reliable power source this has been proven, however only adequate education and standards will provide the security that this can be achieved on a durable basis.

The general group of project stakeholders surrounding a solar energy project is very essential for the well being and success of a project. The main group to be taken into account for integration into quality assurance schemes are all the persons around the financial transactions (banks, installers, dealers, producers, investors, insurers). Since this group of personnel does not have technical interests in such a project they are destined to have a good eye on the energy and financial performance of the installation. Hence a direct approach of this stakeholder group can only be successful if easy to use technical standards and quality seals are offered which they can use as part of their project negotiations and contracts.

If there is an enhanced desire to increase the usage of solar technology in china the utmost importance must be laid on the exact definition of equipment ownership and a direct pointing out of responsibilities concerning operations and service actions. The key ingredient to this is the creation of technical standards or quality seals which can be utilized in contracts.

All these advices are valid both for large solar energy projects in developed or threshold countries in South East Asia such as Thailand and also developing or least developed nations such as Lao PDR. The utilization of lasting technologies and the necessity for a good maintenance by skilled staff are essential for the provision of the energetic results predicted and expected by the investors in large or small scale applications.

The proposed new strategy for solar energy in Lao PDR is based on findings made during our Asia Pro Eco project's study. Back ground for development of new strategy for solar energy in Lao PDR would include the following issues

Current status of solar energy in Lao PDR

- Solar photovoltaic (PV) application. Solar PV power mainly is used for electrification and communication in remote areas. The options in use included (1) stand alone solar home system (SHS), (2) community Battery Charging Station (BCS), (3) community PV power systems (vaccine storage fridge, healthpost or schools lighting, village entertaiment devices, etc); (4) main or auxiliary power supply for communication station.
- Solar thermal utilization has been recently observed in Lao PDR, such as (1) passive solar water heater for domestic use, and (2) simple solar dryer for drying agriculture products.

New strategy for solar energy in Lao PDR.

Base on survey results and literature review, the new strategy for solar energy in Lao PDR has been proposed. The strategy's concerns are appropriation of technologies and accompanied support measures.

Solar energy technology

The most appropriate solar energy technology options for Lao PDR at present times and in not near future, may include the following:

Solar PV application

- Electrification in off-grid areas
  - Individual power supply (SHS, BCS, community solar system) will still be the most apppropriate option for dispersly inhabited remote communities
  - More sustainable power supply would be achieved by using solar PV systems with minigrid or in combination (hybrid system) with other local renewable energy resources, , where feasible, such as micro hydropower, gen set on diesel or biomass fuel, wind power. Here sustainability is also by mean of increasing consumers' ability to pay for service or purechased equipment due to possibility of using AC electricity for more variety of income generating activities.
- Power supply to communication in remote off-grid areas
- Feed-in PV system - long term strategy. It is known that hydropower export is the one of the important sources of foreign exchanges of the Lao PDR. Therefore, feed-in solar PV systems may help (1) reserving surplus of hydropower for export, (2) encouraging private investment and initiatives
- Building integrated solar PV system – as a long term strategy for urban and rural areas.

Solar thermal utilization

- Solar water heater. Although Lao PDR is located in tropic climate zone, but there is a demand in hot water during rather cold winter, especially in northern and highland provinces. This point is truely supported by fact of increaseing use of electric water heaters in Lao PDR recently. Therefore, solar water heaters would play an important role in hot water supply for households, hotel and public establishments (swimming pools, hospital, etc).
- Solar dryer. Solar dryer may find useful application in Lao PDR because of the reasons: (1) high price of imported fossil energy, (2) predominant small scale and dispersed locations of agriculture production and food processing, (3) diversity of proved solar drying technology
- Large solar thermal systems may be considered as a long term strategy. These systems may find application in agriculture and forestry products processing industries, public establishments,

Solar architecture application.

Principle of solar architecture should get more serious consideration in building design and construction to reduce inside-building energy consumption (space cooling, heating, lighting, ventilation).

Support measures.

In order to achieve sustainability and consistency in dissemination of solar energy utilization, some support measures should accordingly be taken.

Regulatory frame work

- Consistent National policy on renewable energy sources utilization
- Unity and appropraite standards for suppliers, users and service providers
- Incentive measures for suppliers, service provider and end-users

Financial mechanism

In order to increase ability and capacity to pay for service and equipment, some financial-related measures should be available:

- Funding support to provide soft credit, subsidy, start up capital, etc.
- Promotion of creation and strengthening of local small entrepreunerships in rural energy service will ganrantee long term sustainability

Human resources development

- Training. Short term basic training on solar and other renewable energy technologies may be necessary for relevant policy makers, personnel of promotion offices. There is a need of basic training on technique and business administration for local technicians and entrepreneurs, who are involved in to rural energy service.
- Education. Long term sustainability of solar energy technology application depends on availability of qualified scientists and engineers in this field. Therefore, systematical education in renewable energy technologies should be established nad get more serious consideration by academic institutions and policy makers.
- Public awareness. Experiences of successful stories in other countries have shown that public understanding and acceptance will garantee quick spreading of newly introduced technology. Including introduction of renewable energy technologies' components into curiculla of secondary schools, or programs of radio/television brocasting and other mass media cannels may effectively help raising public awareness in these issues.

International cooperation

Information and experience exchanges with other countries and international organizations, international support are the quickier and more effective ways to introduce solar and other renewable energy technologies in Lao PDR.

8.2 Recommendation for renewable energy supply concepts in South East Asia - General recommendations

The detailed evaluation of the gathered data in this study leads to the general conclusion that the implementation of renewable energy projects in South East Asia is possible and can be viable. However the following general advice has to be given as recommendation from the content of this study:

Detailed analysis of the local situation is vitally necessary before any investment decision should occur.

- For nations with threshold or near developed status projects are to be targeted which are grid-connected and hence on a profit oriented basis.
- For developing nations there is an ever opening market for off-gird applications. Here micro grids and hybrid installations are under extensive scrutiny by governmental or international donor community driven measures.
- Stakeholder talks and integration of local actors is essential for the success and acceptance especially in developing countries where issues like permits and government allowances are important.
- Within the purchase of equipment for projects extreme emphasis should be laid on the sourcing of quality parts since only uptime of equipment can guarantee the financial viability of projects envisioned.

South East Asia does have a big potential for the inclusion of renewable energy into the regional energy mix. With having ideal conditions for solar radiation and in many ways an abundance of biomass, South East Asia has the pre-requisites for becoming the leader in a sustainable energy provision. Since policies are changing and pragmatic projects prove the success the idea is slowly turning from a vision to reality.

The future for such renewable energy applications is bright for four major reasons:

- Conformity with international policy mainstream on resource efficiency
- cost efficiency in off-grip applications for rural electrification projects
- integration into international climate protection programmes
- resource efficiency and double income strategy in bioenergy-waste projects

If these general issues are targeted for the implementation of solar energy or bioenergy projects further special advices should be followed.

The following facts are the important factors for success and sustainability of rural electrification projects on renewable energy resources:

- Systems should match basic energy needs of users
- Systems maintenance is a key issue. Lack of knowledge in maintaining systems coupled with the non-availability of quality balance of systems (BOS) were the major reasons for their failure
- The issue of project management is particularly important due to the remote location of many installations, where consequently, it is common for the operation and maintenance of the systems to be the responsibility of villagers themselves. In this context, participation of the local organizations becomes very important.
- Financing of a renewable energy project is a crucial issue. In most of developing countries the people in rural areas who are the potential customers of renewable energy systems live below the poverty line and do not have purchasing power to afford this expensive technology.
- International organizations and developed countries play an vital role in such aspects of RES' promotion in developing countries for training, technology transfer, financial organization and support

The following recommendations are essential to the success of renewable energy programs:

- RES Project will have profound positive effect on the well-being of the target end users and empowerment of the rural folk through reducing the burden on women, improved evening entertainment and extra income generating jobs in the evenings, etc.
- Project success should be ensured through an efficient and effective network of promotional activities such as community/group participation, extended network of the credit scheme, publicity through marketing facilitators, radio/TV programmes, articles, trade fairs and shows.
- Above all, there will be a need for national policy that favors a market-driven strategy.

Renewable energy technology projects will have profound positive effect on the well-being of the target end users, if:

- the systems have been designed and installed according to the users' basic needs and ability to pay,
- the presence of a finance scheme has been a much needed catalyst
- users are involved in the dissemination process,
- the presence of standards has ensured that quality systems are installed.

But the typical reasons of renewable energy project failures in developing countries must be taken into account:

- Inadequate organizational preparation. Usually there is a lack of economically viable support structure to provide maintenance and spares.
- Lack of proper market support system that could help increase users' ability to pay for electricity service.
- Lack of public awareness on RE resources, technologies and its applications.
- Insufficient technical training: no standardized training specifically for personnel working on RET systems, in both technical and administrative skills.
- Lack of standards and accreditation of suppliers and installation.
- Government interventions compete with private sector's undertaking; high subsidies and dole-outs distorted market prices.
- Installed renewable energy systems usually are substandard.

The following recommendations should be utilized to improve and speed up RET development programmes in developing countries:

- Overall implementation capacity of the programme should be improved to match its national coverage, through staffing and records management among others.
- System maintenance needs to be decentralized to local artisans who should be so trained.
- Effective follow-up of loan defaulters is required as convenient points of loan repayment.
- The programme should be complementary to, not in competition with, grid electricity, and as such, it should be incorporated with a national rural electrification strategy.
- Alignment of the loan scheme with the conditions of the rural electrification collective scheme.
- The private sector is to be incorporated into the programme through entrepreneurs who would be responsible for programme marketing and system installation and maintenance.

Generally the following important aspects must be considered, while designing a renewable energy technology project:

- Technical aspects: It requires a medium and long-term schedule follow-up of existing installations.
- Social aspects: In order to simplify the adjustment of the new technology to the users, the people's characteristics and habits should be examined and these factors should be considered from the beginning of the project. As other very important tasks, the families should be trained to organize their rationale energy consumption.
- Infrastructure aspects: Clear legislative regulations based on well-defined program aims and criteria should be stated. The following measures were regarded: the training of

small-size entrepreneurs, the promotion of a decentralized spectrum of the dealers of equipment components and spares, the training of experts, the encouragement of equipment manufacturing and the promotion of showcases.

- Economical aspects: Due to high cost of PV equipments, it necessary to be partly subsidized, and due to the low income of rural users, the fees for electrical service should be subsidized in part, too. The following factors should be taken into account for establishing the fees:
- the mean monthly expenditure on electrical energy for a typical family,
- the maintenance costs of the individual system for its entire lifetime, using the annuity method,
- the villagers' proposals for the fee they would be willing to pay.
- the initial payment for installation, aiming to let them build a conscientious feeling that this service was not a gift.
- a new contract should be written, after the end of the project, with an electrical utility, to which the installations will be transferred,
- the monetary account flow of the users' contribution fees.
- Marketing aspects: The best case, a mediator would be chosen among small local companies or craftsmen, who has already the knowledge and capability of making the basic elements of the marketing. These mediators are encouraged to organize their future projects as well as to ensure the replacements and spares supply.

The existing key challenges and barriers for development and application of Renewable Energy technologies especially photovoltaic based systems in developing countries are:

- Lack of long term strategy at the national level
- Lack of incentive policy framework
- Weakness of national capacity on technology development
- Insufficient sustained training of contractors and technicians, dealing with RET
- Lack of awareness and knowledge management
- Lack of financial support and innovative mechanisms like smart subsidies
- Lack of Codes of Practice and Technical Standards.

In order to combat these shortcomings the following actions are to be taken to promote renewable energy technologies (RET) within the national context:

- Policies and legislations on promotion of RET should be formulated and RET development plans with clear target and priorities should be included in the national energy development plan.
- Funds should be set aside from national budget for the promotion and development of RET. It is also suggested to establish rural electrification funds in support of the RET projects.
- More incentives should be provided to attract private sector investment on RET and innovative financial instruments and arrangements for promotion of RET should be introduced. Financial support from mechanisms such as Global Environment Facility (GEF) and Clean Development Mechanism (CDM) should be emphasized.

- Capacity building efforts related to effective institutional arrangement, awareness and technical training for RET development should be enhanced.
- The gender-energy issued efforts should be made to further involve women in the decision-making and implementation of RET projects.
- Involvement of stakeholders (NGO's, local self governments, community based organizations) in the implementation of RET projects.
- Regional and international organizations should make further efforts to sensitize higher level governments on the benefits of RET projects.
- Further development of the technology through transfer and adaptation of already developed technologies and products through inter-country cooperation including South-South cooperation should be supported.

9 General Summary

Within the diagnostic study on Renewable Energy Potential and Feasibility in South East Asia laid down in the previous pages a detailed analysis both technically and economically was undertaken. The areas of research were extended from general information on the chosen countries Lao PDR and Thailand over the present and past situation of their respective national energy sectors to the legal nature of their promotions strategies.

They study has compiled many examples of technologies and project examples. Within this there were a lot of positive and well functioning projects and technologies identified. On the other hand the study also shows, that unless a certain framework is generated renewable energy projects can fail. Especially education measures for installers and operators must be a key issue when a national market is to be opened. These factors are as important as functioning technology and the special design of equipment for the Asian surroundings. Since renewable energy technology in many ways is not high tech, education of installers and repairmen is the key issue for the success of projects.

