

# Bio-Energy Science and Technology Innovation and Policy in Lao P.D.R

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**Abstract:** Lao PDR lacks of conventional energy resources (e.g., Oil or Natural Gas) and 100% of fossil fuels are imported from abroad (mainly through Viet Nam and Thailand) that Fossil fuel consumption in Lao PDR is rising rapidly. In 2008, Lao PDR imported 558 million litres of fossil fuel, an increase from 450 million litres in 2006, which in 2010 will be 561 million litres and 716 million litres by 2015. Therefore, The government in Lao-PDR has planned for developing a strategic reserve of petroleum fuel to help meet the requirement of the country during times of crisis that the government of Lao PDR has provide several schemes for promotion of agriculture sector and renewable energy in the country. The Government aims to increase the share of renewable energies to 30% of the total energy consumption in 2025. To reduce the importation of fossil fuels, the Government outlines a tentative vision to reach 10% of the total transport energy consumption from biofuels is set for the same period.

**Keywords:** Bioenergy, Science, Technology Innovation and policy.

## 1. Introduction

The worldwide scarcity of raw mineral materials: petrol underground reserves sufficient for another 50-60 years, natural gas for about 150 years, and coal for about 200 years. International demand of fuels grows exponentially that affects high international prices and contributes to global warming. Therefore, it becomes time to move towards fuel savings strategies and substitute alternatives sources of energy development along with new adapted technologies. Many countries support and promote new technologies that make use of other renewable resources. Especially of the Lao People Democratic Republic (Lao PDR) [3], that is a land locked country in Southeast Asia with a total land area of 2336,800 Km<sup>2</sup>. The country is bordered by China to the north, Vietnam to the east, Cambodia to the south, Thailand to southwest, and Myanmar to the northwest. Lao PDR has 17 provinces, and its capital and largest city is Vientiane, situated near the border with Thailand [1]. The total population is nearly 6.7 million, average per capital GDP is 960 US\$ per year [2] with a density of 24 persons per Km<sup>2</sup> and population growth rate of 2.5 percent a year. The country has 47 ethnic groups, with 120 ethnic subgroups and languages. Buddhism is the main religion. Lao PDR lacks of conventional energy resources (e.g., Oil or Natural Gas) and 100% of fossil fuels are imported from abroad (mainly through Viet Nam and Thailand) that Fossil fuel consumption in Lao PDR is rising rapidly. In 2008, Lao PDR imported 558 million litres of fossil fuel, an increase from 450 million litres in 2006. The Lao Ministry of Energy and Mines (MEM) estimates that fuel consumption in 2010 will be 561 million litres and 716 million litres by 2015. Estimates by the Lao State Fuel Company are even higher [4].

This requires a lot of investments in energy supply. In this regard, the country needs to use more its natural resources and to import more oil from abroad. These can cause negative impacts to the environment and increase greenhouse gas emission to the atmosphere. Therefore, the Government of Lao PDR as well as the Ministry of Energy and Mine are taking this energy consumption aspect into account seriously. One of the most effective measures and policies to minimize the associated issues, which the Government is currently promoting, is the Energy Efficiency and Conservation program. In this program, 10% of reduction in energy consumption by 2020 in all sectors is being proposed to the Government [6].

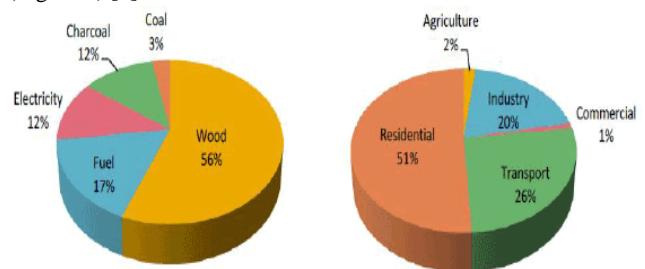
## 2. Previous Energy Consumption and Future Trend of Energy Demand in Lao PDR

Lao PDR is endowed with significant indigenous energy resources, in particular for electricity generation. Hydropower is the most abundant and cost-effective resource for electricity generation. The energy resources range from traditional energy sources such as fuel-wood to coal and hydropower. The forest areas, which cover over 47% of the total land, are a potential source for substantial traditional energy supplies [9].

