

Research development of biofuels potential in Lao PDR

Dona Souliyathai^{1,2}, Yubao Chen^{1,*}, Boualy Vongvisith^{1,2}, Xingyong Li¹, Ming Li¹, Wudi Zhang¹

¹The China-Laos Joint Lab for Renewable Energy Utilization and Cooperative Development, Yunnan Normal University, Kunming, Yunnan, China

²Renewable Energy and New Materials Institute, P.O.Box: 2279, Vientiane capital, Lao PDR

*Corresponding author e-mail: c20072007@163.com

Abstract. Many countries support and promote new technologies that make use of other renewable resources particularly in Lao PDR. Research on energy crops for biofuel production is in its initial step in Lao PDR, and has high potential for biofuels production from the byproduct of agricultural production, such as crop oils including Jatropa, palm oil, soybean and others that can be utilization as feedstock for biofuel production in Laos. The promotion of biodiesel and bio-ethanol production in Lao PDR is target driven rather than based on the overall land area suitable for agriculture. Plantations of agricultural crops suitable for biodiesel and bio-ethanol production may displace traditional crops and grazing areas and disrupt farm livelihoods. Lao government hoping a target of the total transportation energy consumption from biofuel will be achieved in the same period. Therefore, to completely achieve of the Lao government's goals and targets, Lao government has play important role to push up increasing of promotion for production and using of renewable energy. This paper is to study focus on status and risk of biofuels development and the feedstock potential for biofuels production in Lao PDR as well.

1. Introduction

The worldwide scarcity of raw mineral resources is well known. International Energy Agency has suggested that underground petroleum reservations are sufficiently using about 50-60 years in the further, natural gas for about 150 years, and coal for about 200 years (ADB, 2009) [1]. Many countries support and promote new technologies that make use of other renewable resources. In particularly, Lao PDR is a landlocked country without underground petroleum sources, which every year have imported petroleum from the border countries. Lao PDR is one of the 13 least developed countries (LDC) in the Asia Pacific Region which population has increased from 5.5 million in year 2015 to 6.7 million in 2016, annual economic growth duration year 2010 to 2015 was between 7.5% – 8%, and the energy demand within Lao PDR has highest raised importing of petroleum [2]. Especially, the demanding of energy consumption in transportation sectors has rapidly increased of personal vehicle ownerships, Agriculture was and still is the main sector of the national economy follow by the industrial and service.

The National Growth and Poverty Eradication Strategy (NGPES) is the comprehensive strategic framework under which Lao PDR's growth and poverty eradication programs will be developed and



implemented. The NGPES is the result of an extensive process involving development partners and national stakeholders that started in 1996 when the 6th Party Congress defined the long-term development objective as freeing the country from the status of least-developed country by 2020.

2. Energy Situation in Lao PDR

The energy situation in Lao PDR is characterized by low conventional energy consumption. In 2002, biomass energy as fuel wood and charcoal were used in different sectors within country, especially in residential, commercial and small - scale of industrials for 78%, petroleum was only 16 % and electricity has 6%, respectively [3]. The high proportion of fuel wood consumption reflects its widespread use. Imported oil and LPG are mainly used in the industrial sector. Wood fuels consumption in 2002 was 2.4 million tons and accounted for 69% of total energy consumption in Laos. It is estimated that about 94% of the households use wood fuels for cooking. Charcoal is one of the important traditional sources of energy for both urban and semi-urban populations, and is used mainly for cooking. From 2006, petroleum imported in Lao PDR has total about 450 million liters and increased to 558 million liters in 2008 [1].

According to the MEM from 2000-2004, the number of vehicles increased tenfold from 51,000 in 2000 to 557,000. The transport sector consumed 165 million liters of gasoline and 365 million liters of diesel in 2008 [1]. In the same year there was 631 million liters of fossil fuels used for transport, 16 million liters for agriculture and 10 million liters for industry. According to Ministry of Energy and Mine was estimated that fuels consumption in 2010 will be 561 million liters, and still increasing to 716 million liters by 2015, which imports are estimated to rise to 914 million liters by 2020. An alternative projection, based on fossil fuel imports of the Lao State fuel Company, suggests future consumption could be much higher to 831 million liters in 2015 and will be increasing to 1,166 million liters by 2020 [4].