The general strategy of the study to choose two neighbouring countries with different development status in order to get a clear picture of the possibilities for the introduction of renewable energies as power source paid off. By analysing the two different representatives of their statuses (threshold country and least developed country) thoroughly a clear picture could be generated and the advice to investors be generalised as done in the previous chapter. Overall the study could conclude that the trend towards a sustainable energy supply for South East Asia is imminent. Both the policies and the commercial investment is gearing up for the further implementation of such technology. If the market, which is opened up by real market player in connection with government rural development policies and international financing institutions such as the World Bank programmes, is further pursued by all the actors renewable energies will be a major development player. This means that the study has proven that photovoltaics will be a key technology for the joint development of mini- and micro grids for rural electrifications. Bioenergy however will be one of the major players for the economical integration of sustainable elements into large scale power production and the retrofitting of agro-industrial complexes.

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Appendix 1: Statistic of Electricity Production, Domestic Sale, Import & Export of Power of EDL, Theun Hinboun & Houay Ho (Unit in GWh) (1962-2005)

Years	Total Energy generation				Electricite du Laos EDL				Theun Hinboun Power Company				Houay Ho Power Company			
	Genera-tion	Domes sale	Export	Im-port	Genera-tion	Domes.Sale	Ex-port	Im-port	Generation	Domes	Export	Im-port	Generation	Do.Sale	Export	Import
1962	7,15	5,84	0,00	0,00	7,15	5,84										
1963	7,93	5,96	0,00	0,00	7,93	5,96										
1964	10,52	8,51	0,00	0,00	10,52	8,51										
1965	12,37	8,98	0,00	0,00	12,37	8,98										
1966	16,82	12,81	0,00	0,00	16,82	12,81										
1967	19,71	16,99	0,00	0,00	19,71	16,99										
1968	22,86	17,34	0,00	0,00	22,86	17,34										
1969	31,34	21,81	0,00	0,00	31,34	21,81										
1970	42,92	25,30	0,00	0,00	42,92	25,30										
1971	51,91	28,84	4,07	0,00	51,91	28,84	4,07									
1972	216,57	37,48	151,97	0,00	216,57	37,48	151,97									
1973	244,08	53,08	159,98	1,55	244,08	53,08	159,98	1,55								
1974	253,91	49,79	165,66	2,24	253,91	49,79	165,66	2,24								
1975	241,34	60,66	155,29	8,43	241,34	60,66	155,29	8,43								
1976	232,76	63,57	156,62	6,74	232,76	63,57	156,62	6,74								
1977	256,14	64,93	176,72	6,27	256,14	64,93	176,72	6,27								
1978	298,44	63,67	222,51	6,23	298,44	63,67	222,51	6,23								
1979	898,06	65,37	787,97	6,85	898,06	65,37	787,97	6,85								
1980	886,20	64,59	766,41	7,83	886,20	64,59	766,41	7,83								
1981	845,90	105,12	708,70	8,39	845,90	105,12	708,70	8,39								
1982	910,45	107,37	749,76	10,66	910,45	107,37	749,76	10,66								
1983	863,38	124,01	694,42	13,37	863,38	124,01	694,42	13,37								
1984	890,98	127,47	709,72	16,63	890,98	127,47	709,72	16,63								

Years	Total Energy generation				Electricite du Laos EDL				Theun Hinboun Power Company				Houay Ho Power Company			
	Genera-tion	Domes sale	Export	Im-port	Genera-tion	Domes.Sal e	Ex-port	Im-port	Generation	Domes	Export	Im-port	Generation	Do.Sale	Export	Import
1985	906,62	130,39	716,28	18,60	906,62	130,39	716,28	18,60								
1986	867,31	128,15	683,59	17,20	867,31	128,15	683,59	17,20								
1987	566,61	125,53	387,25	18,00	566,61	125,53	387,25	18,00								
1988	552,65	139,10	363,61	19,80	552,65	139,10	363,61	19,80								
1989	698,02	149,20	490,54	23,09	698,02	149,20	490,54	23,09								
1990	820,56	164,58	595,19	27,73	820,56	164,58	595,19	27,73								
1991	834,61	220,67	562,59	34,90	834,61	220,67	562,59	34,90								
1992	751,62	252,74	459,82	41,27	751,62	252,74	459,82	41,27								
1993	919,64	264,79	595,79	47,72	919,64	264,79	595,79	47,72								
1994	1.198,32	279,44	829,25	57,44	1.198,32	279,44	829,25	57,44								
1995	1.084,99	337,47	675,55	76,83	1.084,99	337,47	675,55	76,83								
1996	1.247,84	379,54	792,43	87,56	1.247,84	379,54	792,43	87,56								
1997	1.218,74	433,87	710,21	101,58	1.218,74	433,87	710,21	101,58								
1998	2.156,62	513,27	1.613,45	142,28	947,78	513,27	405,20	142,28	1.208,84	0,59	1.208,25					
1999	2.806,27	565,55	2.228,82	172,20	1.168,70	565,55	598,14	172,20	1.439,56	0,79	1.438,77		198,01	0,45	191,91	
2000	3.438,38	626,35	2.792,84	180,17	1.337,04	626,35	694,19	180,17	1.483,79	0,75	1.483,04		617,55	1,94	615,61	
2001	3.653,66	710,33	2.871,41	183,80	1.553,65	710,33	796,38	182,50	1.507,50	0,73	1.485,26	1,31	592,51	2,74	589,77	
2002	3.604,11	766,74	2.798,34	200,80	1.570,20	766,74	771,43	200,80	1.454,59	1,01	1.453,58		579,31	4,36	573,33	
2003	3.178,20	883,74	2.284,64	229,34	1.316,90	883,74	434,66	229,34	1.432,08	3,81	1.426,93		429,22	6,17	423,05	
2004	3.347,63	902,76	2.424,69	277,59	1.416,46	902,76	507,05	277,59	1.527,71	6,36	1.521,35		403,45	7,17	396,28	

Remark: The domestic sale and the import of the IPPs were neglected by calculating the Total energy domestic sale and import by the authors of the table. The reason is not know by the authors of the presented study.

Appendix 2: Overview about selected studies and pilot projects on RE in Laos

Project Title	Duration	Short Info	Donor	Budget
Studies				
Renewable Energy Technologies in Asia: A Regional Research and Dissemination Program (RET's in Asia)	1999 - 2002 (Phase 2)	**Objective and Content** In this period, the potential of solar radiation in whole country was surveyed and the lesions learned from Phase 1 was analyzed and the applied research of PV was conducted. One Battery Charging Station was installed with 240 W for 4 families and a Solar Pumping with capacity 300 W for pumping water 6 cubic meter per day was demonstrate in Km 14. Several training courses on PV technology were organized for local technicians.	Swedish International Development Cooperation Agency (SIDA)	72.000 $
Renewable Energy Technologies in Asia: A Regional Research and Dissemination Program (RET's in Asia)	2002 - 2005 (Phase 3)	**Objective and Content** The adaptive research on accessories and Balance of System like Current Direct Ballast and Charge Controller were implemented and developed to a completing package. The designed package was tested and monitored. **Outcome** The improved system was installed in Ban Dongmakkai with a size of 70 W per set. There are two test units.	Swedish International Development Cooperation Agency (SIDA)	39.000 $
Mini Hydroelectric Power Feasibility Study for the Lao PDR, Phase 1	October 2001 - December 2001 (Selection of Candidate Sites)	**Objective and Content** The project is divided into 3 phases, each with one or more deliverables: Phase 1: During the first country visit, the study team will review available information on proposed mini-and micro-hydro sites in Laos. In this phase, 5 candidates sites will be selected. **Outcome** 5 candidate Sites are Nam Phouane and Nam Mang, Khamkeat Dist.,Borikhamsay; Nam Ham, Bortean Dist. Sayabouri; Nam Sing and Nam Long, Luangnamtha province.	Canadian International Development Agency (CIDA)	10.000 $ for counterpart (TRI/STEA)
Mini Hydroelectric Power Feasibility Study for the Lao PDR, Phase 1	Phase 2: January 2002 - April 2002 (Selection of Study Sites)	**Objective and Content** The result of this phase will be a report describing the selection of 2 mini-hydro projects for feasibility study. **Outcome** 3 selected sites: Nam Phouan, Nam Sing and Nam Long		

Project Title	Duration	Short Info	Donor	Budget
Mini Hydroelectric Power Feasibility Study for the Lao PDR, Phase 1	Phase 3: May 2002 - April 2003 (Comprehensive Feasibility Studies)	**Objective and Content** This phase constitutes the bulk of the work, and will include environmental assessments as well as socio-economic and training components. Final report including a complete summary of project findings, and a feasibility study to standards acceptable to lending agencies for the provision of implementation funding **Outcome** Feasibility study on Nam Long, Long dist., Luangnamtha Province		
The feasibility of a Support Programme for Domestic Biogas Plants for rural households in the Lao People's Democratic Republic. Report on the first fact-finding mission.	In February 2003.	**Objective and Content** The overall objective of the Project Development Assistance (PDA) is to assess the possibilities to design a project to stimulate the emergence of a biogas sector in Lao PDR. The PDA has been divided into two main parts:1) Fact finding on the key elements concerning the biogas sector; 2) Drafting a project document in case the overall conclusion is positive. **Outcome** A large proportion of Lao's rural households own livestock, setting the scope for a successful biogas programme. However, rural poverty, the nature of agricultural practices and the abundance of forest limit that scope significantly. Therefore, the current effective market for biogas seems modest, whereby it should be noted that the socio-economic developments would indicate improvement at the medium term. The research indicates that Champasack in the south and –to a lesser extent- Savannakhet in central Lao, harbour the highest biogas potential.	SNV/UNDP	not available
Domestic Biogas in Lao Peoples Democratic Republic. Report on the second fact-finding mission.	April - June 2003	**Objective and Content** The general objective for the Second Mission is to validate the assumptions and findings of the First Mission in order for the involved stakeholders to make a well-informed decision on the feasibility of a support project for domestic biogas plants for rural households in Lao PDR. In outline, the second mission seeks information in the three following areas: 1) Demand side 2)Supply side and; 3) Intervention **Outcome** It is expected that a biogas programme will generate sufficient interest from	SNV LAO	30,000 USD

Project Title	Duration	Short Info	Donor	Budget
		the private sector for the marketing and construction of biogas. The Government should formulate policy to involve the private sector. The impact of the present demonstration biogas plants is very limited due to the higher cost of installation. It is recommended to use commercially constructed plants to impart demonstration effects and to establish a subsidy scheme.		
Survey of potential users of biogas in some districts of Vientiane Capital.	in September 2005	**Objective and Content** To identify potential biogas user in semi-urban areas in Vientiane Capital. The livestock situation in these areas was to be appraised and the utilization of energy sources surveyed. In addition, the availability of micro credit system in the villages was identified. **Outcome** Several districts of Vientiane Capital are suitable for the initial introduction of Biogas because the technical conditions are favourable (sufficient number of livestock, interest in alternative cooking fuels, etc.) although the finical conditions are probably less favourable (loans available but at high interest rates; The livestock practice in the visited villages is fulfilling the technical condition for domestic biogas with animals kept in stable (during night time) and consequently sufficient dung available as feedstock; About 30% of visited household indicated an interest in biogas. However, some of them do not know how much they will have to contribute to the initial investment as no decision has been made of the type/kind and cost of the digester to be installed or used in Lao PDR ; Small credit systems are available in the villages which in principle can support the loan for contribution to biogas plant; Mason skills to construct biogas digesters in local areas are available.	SNV LAO	no cost
The Study on Rural Electrification by Renewable Energy in the Lao PDR, Final Report Summary	01.02.2001	**Objective and Content** The study evaluated the pilot project of MIH on rural electrification by RE, particularly Solar and Mini hydro power and identified the pilot areas for new pilot project.	JICA	not available

Project Title	Duration	Short Info	Donor	Budget
Final Report of Existing Micro Hydropower Project, JICA, July 1999	1998-1999	**Objective and Content** The report on the existing micro hydro project portfolio is prepared by the Hydro Power Office of MIH and finance by Government of Japan with the JICA as executing agency. The main objectives are to provide a brief outline of all problems of existing micro hydropower projects in Lao PDR, to describe the present operation and maintenance situation, and to indicate areas of assistance needs and promoting for the rehabilitation. **Outcome** Some 39 existing micro hydro systems (with total capacity of 2.381 kW) capable of serving more than 12.000 HH, of these 18 micro hydro systems (total capacity 565 kW serving about 4.100 HH) are currently not operational, and about 11 of these are suitable for rehabilitation. About 11 of the operational systems (total cap. 765 kW serving about 3800 HH) are in need of repair.	JICA	215.000 USD
Draft final report of Rural Electrification Frameworks Study, June 2004	12 month (October 2003 - June 2004)	**Objective and Content** This study arose from the Lao PDR Power Sector Policy implementation Strategy, which identified the need for a broad review of options for rural electrification in the country. As the result, several studies are being undertaken to consider alternative rural electrification models suitable for Lao PDR that provide: Technical and commercial sustainability, Equal access to the market for existing providers and new entrants, Competitive processes where appropriate, a system of licensing of enterprises which are providing off grid and grid extension services. Objectives: review the existing MIH pilot project for off grid electrification and the proposed scale-up program and recommend improvements; review MIH proposals for establishment and operation of a Rural Electrification Fund and recommend improvements; review the overall RE program of MIH/EDL and define a framework for grid and off-grid based RE appropriate under the conditions in Lao PDR; review existing inventory studies and define a framework for the preparation of a RE Master Plan	Wold Bank	130 000 USD