### 2.1 Previous Energy Consumption in Lao PDR

Since 2000 the import of oil to the Lao PDR has increased annually by ~5%, and this is likely to accelerate to 10% when taking into consideration the rise in numbers of vehicles in the country [7]. The total primary energy demand in Lao PDR increased from 0.3 MTOE in 1990 to 0.9 MTOE in 2010 at an average annual rate of 6.6 percent. The Ministry of Energy and Mine (MEM) has estimated that in 2020, 914 million liters of fossil fuel will be needed. Coal started to figure in the primary energy mix in the late 2000's and had a 11.9 percent share in 2010 [6].

The energy consumption in the country is mainly in the form of traditional fuels, i.e., the use of biomass such as fuel wood (56%) and charcoal (12%) for cooking and heating in rural areas, urban people and small scale factories and industries such as brick factories, tobacco plants, in the noodle processing factories, salt factories, sugar processing plant and some saw mills. This represents around 69% of the total energy consumption. Energy consumption by sector shows that residential sector comprised 51% of energy consumption, followed by transportation with 26%, industrial 20%, and agriculture 2% respectively (Figure 1) [1].



**Figure 1.** Type of energy consumption and energy consumption by sector.

### 2.2 Future Trend of Energy Demand in Lao PDR

Today the vast majority of households in the Lao PDR rely on fuelwood, primarily in the form firewood and charcoal, to meet most of their cooking needs [8]. In which, the total domestic energy demand is anticipated to increase by 3.6 % per annum, increasing from 1.8 million TOE in 2005 to 3.9 million TOE in 2025 (Figure 2). Despite the fact that the overall demand of energy in various economic sectors will remain high until 2025, the share of household sector declines from 77.8% in 2005 to 48.5% in 2025. Energy demand in the industrial sector is increasing at around 8% per year or from 6.1% share to 16.9% during period 2005 to 2025, while the transportation sector grows at 6.8% per annum during that period. Electricity generation is predicted to increase at 11% annually for the period 2005 to 2025. Most of produced electricity is for export to neighboring countries and only 10% is used domestically. The domestic demand for electricity will increase from 425 megawatts in 2006 to 2,863 megawatts in 2025. This increase will be covered mainly by development of hydropower and coal-fired power plants. The demand for transportation fuel is predicted to increase by 5% per year. By 2025, the total demand for refined petroleum products will reach 1,174 million liters, of which 45% is for gasoline (528 million liters) and 55% is for diesel (645 million liters) [1].

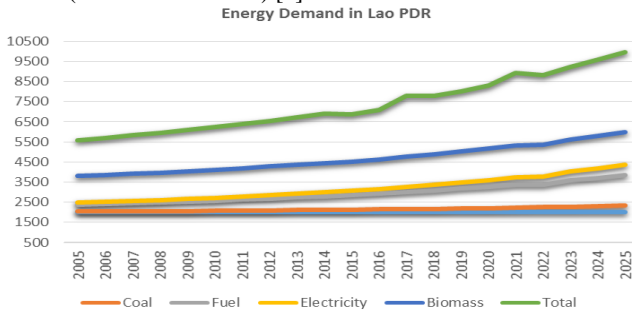


Figure 2. Energy demand in Lao PDR from 2005 to 2015.

Table 1. Estimate of energy demand in Lao PDR by 2025.

Type of energy/year	Coal	Fuel	Electricity	Biomass	Total
2005	30	360	87	1,322	1,789
2006	38	378	97	1,337	1,849
2007	43	406	107	1,352	1,907
2008	50	436	118	1,367	1,970
2009	57	469	130	1,382	2,037
2010	64	504	143	1,397	2,108
2011	73	543	157	1,412	2,184
2012	82	584	172	1,427	2,265
2013	92	629	188	1,442	2,351
2014	103	677	206	1,457	2,443
2015	115	729	225	1,442	2,351
2016	128	784	225	1,488	2,443
2017	142	845	267	1,503	3,003
2018	158	909	291	1,518	2,876
2019	174	979	317	1,533	3,003
2020	192	1,054	344	1,549	3,139
2021	212	1,135	374	1,594	3,604
2022	233	1,135	405	1,579	3,439
2023	256	1,315	440	1,594	3,604
2024	281	1,415	476	1,609	3,781
2025	308	1,523	516	1,624	3,971

The available renewable energy resources in the country can meet some domestic demand. Table 2 illustrates the potential of renewable energy resources of Laos, which may help achieving target of the government for the share of renewable energy up to 30% of energy consumption by year 2025, can be seen in the annex A.