Laos has plenty source of renewable energy, biomass (mainly fuel wood) supply of around 46 million tons per year. It could generate about 3.9 million tons of agricultural residues per year. According to that volume, about 2.9 million tons are from rice straw, 0.44 million tons as rice husk, and 0.15 million tons as maize stalks. An estimate shows that about 264 million cubic meters of gas per year could be generated from the manure of buffalo, cows and pigs [1]. At the present, the exploration of energy source in the country are only hydropower and solar energy for electricity and biomass based fuel wood and charcoals other renewable energy sources for various applications are less explore.

Status and development of Biofuels in Laos.

2.1. Biomass energy resources in Laos.

Biomass is organic matters forestry and agricultural wastes resources that can be converted to energy resources as based on renewable energy resource which biomass or biofuel is addressed here from two perspectives. The first is the use of agricultural residues for household cooking and heating and for commercial purposes to generate electricity. The second is the growth of selected crops as feed stocks for the production of biodiesel and bio-ethanol, which are blended with diesel and gasoline to reduce dependence on imported fuels (ADB. 2011) [1]. Ministry of Agriculture and Forestry (MAF) data for 2010 were used in estimating the potential of biomass energy from agricultural production from year 2015 – 2016 (Table 1) [5], show that agricultural residues are the potential for biomass energy from rice, maize, sugarcane, and other agricultural residues is very high. Residues generated in the field (primary residues) include paddy straw, sugarcane tops, maize stalks, and cassava stalks, while residues produced during processing (secondary residues) include rice husks, sugarcane bagasse, cassava stalks, and maize cobs.

In the table 1 shows the total harvested areas of rice production in 2105 was 965,152 ha, and these areas can produce rice production about 4,102,000 ton per year and 4.3 ton per ha in rice yield, but in the year 2016, rice production was slightly increased for 4,148,800 ton per year [3]. In the another

crops production in 2016, including starch roots as cassava, sugarcane, soybean and moonbeam have been increased year by year, which those crops production are explored in different regions of Laos.

Table 1. Agricultural residues potential for development of biofuels.

No	Crops production	2015			2016			Annual growth rate (%) 2015-2016
		Harvested Area (ha)	Production (ton)	Yield (ton/ha)	Harvested Area (ha)	Production (ton)	Yield (ton/ha)	
1	Rice	965,152	4,102,000	4.3	976,229	4,148,800	4.2	1.1
2	Maize	254,025	1,516,250	6.0	258,956	1,552,320	6.0	2.4
3	Starch roots	75,465	2,382,478	31.6	102,920	2,779,185	27.0	16.7
4	Peanut	20,880	62,010	3.0	26,680	63,020	2.4	1.6
5	Soybean	11,880	18,675	1.6	12,070	19,130	1.6	2.4
6	Mungbean	3,000	4,775	1.6	3,045	4,830	1.6	1.2
7	sugarcane	36,130	2,018,655	55.9	36,190	2,019,000	55.8	0.0
8	Tobacco	6,360	63,040	9.9	6,880	66,800	9.7	6.0
9	Cotton	1,980	1,910	1.0	2,210	2,530	1.1	32.5
10	Coffee	93,385	135,925	1.5	94,210	136,600	1.4	0.5
11	Tea	5,140	6,295	1.2	4,515	7,300	1.6	16.0
12	Vegetable	179,690	1,683,405	9.4	180,820	1,690,900	9.4	0.4

National Statistic Centre (NSC), Department of Planning and Cooperation (DPC), Ministry of Agriculture and Forestry (MAF). 2017. Lao Statistics yearbook

2.2. Analysis of potential energy crops for biofuels production.

The government recognizes the potential of biofuels to help meet the country's energy demand. The potential capacity for biofuels development is being studied by several institutions and will be outlined in the following sections. Owing to the relative dearth of information on biofuels in the country, the report details the findings of a survey on the range of feedstock crops available to identify suitable options for the production of biofuels in the country.