Project Title	Duration	Short Info	Donor	Budget
Draft final report :Volume 2. The Master Plan Study on small hydro in Northern Laos	Jan- 2003 to Nov-2005	**Objective and Content** The overall goal of the study is improvement of the electrification rate, the poverty alleviation, and the economic growth targeting the northern eight (8) Provinces : Phongsaly, Luang Namtha, Oudomxay, Bokeo, Luangprabang, Huaphanh, Xayabury and Xieng khouang in Northern of Laos. Consequently, the purposes are (i) promotion of electrification in un-electrified district centres, (ii) reduction of electricity import from neighbouring countries, and (iii) achievement of the following study obligations by introducing alternative power sources in such areas depending on diesel generation: Preparation of Master Plan of off-grid small hydropower at the year 2020 based on field reconnaissance results and implementation of Pre-Fs, Policy suggestions and recommendations concerning the promotion of off-grid small hydropower schemes and Execution the capacity building of the counterparts about small hydropower planning **Outcome** JICA has dispatched the project formation study team in March 2003 to confirm detailed background of requirement on the study. In Jan-2004, the study was carried out in accordance to three (3) stages: (1). Preliminary Study on Small Hydropower Planning (Jan-2004 - July 2004); (2). Investigation of Selected off-grid Small Hydropower (Oct. 2004 – Jan 2005); (3). Master Plan Formulation (June 2005 – Nov.2005). Comment: RE has become a focal development issue to achieve poverty alleviation, and balanced regional development so as to rectify the concentration of investments in urban areas. However, at a micro-level, it is difficult to justify small independent grid projects due to dispersed beneficiaries and low purchasing power of the poor. Thus EDL is no exception to the rule in showing reluctance in attempting these off-grid projects even with the prospect for future grid connections. Rural off-grid schemes require multiple sources of financing and concerted efforts to bring projects to realization.	the government of Japan, executive agency: JICA	the figure is not available (N A)

Project Title	Duration	Short Info	Donor	Budget
Country Report for Cogeneration Project in Lao PDR	April - September 2004	**Objective and Content** The report deals with collection of data concerning energy sources in the country such as coal, biomass, hydropower, solar and wind energy. In addition, it summarized power sector policy and institutional arrangement for energy. The energy consumption in Lao PDR was illustrated by sector and by type of fuel in percentage. The report deals also with the electricity demand from 2003 to 2020. Last part of the report it summarized on the future of cogeneration project in Lao PDR: "1) Cogeneration in Lao PDR is new technology and just only few people only few people have known about it. 2) There is no any existing cogeneration project in Lao PDR (Except one project in TRI for demonstration). 3) There are lacking of information about the waste wood, sawdust, rice husk, the data collection are facing difficulties. 4) the factories in Lao PDR are not too much and almost are Medium-Small scales. 5) most of factories, companies have no confidence to have the cogeneration because of the raw material and the installation cost of the system. **Outcome** Recommendation:1) It should have the details study on the biomass in Lao PRD. 2) It should have the Cogeneration Workshop or Seminar in Vientiane for explanation to main energy consumers to know about cogeneration. 3)The very soon possibility of cogeneration is sugar factory in Vientiane Municipality. 4) The future positive cogeneration project are Cement factories, some sawmill, sugar factory in Savannakheth and in the North by sugarcane bagasse.	COGEN	3,000 USD

Project Title	Duration	Short Info	Donor	Budget
Rural Electrification Decentralized Energy Options (REDEO)	no information	**Objective and Content** The objective of the project is to provide planners for rural electrification in Cambodia, Laos and Vietnam (CLV) with a set of concrete planning tools for integrating sustainable distributed generation options in planning for rural electrification. Specific objective: 1) to review the existing soft ware programmes which are decision aid tools for economic and financial analysis as well as to some extent of renewable sources of energy. 2)the objective to test and adapt the SOLARGIS software to CLV context based on concrete discussion which in country institution. 3) to ensure that the planning tools are applicable both at national and local level. 4) providing information and exchange of experience of the approaches adopted in other countries. **Outcome** So far, the project section of rural electrification division has received only SOLARGIS software	ASEAN Centre for Energy (ACE)	Budget Line B7-30310
Pilot Projects				
Solar Photovoltaic Electrification in Pakkaya village in Lao PDR	1997-1998 (Phase 1)	**Objective and Content** The project was implemented under Science Technology and Environment Organization (STEO) in cooperation with the Department of Energy Development and Promotions (DEDP). This project installed a Battery Charging Station with capacity 1.500 Wp and five Solar Home System with 50 Wp for each to Pakkaya villagers, Savanakhet, with the aims: improving the living standards of people in rural remote areas; collect and exchange information on Solar Energy use; demonstrate the utilization of Solar Energy Technologies; reduce the practice of slush and burn cultivation, disseminate knowledge on Solar Energy Technology and cooperate with local people. **Outcome** Demonstration Project for PV, Recommendations: conduct policy assessment of government rules, regulation and programs relevant to PV technology development and integrated rural development; human resource development; develop incentives to encourage the involvement of local business and private sector; subsidy policy to cooperate to rural people; strengthen	Canada-Thailand Trilateral Environment (CTTE)	9.500 $

Project Title	Duration	Short Info	Donor	Budget
		regional cooperation. Results: increasing the level of public awareness on PV; improvement in living conditions and development of technical knowledge of Laos's technicians.		
Pilot Project on Biogas Application for Rural Community	1999-2000 (Phase 2)	**Objective and Content** Approximately 80 % of the Lao people live in rural areas, where most of them have no access to electricity, Biogas could meet the basic needs of rural communities (for cooking and lighting). The project installed 8 biogas units with capacity 12 cubic meter in Vientiane, Savannakhet, Champasak, Sarravan and Attapue in order to demonstrate and disseminate Biogas Technology to rural people and create public awareness focusing on government officials and reduce the practices of slash and burn cultivation. **Outcome** Most of installed biogas plants are not in operating during the site visit of SNV team in February 2006. The reasons are lack of maintenance skill of user, not appropriate size and location. The minimum capacity of the plant is 8 cubic meter and the maximum 16 cubic meter.	CTTE	929.900 THB

Project Title	Duration	Short Info	Donor	Budget
Renewable Energy Technologies in Asia: A Regional Research and Dissemination Program (RET's in Asia)	1997 - 1999 (Phase 1)	**Objective and Content** RET's in Asia was conducted by Asian Institute of Technology (AIT), Bangkok, with financial support from the Swedish International Development Cooperation Agency (Sida), and involving six countries in Asia: Bangladesh, Cambodia, Lao PDR, Nepal, Philippines and Vietnam. Three mature renewable energy technologies were identified for dissemination in the participating countries (PV, Solar Drying and Biomass Briquetting). Each participating country had to select National Research Institution (NTIs) as representative and the STENO was selected as the NRI for Lao PDR and STENO selected PV technology to disseminate in Laos. Phase 1 has the scopes to establish a centre for promoting PV; carry out R&D activities for fabrication and adaptation of accessories such as: battery charging controller, converter, inverter and storage battery. **Outcome** As the result: a Battery Charging Station with 1,5 kW and 5 Solar Home System with 75 W per each in Ban Phon ngam, Atsaphon district, Savannaket for 45 Households. Two SHS with 75 W per each in Xiengkhuan and Houaphanh (Lak 12 Samneua)	Swedish International Development Cooperation Agency (SIDA)	60.000$
Joint Research and Development of Solar Home System for Village Electrification in Lao PDR	August 2000 to March 2001	**Objective and Content** The project has been implemented under the cooperation of TRI/STEA and Fuji Electric Construction Co., Ltd. It was conducted at Ban Phosy, Naxaithong dist., Vientiane. There are 15 sets of SHS and one set of SHS is installed in one group comprising 7 houses. Objectives: to research and develop the PV system for rural electrification; Electrified an un-electrified village in suburb of Vientiane; improve the quality of life, skill and knowledge of rural people. **Outcome** This system has been developed from stand alone solar home system and battery charging station to combine together as key house will be both SHS and BCS. SH-BC Hybrid Controller has been developed for this project with the function to charge 3 SB per day.	New Energy and Industrial Technology Development Organization (NEDO), Japan	90.000 $

Project Title	Duration	Short Info	Donor	Budget
Project Report for Demonstration Project on Micro Hydro Technology in Lao PDR		**Objective and Content** The project aims to develop demonstration plant which would be cheaper to construct than existing plants, and would be simple, easier and more economical to maintain than them; MIH and NEF jointly implemented the project with the work outlines: (1) conduct surveys required for design, manufacture, transportation, construction and operation on the plant, (2) design the required system, (3) manufacture all equipment and provide transport facilities, (4) conduct construction and installation of the system, (5) conduct demonstration test and observation of the system. **Outcome** The demonstration plant was understood and accepted by local people supplied, and electrification progressed quickly,	New Energy Foundation (NEF)	not available
Southern Province Rural Electrification Project (SPRE 1)	1997 - 2004	**Objective and Content** Installation of transmission line 115 kV (53km), 22 kV (1,200 km), Off-grid with SHS: 5.300 HH /700HH (2005). Target to be reached 51,770HH in the 7 southern provinces of Laos. **Outcome** The organization of the off-grid rural electrification by the solar home system (SHS) has been established as a part of the SPRE 2. As the off-grid system consists of many small scaled isolated generating systems, it is impossible for the central government to make planning, operation and maintenance of all projects because of geophysical and financial difficulties.	Wold Bank, EDL	WB:36 mill $, EDL: 3 mill $
SPRE 2 Phase 1	2005 - 2007	**Objective and Content: Installation of transmission line 115 kV (?km), 22 kV(? km), Off-grid with SHS :10,000 HH (national wide). Target to be reached 93,000 HH in the 7 southern provinces of Laos.** Outcome: In addition, as a hydropower requires general skills and knowledge of civil, mechanical and electrical technology, a cooperation of MIH/DOE and EDL is indispensable for a construction and an operation of hydropower.	Wold Bank, EDL	no information
SPRE 2 Phase 2	2008 - 2010	**Objective and Content** To support Small Power Producer (SPP): small hydro power pilot scheme (100 kW - 2 MW). Target to be reached: 2 projects	WB, EDL	100,000 - 150,000 USD

Appendix 3: PV applications in Laos

Type of project,	Location of the plant	Planner-Backer	Year of Implementation:	energy type to be generated	Type of system	total installed capacity, (Watts)
Telecommunication system						
Solar PV for Communication (microwave repeaters and substations)	All provinces of Lao PDR	LTC/MCTPC	Since 1980s	electricity for communication systems	stand alone or hybrid systems	122.000 Wp (MIH, 2003)
TRI's demonstration systems						
Demonstration Solar BCS	Savannakhet province	TRI-SIDA TRI-CTTE	1997	Electricity	Community Battery charging station	1.875+1.775= 3.650 W (2 BCS)
Demonstration Solar Home – BC System	Vientiane municipality	TRI-NEDO	2001	Electricity	Solar home-Battery charging station	15 SHBC x 240 Wp = 3.600 Wp
MIH-JICA's pilot systems						
Pilot BCS	Bolikhamxay province	MIH-JICA	1999	Electricity	Battery Charging station	254 SHS
Pilot 55 WpSHS & 110 WpSHS	Vientiane province	MIH-JICA	1998	Electricity	55 Wp SHS 110 WpSHS 1-3 kWp BCS	152x55WpSHS 102x110WpSHS 3 BCS(3165Wp)
Pilot BCS	Bolikhamxay province	MIH-JICA	1998	Electricity	BCS	1x3kWp BCS 1x2kWpBCS
MIH-WB's pilot systems						
Rent-to-buy solar home systems	Vientiane province	EDL- MIH-WB	1999-2001	Electricity for lighting and entertainment	stand alone SHS	11 villages (~ 40 SHS)
Rent-to-buy solar home systems	Luang Namtha province	MIH-WB	2000	electricity for lighting and entertainment	stand alone SHS	901 households in 32 villages
Rent-to-buy solar home systems	Oudomxay province	MIH-WB	2001-2004	electricity for lighting and entertainment	stand alone SHS	1.133 SHS in 44 villages
Rent-to-buy solar home systems	Xayaboury province	MIH-WB	2001-2004	electricity for lighting and entertainment	stand alone SHS	346 SHS in 6 villages
Rent-to-buy solar home systems	Xiengkhouang province	MIH-WB	2001-2004	electricity for lighting and entertainment	stand alone SHS	192 SHS in 2 villages

Type of project,	Location of the plant	Planner-Backer	Year of Implementation:	energy type to be generated	Type of system	total installed capacity, (Watts)
Rent-to-buy solar home systems	Vientiane province	MIH-WB	2001-2004	electricity for lighting and entertainment	stand alone SHS	867 SHS in 22 villages
Sunlabob's systems						
Community system	Remote areas of Lao PDR	Sunlabob Co.	since 2001	electricity for health post, school, private home, etc	Stand alone solar community systems	948 systems, capacity of 59.941 Wp
Pilot, Rented solar (PV) home system	Vientiane mun., Xiengkhouang, Vientiane, Bolikhamxay, Khammuane, Champasak & Sekong provinces	Sunlabob Co.	2003-present	electricity for lighting and entertainment	Stand alone solar home system	925 systems with total installed capacity of 24,610 Wp