### 3. Potential of Renewable Energy in Lao PDR

Lao PDR is agriculture-based country. It has abundant natural resources such as river, mountain, forest, etc., which can be turned into sources of energy generating production. Renewable energy development is an important component of the national economic development to ensure energy security, sustain socio-economic development, and enhance environmental and social sustainability [10]. Potential of biomass in Lao PDR includes energy crops and organic wastes. Energy crops comprise oily crop (palm, jatropha, veronica Montana, sunflower, beans, coconut, etc.), sugarcane, cassava, corn, and quick-growing tree and aquatic cultures. Organic waste includes residues of agriculture-forestry production, by products of agro-forestry industry (sawdust, wood chips, rice husk, corncobs, livestock, and manures) that can be used as fuel [1].

According to a national statistic 2007, wood fuel consumption was more than 2.5 million tons and accounted for nearly 80% of total consumption of the country. It is estimated that about 92% of households use wood for cooking. Besides wood fuel, an estimated 0.3 million tons of agricultural wastes were also available for use as a fuel. Below table 2 illustrates the potential of major biomass sources in Laos [12].

Table 2. The potential of biomass sources in Lao PDR [14].

No	Biomass types	Biomass production by volume (Ton/Year)	Energy Contents		Heating Values MJ/Kg
			GJ	Kteo	
1	Sawdust	24,067	433,206	10.25	18
2	Rice husk	751,925	10,730	254	14.27
3	Corncob	225,099	4,061	94	18.04
4	Baggasse	295,589	2,956	70.7	8-10
<b>Total</b>		<b>1,296,680</b>	<b>450,953</b>	<b>428.95</b>	

By 2020, it is estimated that domestic consumption of timber and plywood will increase to approximately 300,000 cubic metres per annum, assuming an equivalent per capita consumption. This is equivalent to round wood of approximately 600,000 cubic metres at 50 percent conversion. If the current level of sawn timber exports is maintained, total log removals of more than 1 million cubic metres will be required. Given probable sustainable log removals of approximately 300,000 cubic metres per annum, plantation wood will have to supply a large proportion of logs for both domestic consumption and export [13].

Municipal wastes (households' wastes, communal wastes, food-processing wastes). It was estimated that utilization of livestock wastes for biogas production could generate around 2.8×10<sup>8</sup> m<sup>3</sup> of biogas per year or equivalent to 5×10<sup>8</sup> kWh electricity (about 216 MTOE). Hydropower is the most important energy resources in Lao PDR, which technical potential was estimated around 26,000 MW, excluding small scale hydropower sites (below 15 MW) with estimated potential around 2000 MW. In the Lao PDR, hydropower projects with capacity below 15 MW are classified as small-scaled hydropower. There is lack of data on wine energy potential, particularly at a height above 50 m. According to international data source, there may be some wine potential in central provinces of Lao PDR, especially up of high mountains along Lao-Vietnam border (Savannakhet and Khammouane provinces) where at a height 50m above, wine

speeds reach 5.8m/s. The theoretical potential for wine energy in Lao PDR is estimated to be more than 182,000 MW though the potential under very good and excellent wine regimes is relatively small at around 2,800MW [1].

### 3.1 Status of Renewable Energy Development in Lao PDR

In the past, fuel crops plantation for production of biofuels had been initiated by private investors. These developments however were pilot and demonstration projects. The Government of Lao PDR has setup policy in order to promote biofuels production and use, particularly from jatropha and other appropriate energy feedstock. Installation of small solar home systems have been carried by public as well as private sectors, with funding from the World Bank, international organizations or own investment of local private companies. At present, around 20,000 households have been supplied electricity through solar home systems. Larger PV systems (capacity up to 40-100 kWp) have also been piloted within cooperation project between MEM and NEDO (Japan), as a component of a hybrid power system with micro hydropower in remote rural area.