BCS: Battery Charging Station

SHS: Solar Home System

TRI: Technology research institute

STEA: Science, Technology and Environment Agency

RETC: Renewable Energy Technology Centre

CTTE: Canadian-Thai Trilateral Environment project

NEDO: New Energy & Industrial Development organization

JICA: Japan International Cooperation Agency

SIDA: Swedish International Development Agency

MCTPC: Ministry of Communication, Transport, Post and Construction

LTC: Lao Telecom

MIH: Ministry of Industry & Handicraft

EDL: Electricite du Laos

SHBC: Solar home - Battery charging systems

InWent: Internationale Weiterbildung und Entwicklung gGmbH

Appendix 4: Basic Data on Agriculture and Cultivation in Lao PDR

Crop	Production pattern	Cultivation technology	Land preparation Costs LAK/ha	Harvest technologies	Harvesting Cost LAK/ha	Production cost LAK/ha
Rice	Two methods are used for planting. Broadcasting and transplanting by hand are practiced. • In upland and rain fed low land areas farmers practice one crop per year during wet season. Varieties used are almost all local. Life cycle is about 90 – 150 days. • In irrigated area farmers practice two cropping per year. Varieties used are almost all improved. Duration is about 120 – 130days dependant on varieties. Most of the agriculture in the Lao PDR is carried by family labor and an average cultivated area per farm is about 1-2 ha.	**Land preparation:** - In up land area 100% is done by hand. - In rain fed lowland 70% is done by hand and 30% by using buffalo. - In irrigated area, 95% is done by machine. **Seedling uprooting:** Completed by hand. **Transplanting:** Completed by hand.	Shifting cultivation, 1,800,000 kip. Buffalo, 1,050,000 kip. Walking machine, 750,000 kip Tractor, 1,500,000 kip. Transplanting by hand, 1,250,000 kip	In every case harvesting made by hand. **Threshing:** - Shifting cultivation 100% made by hand. - Rain fed lowland rice 70% made by machine. - In irrigated area 100% made by machine.	Shifting cultivation, 750,000 kip. 1,000,000-1,500,000 kip in rain fed lowland rice and irrigated rice.	2,550,000 kip – 5,420,000 kip

Crop	Production pattern	Cultivation technology	Land preparation Costs LAK/ha	Harvest technologies	Harvesting Cost LAK/ha	Production cost LAK/ha
Maize	Two categories are used for maize cultivation: • In up land area almost farmers practice during wet season. Varieties used include sweet and local. Life cycle is about 90-125 days. • In irrigated area almost farmers grow during dry season. Varieties using mostly sweet corn. Life cycle is about 100-130 days.	**Land preparation:** - In up land area land preparation is done by hand. - In irrigated area is done by machine. **Seed sowing:** Almost always done by hand.	Hand, 1,800,000 kip. Walking machine 750,000 kip. Tractor, 1,500,000 kip.	In every case harvesting made by hand.	750,000 kip – 1,000,000 kip.	2,800.,000 kip – 5,870,000 kip
Soy bean	Two category are used for maize cultivation: • In up land area almost farmers practiced during wet season. Varieties using almost sweet and local. Life cycle is about 100-125 days. • In irrigated area almost farmers grow during dry season. Varieties using mostly sweet corn. Life cycle is about 125-130 days.	**Land preparation:** Land preparation can be done by hand, by using buffalo and by walking tractor (hand tractor). **Seed sowing:** Seed sowing is almost done by hand.	Walking machine 750,000 kip. Tractor, 1,500,000 kip.	In every case harvesting made by hand.	700,000 kip.	1,450,000 kip – 5,760,000 kip

Crop	Production pattern	Cultivation technology	Land preparation Costs LAK/ha	Harvest technologies	Harvesting Cost LAK/ha	Production cost LAK/ha
Mung bean	Two categories are used for maize cultivation: • In up land area almost farmers practice during wet season. Varieties used are mostly sweet and local. Life cycle is about 100-125 days. • In irrigated area almost all farmers grow during dry season. Varieties used are mostly sweet corn. Life cycle is about 125-130 days.	**Land preparation:** Can be done by hand, by using buffalo and by walking tractor (hand tractor). **Seed sowing:** Seed sowing is almost always done by hand.	Walking machine 750,000 kip. Tractor, 1,500,000 kip.	In every case harvesting made by hand.	1,400,000 kip.	2,150,000 kip – 6,610,000 kip
Mustard	Mustard can grow at any time of year provided there is enough water. Duration is about 40 – 90 days. Two methods are used for planting: - Broadcasting method is done for consumption, - Transplanting by hand method is for seed.	Land preparation: Can be done by hand, by using buffalo and by walking tractor (hand tractor). Seed sowing/transplanting: Almost always done by hand. Remark: transplanting is done for seed.	Walking machine 750,000 kip. Tractor, 1,500,000 kip.	In every case harvesting made by hand.	700,000 – 1,680,000 kip (for seed)	1,400.000 kip - 6,255,000 kip (for seed)

Appendix 5: Data Sheets of selected PV plants

TRI/STEA-NEDO demonstration projects: Solar home-Battery charging systems

Type of project:	Demonstration
Location of the plant:	Dong Phosy, Naxaithong district, Vientiane municipality
Years of Implementation:	1999
Operator: (Name and address)	Key house owner
Planner: (Name and address)	TRI-NEDO cooperation project
Description of the technology: (name, function, supplier)	Solar home – Battery charging system (SH-BC) includes solar home systems and battery charging station in one system. The two components of SH-BC: **Key House:** 2 x 120 Wp Solar Panel 1 x 20 A Charge Controller, which is to charge 3 batteries at one time 1 x mounting pole 3 x 70 Ah Car battery 1 FL x 10 W DC socket (for 25 W B/W TV) **Satellite House:** 1 x discharge controller 1 x 70 Ah battery 1 FL x 10 W DC socket (for 10 W Radio)
Energy service to be generated: (like electricity, light, heat, etc.)	Electricity for lighting and small entertainment appliances (B/W TV, Radio-cassette player) for cluster of 7 houses
Plant type:	Stand alone solar home – battery charging system
Producer of modules	Sharp corporation
Amount of modules	2
Total module area	1,4 m²
Power output of installation: (kW or others like light generation)	240 Watt
Nominal voltage:	12 V
Number of inverter:	0
Income from enery service:	no
Saving from energy service:	24 US$/year, Saved costs of battery charging at far away electrified area, Kerosene or Candles
Uptime of installation: (meaning availability of service in the day, e.g. solar lamp at night)	Usually the systems were designed in order to provide power fro 3 hrs per day during 3 days without sunshine
Investment costs:	n/a (grant)
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	10 US$/year Battery fluid
Labour intensity per power unit or year: (amount of work per kWh or year)	Not labour intense automatic charge control
Labor costs:	None
Technically critical part:	Battery and charge-discharge controller
Costs of technically critical part: (costs of that part)	120 US$ (for 3 Batteries)

MIH-JICA pilot project

Type of project:	Pilot
Location of the plant:	Don Xayoudom island, Vientiane province
Years of Implementation:	1999-2003
Operator: (Name and address)	village electricity committee, Don Xayoudom island, Keooudom district, Vientiane province
Planner: (Name and address)	RED[10]-JICA
Description of the technology: (name, function, supplier)	Solar home system including: 1 x 55 Wp Solar Panel 1 x 15 A Charge Controller 1 x mounting pole 1 x 110 Ah Car battery 1 x 8 W Energy saving fluorescent lamps 1 x DC 12 V wall outlet
Energy service to be generated: (like electricity, light, heat, etc.)	Electricity for lighting and small entertainment appliances (B/W TV, Radio-cassette player)
Plant type: (grid connected, stand alone, solar home system, hybrid)	Stand alone solar home system
Producer of modules	Sharp Corp.,
Amount of modules	1
Total module area	0,78 m²
Power output of installation: (kW or others like light generation)	55 Watt
Nominal voltage:	12 V
Number of inverter:	0
Income from enery service:	no
Saving from energy service:	24 US$/year Saved home energy expenses – Kerosene, battery charging in electrified areas ~ 2 US$/month
Uptime of installation: (meaning availability of service in the day, e.g. solar lamp at night)	Usually power availability within 3 days without sun, 3 hours of power available per day
Investment costs:	525 US$
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	5 US$/year Battery fluid
Labour intensity per power unit or year: (amount of work per kWh or year)	Not labour intense automatic charge control
Labor costs: (costs of a correctly skilled operator per day, month or year)	none
Technically critical part: (most likely to fail part, like engine in gen-set or battery in solar home system)	Battery and charge controller
Costs of technically critical part: (costs of that part)	40 US$ Battery

[10] RED-Rural electrification division, Department of Electricity, Ministry of Industry & Handicraft.

MIN-WB off-grid pilot program (1999-2004): Rent-to-buy Solar Home System

Type of project:	Pilot
Location of the plant:	516 None Savang, Keooudom disrict; Vientiane province
Year of Implementation:	2003
Operator: (Name and address)	Mr Bounthan, Sengsavng ESCO, Thalad town, Keooudom district, Vientiane province
Planner: (Name and address)	Off-grid Promotion Office, Rural Electrification Division (DOE/MIH) Ban Phai, Vientiane, Lao PDR
Description of the technology: (name, function, supplier)	Solar home system including: 1 x 20 Wp Solar Panel 1 x 3 A Stecca Charge Controller 1 x mounting pole 1 x 40 Ah Car battery 2 x 7 W Energy saving lamps
Energy service to be generated: (like electricity, light, heat, etc.)	Electricity for lighting and small radio
Plant type: (grid connected, stand alone, solar home system, hybrid)	Stand alone, solar home system
Producer of modules	Chinese company
Amount of modules	1
Total module area	0,25 m²
Power output of installation: (kW or others like light generation)	20 Watt
Nominal voltage:	12 V
Number of inverter:	no
Income from enery service:	no
Saving from energy service:	30 US$/year Saved cost of Battery charging (the batteries are carried by small boat to charge in electrified village, roundtrip takes about 3 hours); or saved Kerosene and Candles
Uptime of installation: (meaning availability of service in the day, e.g. solar lamp at night)	3 hours of power available per day
Investment costs:	15 $ initial payment (installation fees) Monthly payment: 2 $ and 1 $ for 5- and 10-year repayment period respectively
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	0 US$/year User refills battery fluid by himself
Labour intensity per power unit or year: (amount of work per kWh or year)	Not labour intense automatic charge control
Labor costs: (costs of a correctly skilled operator per day, month or year)	not applied, (Users operate systems them selves)
Technically critical part: (most likely to fail part, like engine in genset or battery in solar home system)	Battery and charge controller
Costs of technically critical part: (costs of that part)	from 6-14 US$ per year depending on how carefully the system is used Battery

Sunlabob rental systems (2002-present) - Community Solar PV system

Type of project:	Full scale rental PV system
Location of the plant:	Ban Kuay village, Sangthong district, Vientiane municipality
Year of Implementation:	2004
Operator: (Name and address)	Mr Khamsao and Mr. Bualay, technicians from near by Bansorg village, Sangthong distirct, Vientiane municipality
Planner: (Name and address)	Sunlabob rural energy system Co. LTD P.O.Box 9077. Watnak. Vientiane, Lao PDR
Description of the technology: (name, function, supplier)	2 x 110 Solar Panels, 1 x 20/20 Stecca Charge Controller Mounting pole and panels frame 2 x 150 Deep cycle sealed maintenance free batteries 5 x 7 W Energy saving lamps 1 x 50 L STECA vaccine storage
Energy service to be generated: (like electricity, light, heat, etc.)	Electricity for village clinic lighting and vaccine fridge
Plant type: (grid connected, stand alone, solar home system, hybrid)	Stand alone
Producer of modules	Suntech-power Co., Ltd
Amount of modules	2 x 110 Wp
Total module area	2 x (0,8x1,4) =2,24 m²
Power output of installation: (kW or others like light generation)	220 Watt
Nominal voltage:	12 V
Number of inverter:	0
Income from enery service:	no
Saving from energy service:	About 20 US$/month or 240 US$/year Saved expenses on recharging Battery bank in electrified village (16 km far away); Kerosene or Candles
Uptime of installation: (meaning availability of service in the day, e.g. solar lamp at night)	3-4 hours of power available per day for lighting and 24 hours for vaccine fridge, within 3 days without continuously sunshine,
Investment costs:	2,890 US$ (including solar system and 50 L vaccine fridge)
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	no (sealed maintenance-free batteries are used)
Labour intensity per power unit or year: (amount of work per kWh or year)	Not labour intense automatic charge control
Labor costs: (costs of a correctly skilled operator per day, month or year)	none
Technically critical part: (most likely to fail part, like engine in genset or battery in solar home system)	Battery (to be replace in 5 years) and charge controller (between 8-10 years)
Costs of technically critical part: (costs of that part)	80 US$ for Battery 120 US$ for charge controller