In addition, micro hydropower and pico hydropower have been developed to supply electric power to households in off-grid remote rural areas. Upto now, installed capacity of small scale hydropower projects (capacity less than 15 MW) have reached 23 MW. Biodiesel development from Jatropha, Vernicia Montana, Animal Fat, used tires and City wastes have been piloted by private sector. Fuel crops plantation for biofuels production has also progressed, especially Jatropha, Vernicia Montana, Palm, Sugarcane, Cassava plantation. Parallel to development of renewable energy resources, energy efficiency and energy conservation (EE&EC) issues have played more and more important role in energy sector of Lao PDR [1].

### 3.2 Existing and Potential Biofuels producers in Lao PDR

Currently, there is no commercial production of biofuels in the Lao PRD. Three companies, Makkao Lao Biodiesel Ltd., Lao Agrotech Ltd., and Kolao Farm and Bio-Energy Company Ltd., have carried out pilot scale demonstrations for biodiesel production. There is no facility to produce bioethanol in the country [11].

#### 3.2.1 Makkao Lao Biodiesel Company Limited

This company has established a biofuel processing facility in the country that production capacity of 500 liters per day of crude oil from Vernicia Montana and expects to produce more than 10 tons per month of biofuel. The seeds of Vernicia Montana are rich in oil and traditionally used in rural areas of the region for lighting. The species have been introduced in the upland areas of the Northern provinces of Hauphanh, Oudomxay, Xiengkhaung, Laungprabang, Xayabury, Vientiane and Borikhamxay during last five years. In 2013, the plantation area of Vernicia Montana in the country is about 13,000 ha (see Table 3), which the plantation is raised with the help of local farmers following various contractual arrangements "1+4 farming contract" system in Hauphanh and "2+3 farming contract" system in remaining provinces [11].

**Table 3.** Area under Vernicia Montana plantation in the country.

Name of province	Districts No.	Villages No.	Households No	Area (ha)
Laungprabang	12	273	8,012	7,421
Hauphanh	8	131	2,941	3,505
Oudomxay	5	335	29,970	835
Xiengkhaung	5	25	139	351
Vientiane	7	13	106	202
Borikhamxay	2	4	4	4
Xayabury	1	6	-	800
<b>Total</b>	<b>40</b>	<b>787</b>	<b>41,172</b>	<b>13,119</b>

#### 3.2.2 Kolao Farm and Bio-Energy Co Ltd.

In Lao PDR, a large area of land under Jatropha plantation include in the 10 of provinces (see Table 4). Kolao Farm and Bio-Energy Company is one of the biggest energy companies which have been into commercial Jatropha plantation business since 2006. The installed capacity of the biodiesel processing unit is 40 tons per day of seed crushed. The Kolao Farm and Bio-Energy Company in 2012 produced around 0.1 million of biodiesel (B-100) which was used domestically as well as exported. In total, private companies have approximately 60,000 ha of land under Jatropha plantation. In additional, thousands of farmers are involved in Jatropha program across the country [11].

**Table 4.** Area under jatropha plantation within 10 provinces in the country.

Name of province	Area planted (ha)	
	2009	2013
Xayabury	4,006	5,000
Vientiane Capital	6,033	1,000
Borikhamxay	475	-
Khammaune	192	-
Champasak	3,959	-
Oudomxay	4,672	5,000
Bokeo	1,903	2,000
laungnamtha	1,811	2,000
Laungprabang	1,073	3,000
Saravane	1,593	2,000
<b>Total</b>	<b>25,717</b>	<b>20,000</b>

#### 3.2.3 Lao Agro Tech Co., Ltd.

This company is involved in Biodiesel production using palm oil. The company sold around 0.2 million liter of blended fuel (B-5) to its subsidiaries. Palm (*Elaeise guineensis*) was introduced in Lao PDR in 2008 by the Lao Agro-tech Company with technical assistance from its Thailand based parent company for biofuel production. The total area under palm plantation in the country is close 410 ha, the plantation are spread in four provinces with majority raised under the biodiesel pilot project by the Lao Agro-tech Company (see Table 5). In addition there are other palm plantations raised in the country. The other companies Vanith Farms based in Phonhong district of Vientiane province and Jeeplaine Fans Factory in Thaphabath district of Borikhamxay province have also introduced palm varieties [11].

**Table 5.** Area under palm plantation in the country.

Name of province	Area in 2013 (ha)
Vientiane Capital	79.84
Vientiane province	150
Borikhamxay province	78
Xayabury province	103
<b>Total</b>	<b>410.84</b>

### 3.3 Existing Institutional Arrangements Supporting Biofuels Production

Considering the long value chain of biofuel production from feedstock plantation to the final biofuel use, it becomes imperative to have a sound institutional arrangement incorporating different stakeholders at the different stages. Organized interlinking of concerned institutions is likely to help meet the countries biofuel objectives. Currently, there are four pilot biodiesel demonstration units set up by three private companies. These companies acquired support from various government agencies, local organizations, research institutes non- government institutions and funding agencies. The main government ministries

working towards the development of biofuels are mentioned below.

1. Ministry of Energy and Mine (MEM)
2. Ministry of Science and Technology (MOST)
3. Ministry of Industry and Commerce (MIC)
4. Ministry of Natural Resource and Environment (MONRE)
5. Ministry of Planning and Investment (MPI)
6. Ministry of Agriculture and Forestry (MAF)
7. Ministry of Public Works and Transport (MPWT)
8. Ministry of Finance (MoF)
9. Bank of Lao PDR

The Ministry of Energy and Mine in its Renewable Energy Development Strategy in Lao PDR in 2011 identified 11 line departments envisaged as the prospective stakeholders in the biofuel program of the ministry (see an annex B) [11].

#### 4. Strategy and Policy for Renewable Energy Development in Lao PDR

The Government of Lao PDR's vision is to promote the development of renewable energies as an important component of the national economic development to ensure energy security, sustain socio-economic development and enhance environmental and social sustainability.

##### 4.1 Policy

The promotion and development of renewable energies is one of the priority policies of the Government to stabilize energy supply and to assist in the social and economic improvement of the country.

The Lao Government supports domestic and foreign entrepreneurs and investors to invest in energy projects at the village level. The development of renewable energy resources while responding to the needs of the local people contributes to the process of becoming self-sufficient in energy supply and for the development of energy exports. Renewable energy development involves participation of public and private sectors.

Policies on the promotion and development of renewable energies in Lao PDR focus on Small power development for self-sufficiency and grid connection, biofuels production and marketing, and development of other clean energies in the country.

##### 4.2 Targets for 2025

The Government aims to increase the share of renewable energies to 30% of the total energy consumption in 2025. To reduce the importation of fossil fuels, the Government outlines a tentative vision to reach 10% of the total transport energy consumption from biofuels. This target will be regularly revisited and revised, feeding in results of special studies, lessons learned from on-going implementation, and international technological developments in the field of renewable energy. The government policy is to promote investments in energy production from public and private sectors, and from local and foreign investors.

In constructing the renewable energy road maps, timelines and milestones were defined for the proposed policy, legal, financial, market and organizational interventions for each renewable energy type to meet the national target and specific renewable energy targets for 2025. Road maps for the following renewable energies are following below [1].

##### 4.2.1 Promotion and development of bio-fuels

Bio-energy provides an alternative fuel supply for the transportation sector and in the supply of energy to rural communities. Without domestic oil and gas resources, Lao PDR is completely dependent from external sources for its petroleum

fuel requirements. To reduce the importation of fossil fuels and optimize the use of marginal lands, the Government will encourage and actively promote development of fuel crops in the country with a preference for smallholder production under maintained community land ownership and control.

This strategy aims to kick-start the development of the biofuels market in the country through the provision of incentives to farmers, domestic and foreign investors to engage in the production of biofuels for domestic utilization and at the same time monitor its development and ensure proper mitigation of negative impacts. The tentative vision for the promotion and development of biofuels are the following:

- Substitute 10% of the transportation fuel demand by 2025;
- Increase deployment of biofuels technologies in rural areas.

##### 4.2.2 Promotion and development of small hydropower

Hydropower resource is the most abundant energy resource in Lao PDR. The development of small hydropower (capacity up to 15 MW) could play an important role in meeting the country's objectives of increasing rural electrification coverage from the current level of 70% to 90% in 2020. Lao PDR has substantial potential for small hydropower development which is estimated to be around 2,000 MW. The government intends to develop around 650 MW of small hydropower capacity between 2010 and 2025 by private and community.