Sunlabob rental systems (2002-present) - Rented Solar Home System

Type of project:	Pilot
Location of the plant:	Bansorg, Sangthong district, Vientiane municipality
Year of Implementation:	2003
Operator: (Name and address)	Mr. Bualay and Mr Khamsao Bansorg, Sangthong district, Vientiane municipality
Planner: (Name and address)	Sunlabob rural energy system Co. LTD P.O.Box 9077. Watnak. Vientiane, Lao PDR
Description of the technology: (name, function, supplier)	Solar home system including: 1 x 110 Wp Solar Panel 1 x 5 A Stecca Charge Controller 1 x mounting pole 1 x 120 Ah Sealed deep cycle battery 2 x 7 W Energy saving lamps
Energy service to be generated: (like electricity, light, heat, etc.)	Electricity for lighting and radio
Plant type: (grid connected, stand alone, solar home system, hybrid)	Stand alone, solar home system
Producer of modules	Suntech-power Co., Ltd
Amount of modules	1
Total module area	0,25 m²
Power output of installation: (kW or others like light generation)	150 Watt AC output (21" colour TV, VCD) 20 W DC lamps
Nominal voltage:	12 V
Number of inverter:	1
Income from enery service:	40 US$ per month from evening TV and VCD movies shows
Saving from energy service:	~ 230 US$/year Diesel for 3 hrs daily gen. set running (1 litters per day x 0,65 $/L x 365 days)
Uptime of installation: (meaning availability of service in the day, e.g. solar lamp at night)	Availability 3 days without sun, 3 hours of power available per day
Investment costs:	10 US$ one-time connection fees, and 15$ monthly rent
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	15 $/month x12 months = 180 US$/year monthly rent
Labour intensity per power unit or year: (amount of work per kWh or year)	Not labour intense automatic charge control
Labor costs: (costs of a correctly skilled operator per day, month or year)	village technicians get their margins from total monthly rents
Technically critical part: (most likely to fail part, like engine in genset or battery in solar home system)	Battery and charge controller
Costs of technically critical part: (costs of that part)	100 US$ (battery) and 60 $ (Charge controller) If fault, company replaces it without any charges from users

Sunlabob rental systems (2002-present) - Solar PV water Pumping system for rural community

Type of project: (R&D, pilot scale or full scale)	Pilot scale
Location of the plant:	Bansorg, Sangthong district, Vientiane municipality
Year of Implementation:	2005
Operator: (Name and address)	Mr. Bualay and Khamsao Bansorg, Sangthong district, Vientiane municipality
Planner: (Name and address)	Sunlabob Rural energy system Co.LTD P.O.Box 9077. Vientiane, Lao PDR www.Sunlabob.com
Description of the technology: (name, function, supplier)	Community Solar PV water pumping system 4 x Solar panels 1 x Water Pump set (ETAPUMP & Controller, Lorentz) Water tank V = 16.000 L Water pipes + taps Delivery water pipes
Energy service to be generated: (like electricity, light, heat, etc.)	Electricity to drive water pump from a river (35 m delivery head)
Plant type:	Stand alone water pumping system
Producer of modules	Suntech – power Co., Ltd (China)
Amount of modules	4
Total module area	3.8 m²
Power output of installation: (kW or others like light generation)	4 x 110 = 440 Watt
Nominal voltage:	24 V
Number of inverter:	0
Income from enery service:	Pumped water is to be distributed among villagers, who have to pay monthly fees (about 10.000 kips)[11] for used water
Saving from energy service:	saved times and labour of women and children for carrying water from the river
Uptime of installation: (meaning availability of service in the day, e.g. solar lamp at night)	Water pumping for about 6 hours daily and serves villagers during the day through distribution pipe-network and faucets
Investment costs:	5.200 US$ (PV+Pump set, here not included costs of water tank construction materials, and water distribution components)
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	~ 10 US$ / year (lubrication oil)
Labour intensity per power unit or year: (amount of work per kWh or year)	none
Labor costs: (costs of a correctly skilled operator per day, month or year)	**5** US$/month (labour charges for two village technicians)
Technically critical part	Water pump (imported from Europe)
Costs of technically critical part: (costs of that part)	1.800 US$ /year

[11] These monthly fees are under negotiation between Sunlabob and village authority.

Appendix 6: Selected Profiles of Energy Crops

Rice profile

Name:	Rice
Latin Name:	Oryza sative Family
Appearance:	Blades with one panicle
Size:	50 -160 cm
Cultivation:	Mainly wet cultivation
Origin:	Tropics and Subtropics of Asia
Spreading:	Tropics and Subtropics of Asia (e.g. Burma, Thailand, Laos, South of China); USA; North of Italy
Usage:	Food
Yield/ha: Whole Plant	_____
Yield/ha: Grain	3
Dry Matter at Harvest Time:	2,1
Water Consumption:	600
Cultivation Time (days):	120
Regular Harvest Time:	March – July
Harvest Time with the highest Biomass Yield:	120
Crops per Year:	3
Dry Matter/Year in Ton:	0,19

Sweet corn *Zea mays L. saccharate*

Name:	Sweet corn
Latin Name:	Zea mays L. var. saccharata
Appearance:	Green leaves, yellow grains
Size:	Up to
Cultivation:	Needs many nutrients
Origin:	Mexico
Spreading:	Tropics, Subtropics; by cultivation: temperate zone
Usage:	Food
Yield/ha: Whole Plant	______
Yield/ha: Grain	5
Dry Matter at Harvest Time:	3
Water Consumption	400
Cultivation Time (days):	80
Regular Harvest Time:	every year
Harvest Time with the Highest Biomass Yield:	80
Crops per Year:	5
Dry Matter/Year in Ton:	0,68

Soybean Glycine max Merr.

Name:	Soy bean
Latin Name:	Glyzine maxi Merr.
Appearance:	Per stem. 3 oval scraped green leaves, blossom: lilac to white
Size:	30 – 200 cm
Cultivation:	Warm with sufficient precipitate; soil: loose, aerate, good water retaining ability, slightly acidic to neutral
Location:	High temperatures, sunny
Origin:	Probably China
Spreading:	Worldwide in warm regions, especially: China, Brazil, North America, Africa, Balkan countries
Usage:	Food
Yield/ha: Whole Plant	______
Yield/ha: Grain	4
Dry Matter at Harvest Time:	1,8
Water Consumption	375
Cultivation Time (days):	75
Regular Harvest Time:	May – July
Harvest Time with the Highest Biomass Yield:	75
Crops per Year:	5
Dry Matter/Year in Ton:	0,35

Mung bean *Vigna radiata*

Name:	Mung bean
Latin Name:	Vigna radiata
Appearance:	10 cm long legumes
Size:	0,30 m – 1,50 m
Cultivation:	Heavy, robust soil pH value 4,5 – 6,5 can be cultivated up to 2000 m high
Location:	Warm between 20 – 28°C
Origin:	East Asia
Spreading:	South East Asia, Australia, America, East Africa
Usage:	Food
Yield/ha: Whole Plant	_____
Yield/ha: Grain	3
Dry Matter at Harvest Time:	1,35
Water Consumption:	225
Cultivation Time (days):	45
Regular Harvest Time:	every year
Harvest Time with the Highest Biomass Yield:	45
Crops per Year:	8
Dry Matter/Year in Ton:	0,33

Appendix 7: Monitoring of the Crop Cultivation in Various Stages

The team of CDEA was responsible for the cultivation monitoring. Appendix 7 gives an overview about this activity.

Monitoring of the energy crop cultivation on December 27./29., 2005

Field visit:	December 27, 2005
Crop name:	Mustard, local variety
Seed sowing:	November 2, 2005
Transplanting:	November 24, 2005
Up to date:	55 days

Can grow any season said Mr . Thongchanh, Head of Hatedokeo Horticulture Station (in case of using fertilizer)

Field visit:	December 27, 2005
Crop name:	Mustard, local variety
Up to date:	45 days

Seed sowing direct (no transplanting)

Transplanting:	November 24, 2005

Cultivation by traditional way

No fertilizer application

Easy growand can cultivate any season, said Mr. Khamseng (farmer)

Field visit:	December 29, 2005
Crop name:	Rice
Variety	TDK-7
Seed sowing:	December 1, 2005
Up to date:	28 days informed by Mr. Thongchanh head of Hatdokeo Horticulture Station.

Field visit:	December 27, 2005
Crop name:	Soy bean
Variety	HDK-4
Seed sowing:	November 22, 2005
Up to date:	35 days

Field visit:	December 27, 2005
Crop name:	HDK-186
Seed sowing:	December 15, 2005
Up to date:	12 days

Field visit:	December 29, 2005
Crop name:	Maize
Variety	HDK-4
Seed sowing:	November 01, 2005
Up to date:	56 days

Field visit:	December 29 2005
Crop name:	Maize (sweet corn)
Variety	Super sweet
Seed sowing:	October 09, 2005
Up to date:	80 days

Field visit:	December 29 2005
Crop name:	Water hyacinth

They grow in water
There is a lot in Laos
Easy to grow
It was suggested by Mr. Viengsavanh, Manager of Center International of Agriculture Tropical (CIAT) that this crop can give high potential of biomass.

Monitoring of the energy crop cultivation on January 6, 2006

Field visit:	January 6, 2006
Crop name:	Mung bean
Variety:	HDK-186
Seed sowing:	December 15, 2005
Up to date:	22 days

Field visit:	January 6, 2006
Crop name:	Soy bean
Variety:	HDK-4
Seed sowing:	November 22, 2005
Up to date:	45 days

Field visit:	January 6, 2006
Crop name:	Maize
Variety:	HDK-4
Seed sowing:	November 01, 2005
Up to date:	64 days

Field visit:	January 6, 2006
Crop name:	Rice
Variety:	TDK-7
Seed sowing:	December 01, 2005
Up to date:	36 days informed by Mr. Thongchanh, Head of Hatdokeo Horticulture Station.

Field visit:	January 6, 2006
Crop name:	Mustard, local variety
Seed sowing:	November 02, 2005
Transplanting:	November 24, 2005
Up to date:	65 days

Can grow any season said Mr . Thongchanh, Head of Hatedokeo Horticulture Station
(in case of using fertilizer)

Monitoring of the energy crop cultivation on February 10th, 2006

Field visit:	February 10, 2006	 
Crop name:	Maize	
Variety:	HDK-4	
Seed sowing:	November 21, 2005	
Up to date:	99 days	

Field visit:	February 10, 2006	
Crop name:	Rice	
Variety:	TDK-7	
Seed sowing:	December 01, 2005	
Up to date:	71 days	

Field visit:	February 10, 2006	 
Crop name:	Soy bean	
Variety:	HDK-4	
Seed sowing:	November 22, 2005	
Flowering stage:	At between 21-28 December, 2005 (at 28-35 days after seed sowing)	
Milky stage:	At between 5-9 January, 2006 (at 44-48 days after seed sowing)	
Ripening stage:	15-25 January, 2006 (at 54-64 days after seed sowing)	
Harvest for seed:	At February 3, 2006	
Total 73 days after seed sowing		

Field visit:	February 10, 2006
Crop name:	Mung bean
Variety:	HDK-186
Seed sowing:	December 21, 2005
Up to date:	99 days

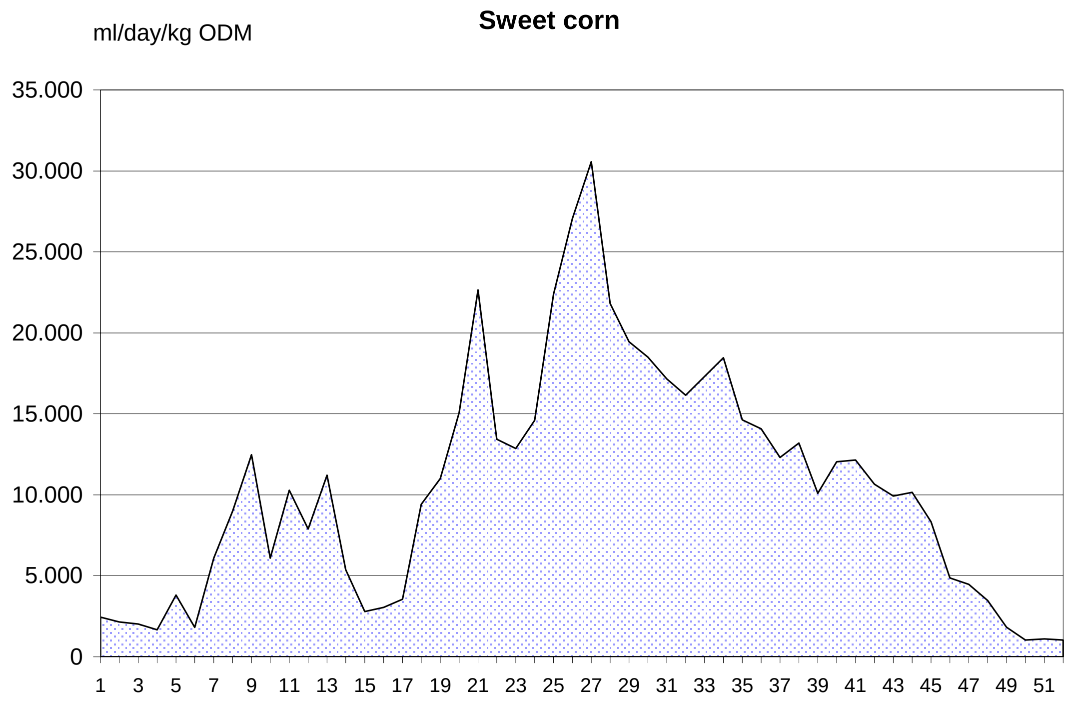
Field visit:	February 10, 2006
Crop name:	Mustard
Seed sowing:	November 02, 2005
Flowering stage:	25-31 December, 2005 (at 53-59 days after seed sowing)
Milky stage:	1-7 January, 2006 (at 60-70 days after seed sowing)
Ripening stage:	15-25 January, 2006 (at 74-84 days after seed sowing)
Harvest for seed:	At January 31, 2006
(Total 90 days after seed sowing	

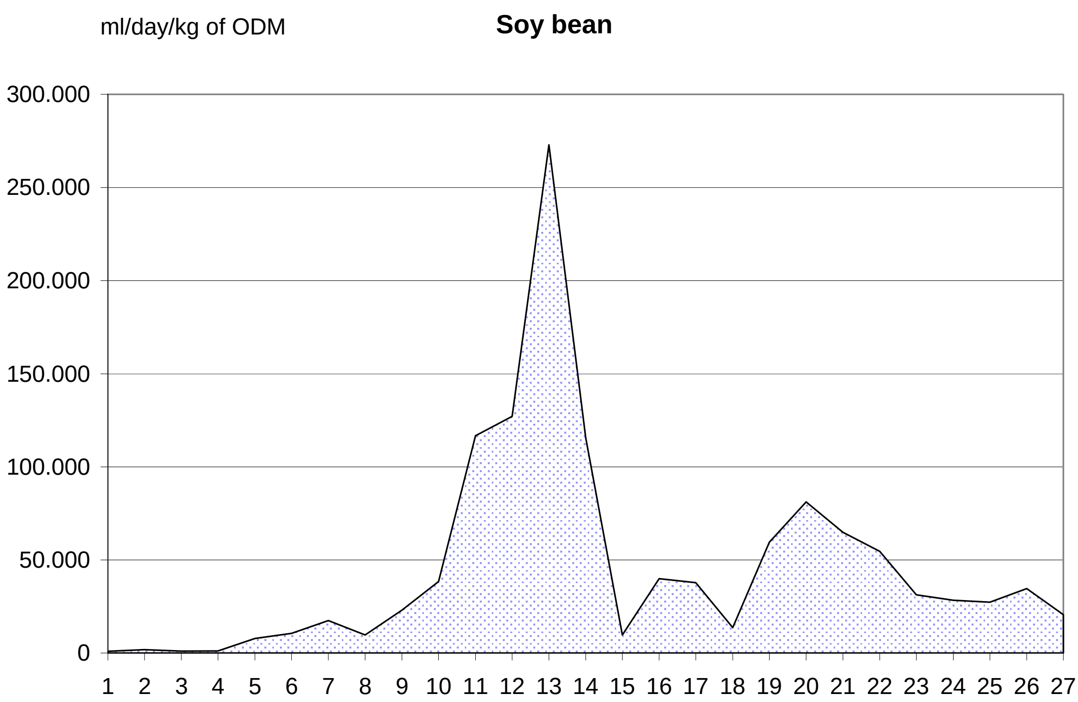
Appendix 8: VDI Guidelines 4630 “Vergärung organischer Stoffe” (Fermentation of organic substances)

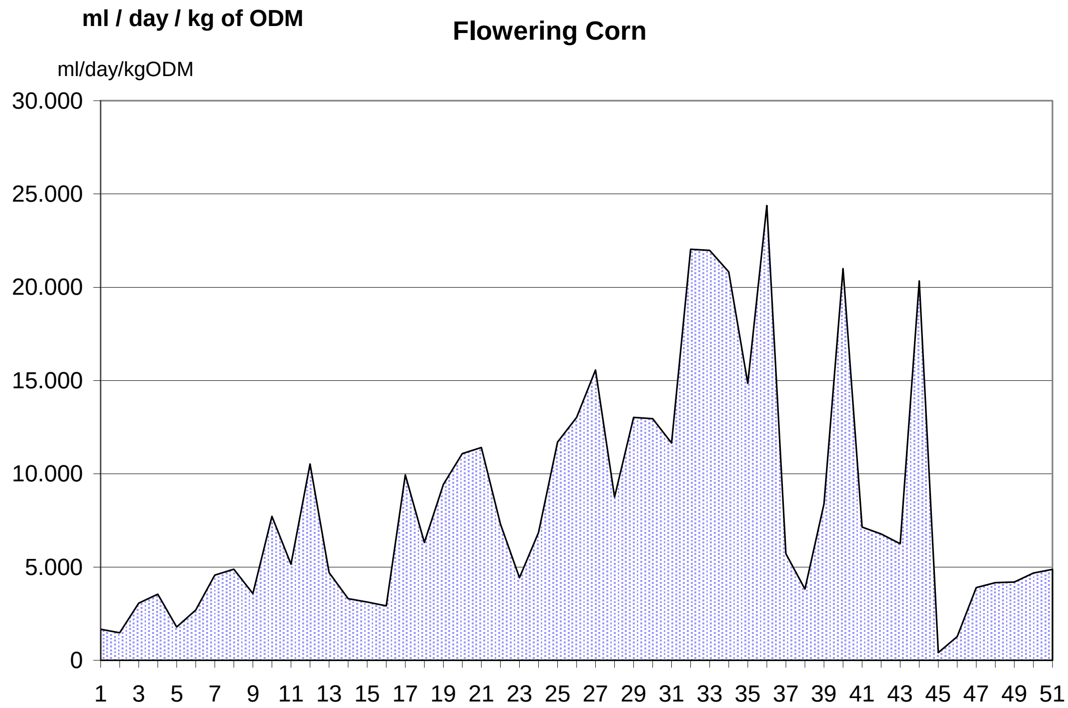
Appendix 9: Crop Data Sheets

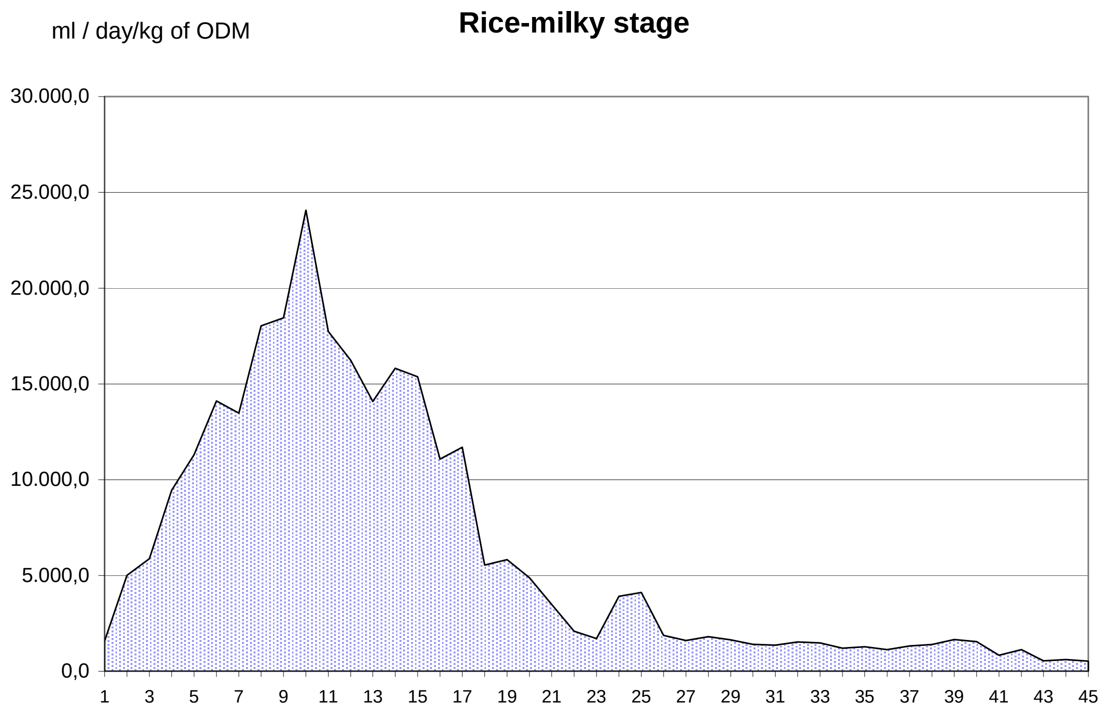
Appendix 10: Laboratory Analysis Results