##### 4.2.3 Promotion and development of solar energy

Solar energy is one of the abundant energy resources in Lao PDR. The country receives an average solar irradiation between 3.5 to 5 kWh/m<sup>2</sup>/day. Solar energies can play an important role in achieving government objectives to provide energy services to off-grid and remote areas, stimulate private sector investments, and improve energy efficiency in households and commercial buildings. For the period 2010-2020, the Government under the Rural Electrification Master Plan (REMP) aims to upscale the program covering additional 19,000 households within 331 villages in 11 provinces.

##### 4.2.4 Promotion and development of biogas

Significant potential exist in Lao PDR for biogas production from animal and livestock wastes, agro-industrial wastes, municipal solid wastes and waste water treatment plants. The Government aims to sustain these initiatives by up scaling and increasing the number of households using biogas by 50,000 in 2025 to reduce the importation of LPG, the use of firewood and charcoal, and the use of electricity for heating. The Government also promotes the development of large-scale biogas production for lighting, heating and electricity generation (either for project owner's own use or for grid connection) using several feedstock such as agro-industrial wastes, municipal solid wastes, waste water treatments, and others.

##### 4.2.5 Promotion and development of other biomass energies

Lao PDR generates substantial amount of wastes from agriculture and forest production and processing such as sugarcane bagasse, rice husks, corn cobs, wood wastes, etc. Also, with growing urbanization, main cities are also generating significant amount of solid wastes. At present, there is no large-scale exploitation of these resources for energy generation. The Government recognizes the use of these agricultural and municipal solid wastes to form part of the overall energy mix to ensure energy security of the country.

##### 4.2.6 Promotion and development of wine energy

Based on the existing data, Wind energy can be potentially developed for large-scale grid connected power generation and for hybrid systems providing energy services to rural and remote

villages. The Government aims to develop around 50 MW of wind power by 2025 to promote the development of wind energy in the country.

#### 4.2.7 Promotion and development of the other alternative energy sources for transport

The government promotes and encourages domestic and foreign, public and private sectors, to invest in research, development and demonstration as well as in feasibility studies of other alternative energy technologies and sources for transportation sector.

### 5. Conclusions

In line with the international development in the green energy space, Lao PDR too has displayed intent to exploit the natural resources available to country. The country plans to shift from conventional fossil fuel energy sources (for which country completely relies on imports) towards renewable energy sources. The government of Lao PDR launched its Renewable Energy Development Strategy in October 2011 by Ministry of Energy and Mine to increase the share of renewable energies to 30% of the total energy consumption by 2025. Specific to transport sector, a target of 10% of the total transportation energy consumption from biofuels is set for the same period. To achieve the goals set by the government, there must be a clear and systematic policy following as:

- Increase the use of renewable energy to hold at least a 30% share of the total energy produced by 2025, based on government targets, and ensure all households have access to electricity;

- Create mechanisms and incentives for investment and facilitate the renewable energy market to attract more private sector investment in the development of renewable energy projects. Maintain industrial growth while decreasing costs step by step, to promote a competitive market. Develop policies that support fund raising and public investment in the promotion and demonstration of renewable energy.

- Conduct research and use leading technology in un-developed areas. Integrate alternative energy within various infrastructures such as education, health, water supply, irrigation and sanitation, roads and communication to promote social welfare, production, trade and economy for people in the rural areas;

- Promote and facilitate the construction of materials and equipment factories for renewable energy technology within the country in order to produce low price technology, improve the service, create more jobs and enhance the technical skills of the local people.

Some suggestion that policy interventions are probably the most important support required from the local government in areas ranging from feedstock plantation to biofuel production following as [11].

- The Government needs to fix up minimum feedstock gate price, as this will benefit small farmers

- The Government may identify marginal land and waste land, which may be provided to landless farmers to cultivate

biofuel crops to increase feedstock production and also enhance their livelihoods

- The Government needs to provide support through policy formulation for contract farming ensuring feedstock buy back with a minimum guaranteed price for the feedstock. In Lao PDR, contract farming exists, but there are violations in the absence of legal bindings to the mechanism

- The Government through policy intervention may provide a guaranteed market for the byproducts of biofuel production.