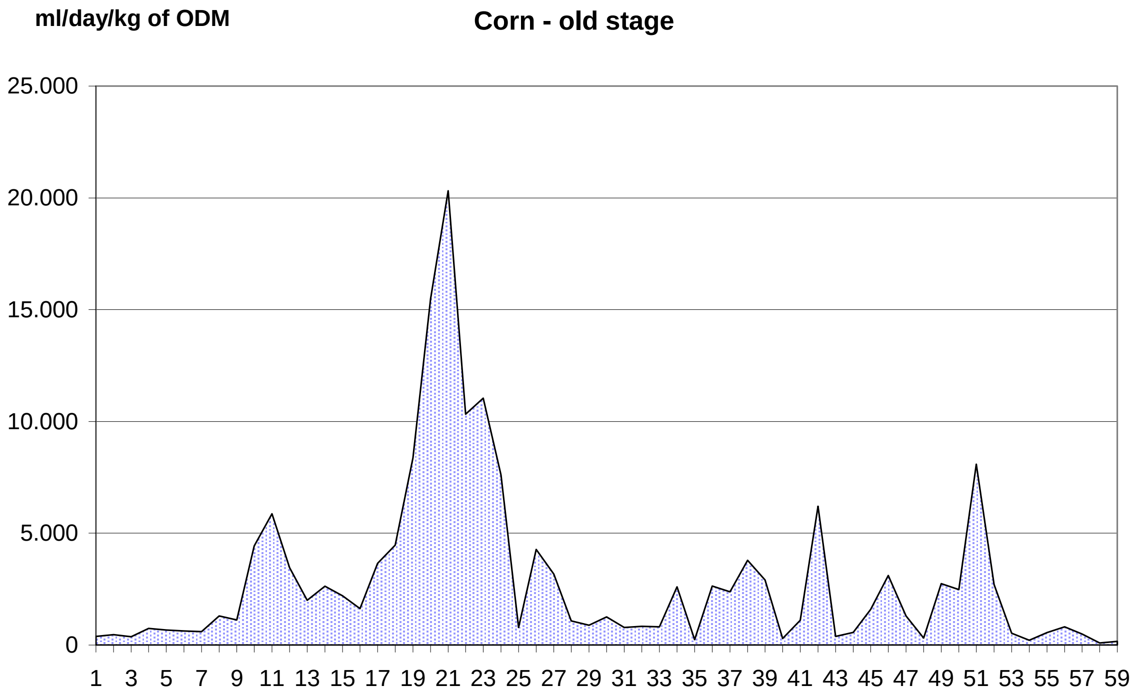
Mono crop trails

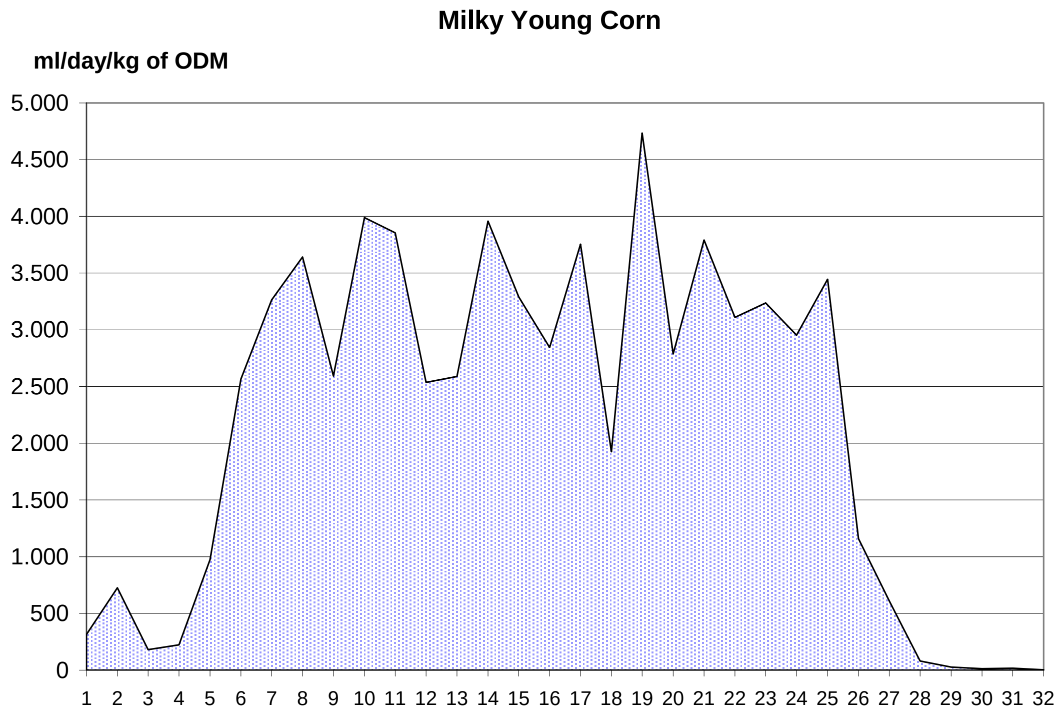


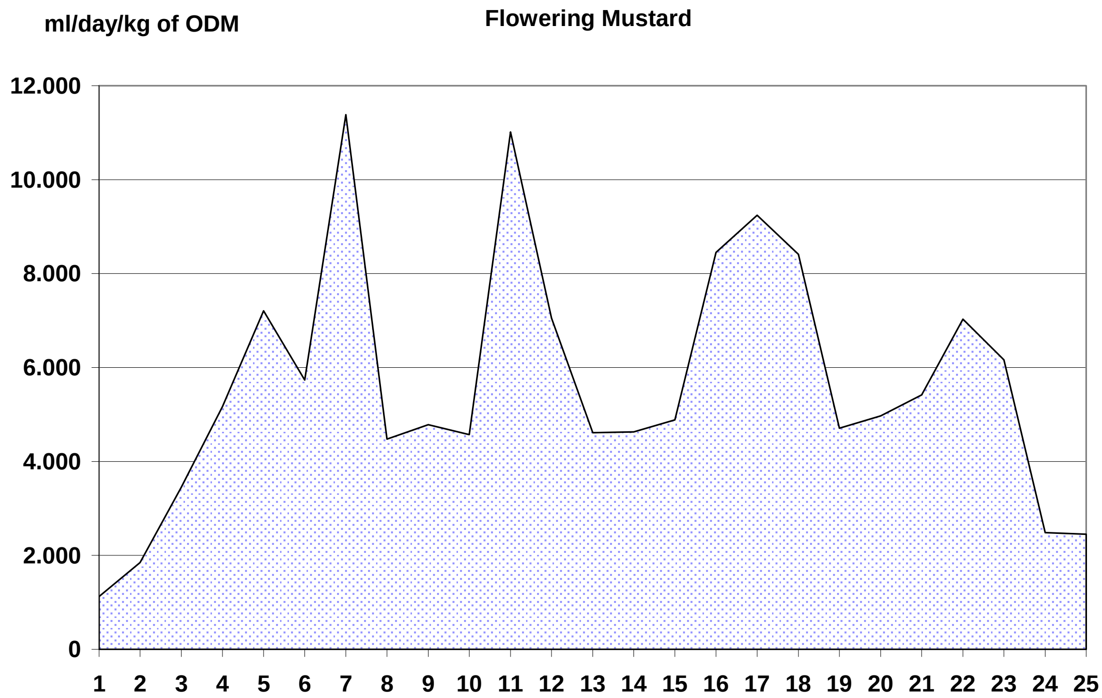


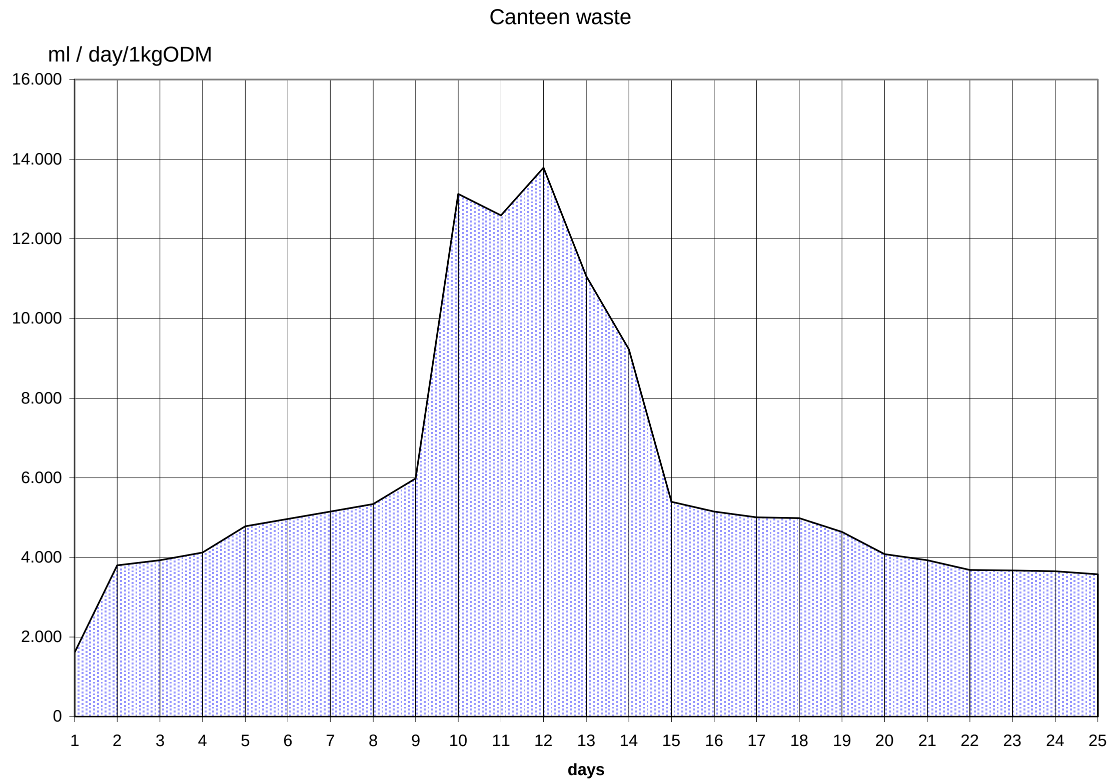

ml / day / kg of ODM
Flowering Corn
ml/day/kgODM
30.000
25.000
20.000
15.000
10.000
5.000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51


ml / day/kg of ODM
Rice-milky stage
30.000,0
25.000,0
20.000,0
15.000,0
10.000,0
5.000,0
0,0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45

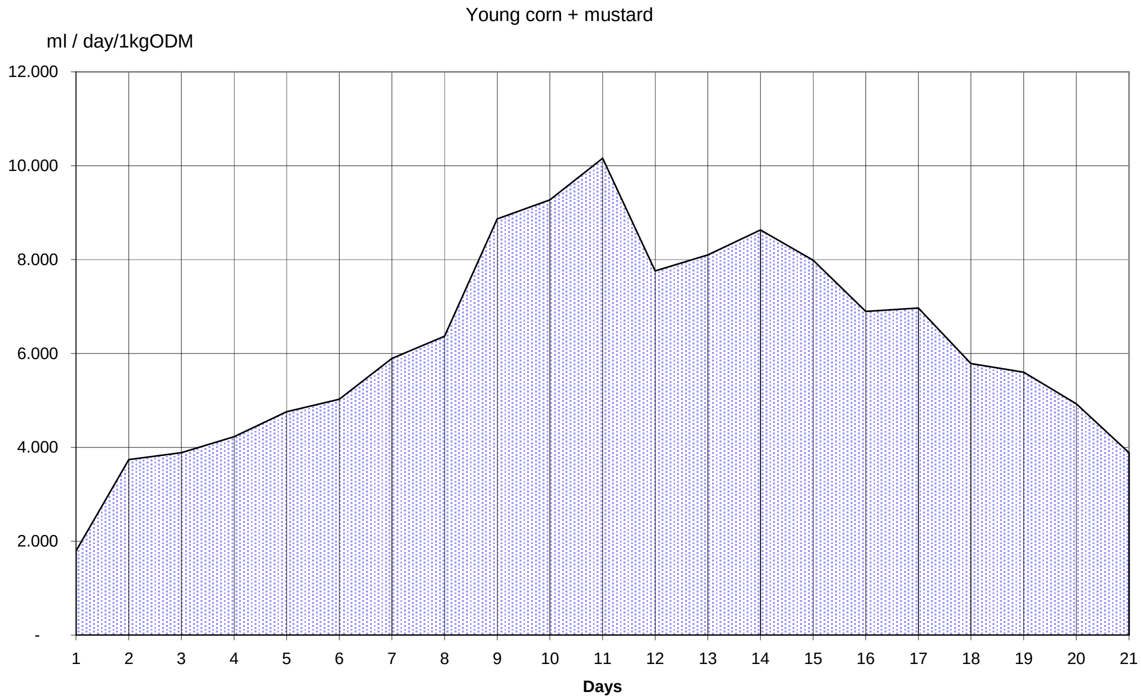

ml/day/kg of ODM
Corn - old stage
25.000
20.000
15.000
10.000
5.000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59

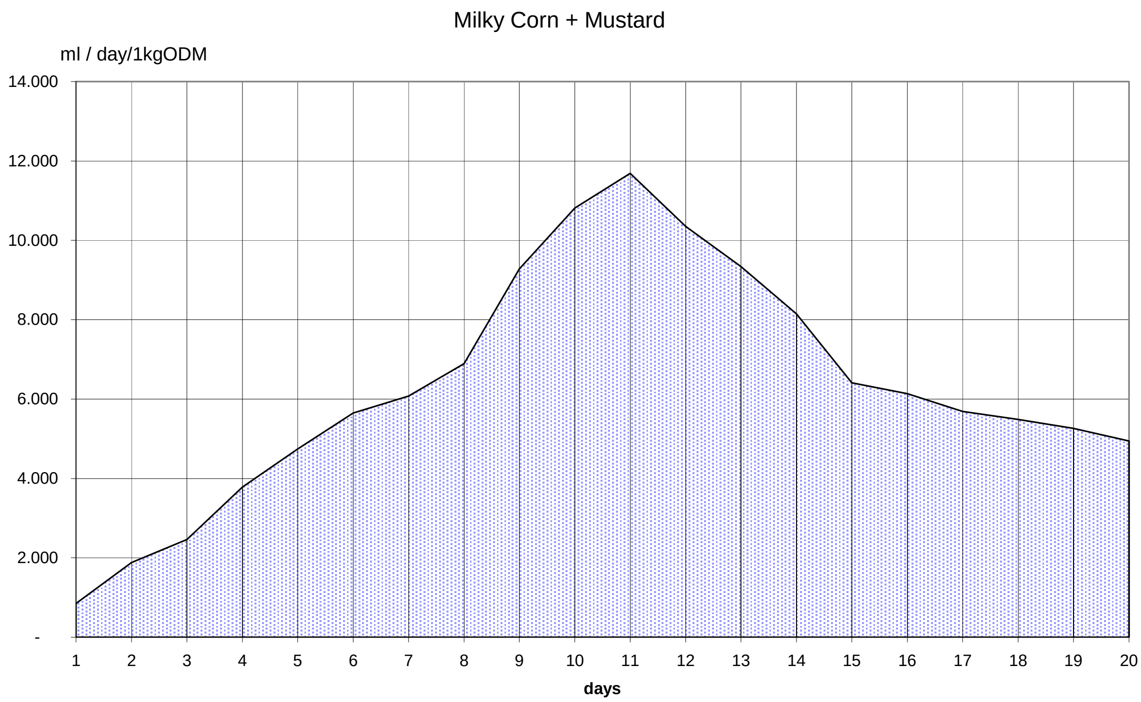

Milky Young Corn
ml/day/kg of ODM
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
500
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

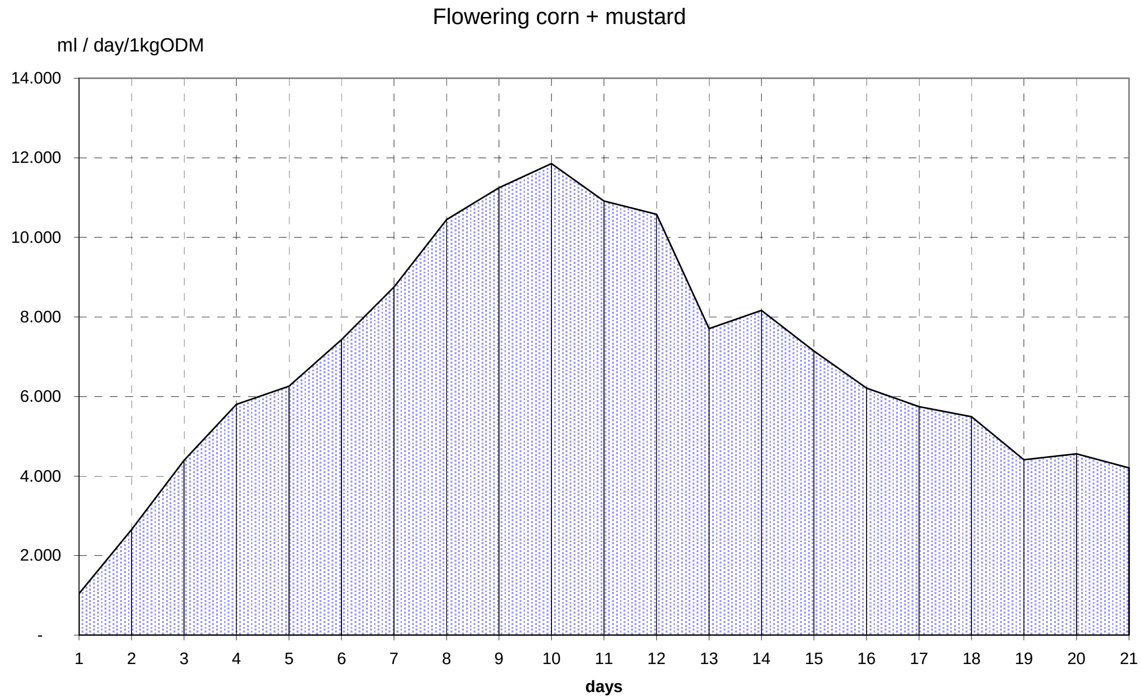

ml/day/kg of ODM
Flowering Mustard
12.000
10.000
8.000
6.000
4.000
2.000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25


Canteen waste
ml / day/1kgODM
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
days

Mixed trails






Flowering corn + mustard
ml / day/1kgODM
14.000
12.000
10.000
8.000
6.000
4.000
2.000
-
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
days

Appendix 11: Biogas Technology data sheets

10.1.1.1 TRI-CTTE demonstration biogas plant at RETC

Type of project:	Demonstration
Location of the plant:	Renewable Energy Technology Centre (RETC), km 14. Xaythany district, Vientiane municipality
Year of Implementation:	1999
Operator: (Name and address)	Mr. Souk RETC, Km 14 Xaythany district, Vientiane municipality
Planner: (Name and address)	Mr. Soukanh Vannapho, Technology Research Institute (TRI), STEA Tel.: 021 218711; Mobile: 020 5666982
Volume and type	8 m^3 ,Dome type
Description of the technology: (name, function, supplier)	*dry matter content:* low-solids digestion (water content >90 %) *temperature:* mesophilic process (35-37 °C) *number of involved digesters:* two-step procedures *running of the process:* continuous flow reactor
Co-generator: ($kw_{el,}$ performance, invest and maintenance)	None
Energy service to be generated: (like electricity, light, heat, etc.)	Heat for cooking
Biogas production:	460 m^3/year
Income from biogas production:	
Saving from biogas production:	~ 2.3 US$/month saved charcoal (1 bag x 20 kg/bag)
Energy production:	2.700 kWh/year (thermal energy for cooking)
Energy consumption per year: (energy demand for plant operation)	No
Income from energy production:	no
Saving from energy production:	No
Heat production:	none
Heat consumption per year: (energy demand for plant operation)	None
Income from heat production:	None
Saving from heat production:	None
Operation hours per year:	> 3.200 hrs/year

(meaning availability of service in hours, e.g. solar not a night)	(3 hours per day for cooking only)
Inestment costs:	1,100 US$ (CTTE's grant)
Input material:	Input1: human increment 900 kg / year
Amount and kind of livestock	permanent inhabitants: 4 people, occasional (trainees): 10-15 people x 2 times/year X 5 days/times
Amount of digestate:	not collected
Use of digestate:	None
Income from digestate:	None
Saving from digestate:	None
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	Information not available
Labour intensity per power unit or year: (amount of work per kWh or year)	Information not available
Labor costs: (costs of a correctly skilled operator per day, month or year)	not applied (the user operates digester him self)
Technically critical part: (most likely to fail part, like engine in genset or battery in solar home system)	None
Costs of technically critical part: (costs of that part)	None

10.1.1.2 Lao-Chinese Cooperation program's biogas plants

Type of project:	Demonstration
Location of the plant:	Nongphouvieng village, MaiPakngum district, Vientiane municipality
Year of Implementation:	2004
Operator: (Name and address)	Owners operate digesters by themselves, with support from village technician
Planner: (Name and address)	Chinese Technicians, (address is not available)
Volume	6 m^3
Description of the technology: (name, function, supplier)	*dry matter content:* low-solids digestion (water content >90 %) *temperature:* mesophilic process (35-37 °C) *number of involved digesters:* two-step procedures *running of the process:* continuous flow reactor
Co-generator: ($kw_{el,}$ performance, invest and maintenance)	None
Energy service to be generated: (like electricity, light, heat, etc.)	Heat for cooking and light
Biogas production:	797,7 m^3/year
Income from biogas production:	No
Saving from biogas production:	20.000 kip/bag x 2 bags ~ 4 US$/month saved charcoal
Energy production:	.none
Energy consumption per year: (energy demand for plant operation)	No
Income from energy production:	no
Saving from energy production:	No
Heat production:	none
Heat consumption per year: (energy demand for plant operation)	None
Income from heat production:	none
Saving from heat production:	None
Operation hours per year: (meaning availability of service in hours, e.g. solar not a night)	~ 2200 hrs/year Daily use: cooking (3 hrs/day) and lighting (3 hrs)
Inestment costs:	450 US$
Input material:	Input1: pig manure, 2.190-2.320 kg / year

Amount and kind of livestock	3-4 pigs
Amount of digestate:	~ 200 kg/month
Use of digestate:	Use in vegetable planting. Vegetable is for self consumption and for sale at the district centre's or to tradesmen from Vientiane municipality markets
Income from digestate:	(no direct income)
Saving from digestate:	Information not available
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	None
Labour intensity per power unit or year: (amount of work per kWh or year)	Information not available
Labor costs: (costs of a correctly skilled operator per day, month or year)	not applied (users manage and operate the digesters themselves)
Technically critical part: (most likely to fail part, like engine in genset or battery in solar home system)	None
Costs of technically critical part: (costs of that part)	None

10.1.1.3 Sunlabob's Commercial-based biogas plant

Type of project:	Demonstration
Location of the plant:	Bansorg village, Sangthong district, Vientiane municipality
Year of Implementation:	2005
Operator: (Name and address)	Mr. Bualay Keomangkorn, & Mr. Khamsao Khamphravongsa, Bansorg village, Sangthong district, Vientiane municipality
Planner: (Name and address)	Sunlabob Co. (Watnak. Vientiane mun.) SNV (Naxay. Vientiane mun.)
Volume	6 m^3
Description of the technology: (name, function, supplier)	*dry matter content:* low-solids digestion (water content >90 %) *temperature:* mesophilic process (35-37 °C) *number of involved digesters:* two-step procedures *running of the process:* continuous flow reactor
Co-generator: ($kw_{el,}$ performance, invest and maintenance)	None
Energy service to be generated: (like electricity, light, heat, etc.)	Heat for cooking: daily biogas output is enough for cooking meals for four - members family
Biogas production:	~900 – 1000 m^3/year
Income from biogas production:	None (for self consumption only)
Saving from biogas production:	Exact values were not yet evaluated. Currently biogas can substitute firewood for daily cooking, which counted for 50-60 kg/months. Firewood is collected from plantation or nearby community forests with no charges. Biogas may help saving women times for collecting wood and cooking; reducing hazardous from smokes
Energy production:	None
Energy consumption per year: (energy demand for plant operation)	None
Income from energy production:	None
Saving from energy production:	None
Heat production:	none

Heat consumption per year: (energy demand for plant operation)	None
Income from heat production:	none
Saving from heat production:	None
Operation hours per year: (meaning availability of service in hours, e.g. solar not a night)	~ 3.285 h cooking and lighting (3 times/day x 3 hrs/time x 365 days/year)
Investment costs:	500 US$
Input material:	Input1: pigs manure, 4.200 kg /year (estimation)
Amount and kind of livestock	5-6 pigs,
Amount of digestate:	Information not available
Use of digestate:	(for vegetable planting),
Income from digestate:	(not estimated yet)
Saving from digestate:	Information not available
Yearly service costs of operation: (e.g. lubrication oils, battery fluid)	Information not available
Labour intensity per power unit or year: (amount of work per kWh or year)	Not applied yet
Labor costs: (costs of a correctly skilled operator per day, month or year)	Not evaluated yet
Technically critical part: (most likely to fail part, like engine in genset or battery in solar home system)	None
Costs of technically critical part: (costs of that part)	None

Appendix 12: Financing Biogas through Microfinance in Nepal

WINROCK INTERNATIONAL

Project Description

Winrock International is collaborating with the Nepal Biogas Support Programme (BSP) and Alternative Energy Promotion Centre (AEPC) to promote the installation of high quality biogas plants in Nepal. With the support of the Nepali, Dutch and German governments and USAID, more than 120,000 plants have been installed since 1992.

Background

The key to BSP's success so far is its innovative pairing of government and international donor support with private sector involvement, and strong quality control mechanisms and monitoring infrastructure. Today there are 40 companies that construct, market, install and provide guarantees for the biodigesters. These companies directly employ approximately 5,000 people, mostly masons but also some office staff. Indirect employment in terms of materials manufacturing, transportation and operation and maintenance (O&M) training is estimated to be another approximately 6,000 people. BSP provides extensive quality control services for the biogas program. Each year BSP's quality control officers randomly visit 5% of the plants constructed in that and each of the previous two years to monitor plant quality and durability and the quality of O&M training provided to users. Ensuring high quality plants has given confidence to users to purchase new systems, to banks to provide financing, and to NGOs to continue promoting the use of renewable biogas energy among rural populations in the country.

The program is currently structured as follows. A purchaser of a biogas digester buys the system directly from the manufacturer, who sells it at a cost of Rs 17,000-20,000 (US $240-285). The manufacturer receives a subsidy from the government for the balance of the system cost, which ranges from Rs 5,500 to 11,500 (US $78-163), depending on the size of the plant and the geographic area in which it is installed.[12] At present, 75% of the purchasers have sufficient disposable income to pay for the systems up front. The remaining 25% of users take loans from the Agricultural Development Bank (ADB/N) or one of approximately 59 participating savings and credit cooperatives, rural development banks, microfinance institutions, and other rural finance providers (all jointly referred to as MFIs in this document) to purchase their systems. The ADB/N provides a 5-year loan with collateral at 15% interest, but access to ADB/N financing is limited to larger towns. MFIs provide loans for 18 months using group collateral at an interest rate not exceeding 16%.

BSP has a goal of installing an additional 200,000 biodigesters by 2009. Most of those who can afford to purchase biodigesters without the aid of credit—the "low-hanging fruit"—have already been tapped. Though there is high demand for biogas among poorer people, most of these potential customers cannot afford to pay for the systems up front and do not have

[12] The government subsidy for biogas decreases every year, with the goal of doing away with the subsidy altogether once the biodigester market is sufficiently robust.

access to the 59 participating MFIs in their area. Therefore, they cannot access these improved biogas services (and take advantage of the government subsidy).

Microfinance for Biogas Energy

Winrock is working with BSP to significantly expand the installation and use of biodigesters by increasing access to microfinance for lower-income purchasers. Since 2003 Winrock has identified, trained and worked with more than 200 MFIs by training them about biogas and its benefits and how to access available funding sources for lending for biogas. Using a reference manual developed by Winrock to demonstrate the viability of biogas technology as an MFI loan product, Winrock, together with AEPC and BSP, has organized more than ten trainings for almost 200 MFIs in different parts of the country. MFIs from more than 30 districts of Nepal have participated the training programs.

Winrock is also working with AEPC, the agency responsible for managing the Nepal Government's renewable energy subsidy program and a revolving fund in the amount of 2.5 million Euros to finance the purchase of biogas plants around the country, to allow microfinance apex bodies to receive AEPC financing for biogas. This is expected to significantly increase the number of MFIs providing loans for biogas systems—and thus the number of systems in operation.

Anticipated Results

The ultimate goal is to increase sales of biodigesters to at least 200,000 additional rural households by 2009. The number of biodigester construction companies is expected to remain relatively constant, but the number of masons employed to construct the plants is expected to increase by 25%. Winrock expects that some 40,000 poor households will have received loans for biogas plants from MFIs by 2009 as a direct result of this work.

By making high quality biogas digesters available at a reasonable price, the proposed project will improve access to modern energy services in rural Nepal and will achieve significantly increased health, socio-economic, and environmental benefits, including:

- Biogas displaces dirtier, less efficient cooking fuels and reduces the consumption of firewood at a rate of 2 tons per biogas household per year.
- Each biogas plant will reduce greenhouse gas emissions, such as carbon dioxide, N_2O and CH_4, from fuelwood and cow and buffalo manure. An additional 200,000 biogas plants installed will offset additional 920,000 tons of CO_2 per year.
- Household biogas technology has proven to have significant health benefits, particularly to women and children, by reducing indoor smoke, which causes eye infections and acute respiratory infection, the leading cause of death in children under five.
- Women and girls in households with biodigesters save an average of 3 hours per day on firewood collection, cooking, and cleaning pots. They can use their saved time for other income generating activities.
- Around one quarter of the biogas users have substituted biogas for lower quality, dirtier, more dangerous and more expensive kerosene lighting.
- Approximately 5,000 people are employed by the 40 private companies that build the biogas plants.

- Over 70% of biogas plant owners have built sanitary toilets attached to their biogas plants (for the plants constructed in the past year this number is around 92%), resulting in improved hygiene and sanitation.
- Farmers use the slurry produced as organic fertilizer, replacing lower quality and costly fertilizers that must be purchased.
- The slurry also is very useful as fish food. Research has shown that using slurry as fish food, fish growth can almost double.
- Increased job creation and income generating opportunities for rural people and biodigester producers/distributors.
- Reduce the use of chemical fertilizer. Winrock estimates that the use of the fertilizer urea will be reduced by around 6,000 tons as a result of the expansion.
- Farmers with biogas plants have switched from grazing their animals on the farm or in public locations to stall feeding them in order to capture the manure more easily. Thus, more land is spared from overgrazing, more compost fertilizer is now available to farmers, and public spaces have become more sanitary.
- Reduced deforestation resulting from decreased wood fuel use.
- Improving local sanitary conditions by encouraging the building of sanitary toilets at the same time as biogas plants are constructed, as described above.