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**Annex A. Potential and capacity to meet 30% target of renewable energy development until 2025.**

Item	Renewable energy types	Aptitude potential	Existing	2015		2020		2025	
		MW	MW	MW	Ktoe	MW	Ktoe	MW	Ktoe
<b>A</b>	<b>Electricity</b>			140		243		728	416
1	Micro Hydropower	2000	12	80	51	134	85	400	256
2	Solar	511	1	22	14	36	23	33	21
3	Wind	>40		6	4	12	8	73	47
4	Bio energy	938		13	8	24	16	58	37
5	Biogas	313		10	6	19	12	51	33
6	Solid waste	216		9	6	17	11	36	23
7	Geothermal	59							
<b>B</b>	<b>Bio-fuel</b>	<b>ML</b>	<b>ML</b>	<b>ML</b>		<b>ML</b>		<b>ML</b>	
1	Ethanol	600		10	7	106	178	150	279
2	Biodiesel	1200	0.01	15	13	205	239	300	383
<b>C</b>	<b>Thermal energy</b>	<b>Ktoe</b>	<b>Ktoe</b>						
1	Biomass	227			23		29		113
2	Biogas	444			22		44		178
3	Solar	218			17		22		109
<b>Total</b>									
Energy demand (Ktoe)		2145			2504		4064		4930
Renewable energy contribution					172		668		1479
Proportion		30%			7 %		20%		30%

**Annex B. Institutional arrangement for biofuel program.**

No	National Agencies	Objective	Biofuel program specific role and responsibility
<b>Ministries and Government Department</b>			
1	Ministry of Energy and Mine (MEM)	The national level cross-sector coordination body supports development for implementation of specific action plans for Renewable Energy programs	The Institute of Renewable Energy Promotion (IREP) of MEM is responsible for all the biofuel programs in the country. The institute manages the pilot program for biofuel development and also works on developing policies and strategies to help meet national biofuel targets.
2	Ministry of Industry and Commerce (MIC)	It is the government ministry responsible for governing and developing industrial and commercial activity in Lao PDR	All imports (equipment and machinery imports, seeds) Role in retail chain development for the biofuels
3	Ministry of Agriculture and Forestry (MAF)	The apex agency is responsible for management of country's natural resources including allocation, protection and management of agricultural land, forests, watershed, conservation and protected areas.	To permit agriculture sector commercial activities To permit introduction of new species to the country
4	Ministry of Planning and Investment (MPI)	The main function of the MPI is to coordinate with the Government's line ministries in the development of their socio-economic development strategies. MPI is also responsible for implementing investment, promoting regulation, and for overall investment approval.	It prevents investment which potentially causes negative impact on the environment at present or in the long-term 163 and requires investors to protect the environment. It promotes and grants incentives to investment activities that protect the environment or biodiversity
5	National Agriculture and Forestry Extension (NAFES), (Department of the Ministry of Agriculture and Forestry)	Institution solely dedicated for the agriculture extension activities	Capacity building of farmers for improvement of farm productivity
6	Ministry of Natural Resources and Environment (MONRE)	National resources and environment management	Responsible for developing and enforcing requirements and guidelines and to minimize adverse environmental and social impacts of any plantations of biofuel feed-stock crops
7	Ministry of Public Works and Transportation	Promote the use of alternative fuels in individual vehicles, public transportation	The introduction of policies that promote the use of alternative fuels in transport sector
8	Ministry of Finance	Determines policies on taxes and duties	Determines appropriate tax and duties policies for land use, vehicles and equipment to be used for renewable energy projects while at the same time assist in raising funds for renewable energy development
<b>Financial Institutions</b>			
9	Central Bank of Lao PDR	Apex bank in the country responsible for banking sector policies	Consider credits and low interest loans for priority sectors including agricultural promotion, fuel crops plantation development and SME projects
<b>Technology Partnerships</b>			
10	Renewable Energy and New Materials Research Institute, (Ministry of Science and Technology (MOST))	The Institute has the mandate to conduct research on new energy technologies and fuel products	The institute conducts research and pilot testing of the renewable energy options including the quality of biofuel produced. The institute also disseminates the learning to the stakeholders.
<b>Other Entities</b>			
11	Lao State Fuel Company	State fuel company responsible for import and retailing of ~30% petroleum fuel.	Lao State Fuel Company is the largest player in the fuel market in the country and it also has aggressive plans to introduce biofuel in its sales portfolio.