2.2.1. Crops for biodiesel production.

Promising oil-producing energy crops available in the Lao People's Democratic Republic (Lao PDR) include Atrophy, coconut, oil palm, and the castor oil plant. The agronomic and oil production capacity of these crops differ greatly. Exploitation of these crops for oil production on a large scale has not yet been attempted in the country. For biodiesel production, the most valuable crops are those that require low inputs and have high oil content. The *Bernicia 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 (Table 2 and Table 3) [6].

Table 2. Area under *Bernicia 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
Total	40	787	41,172	13,119

Kolao Farm and Bio-Energy Company is one of the biggest energy companies which have been into commercial *Jatropha* plantation business since 2006. The total of palm plantation area in the country is nearly 410 ha, the plantation are spread in four provinces with majority raised under the bio-diesel pilot project by the Lao Agro-tech Company.

Table 3. 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
Total	25,717	20,000

This annual plant is also grown in the Laos and currently covers a total area of 8,920 ha. Soybean (*Glycine max*) can grow in altitudes of up to 3,000 meters and, hence, is suitable for mountainous regions such as the north in country. The beans can have a maximum oil content of approximately 20%, or 0.17–0.67 t/ha [6].

2.2.2. Crops for ethanol production. *Ethanol production can be used as alternative for fuel.* Crops for ethanol production are the saccharose- (sugar) and starch-producing crops such as sugarcane, cassava, and maize. Sugarcane (*Saccharum officinarum*) is one of the most efficient plants at transforming the sun's energy into carbohydrates. It can produce highly at 110 t/ha of stalks annually. In the Lao PDR, area of sugarcane cultivation is about 36,190 ha, producing an average annual yield of 55.8 t/ha [6]. The main output of this plant is saccharose and biomass. The saccharose can be transformed into ethanol [7]. Approximately 15 kilograms of sugarcane are needed to produce 1 l of ethanol. Cassava (*Manihot esculenta*) is an easily cultivated, woody shrub that is grown widely in the Lao PDR, which the production was 2,779,185 ton, annual yield was 27 ton/ha and annual growth rate was increased to 16.7% when compared with the last year, average annual yields of maize are usually in the range of 6 t/ha [6]. Besides the production of ethanol, maize is used for food and feed production in the Lao PDR.

2.3. *Biofuel development situation.*

In the past, fuel crops plantation for the production of biofuels had been initiated by private investors. 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. 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 by importing of fossil fuel approximately 560 million liters in 2010, and significantly increased to 5% per year to causes the external supplying disruptions and increased price of fossil fuel, that its negative impacts to Lao country's balance of payments [1]. So that, the objective of Lao government is to reduce of fossil fuel and also optimize the use of marginal lands. Therefore, Lao government have to encourage and actively promotion and development of alternative energy technology by using byproduct of agricultural wastes and other crops to do not conflict with food safety within country from a preference with smallholders production under maintaining community land ownership and as well as controlling.

The bio-fuel sector is currently hardly developed in Laos, but there is a growing interest amongst the government, private sector, research institutes and NGOs have been conducted research on biogas, biodiesel (especially with *Jatropha*), ethanol, biogas and biomass gasification to produce electricity. Biodiesel can be produce 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, particularly are *Jatropha*, *Vernicia Montana*, Palm, Sugarcane, Cassava plantation area.

Several potential biofuel investors are showing a growing interest in acquiring land and starting plantations with a view to producing fuel from energy crops in the Lao People's Democratic Republic (Lao PDR). Some initiatives aim to contribute to the promotion and development of fuel crops as feed stocks for biodiesel and ethanol production; however most remain at the conceptualization stage and there has been little, if any, implementation. Current and potential players in the biofuels arena fall into four categories: government authorities, nonprofit associations and research institutes, private companies, and international nongovernment organizations.

3. Risk of Biofuel development analysis.

3.1. *International Challenges.*

Various external challenges exist which affect the promotion and the development of renewable energies, and these are:

- Climate change due to the release of carbon dioxide in the atmosphere;

- Developing economies are transforming from agriculture to industrial based economies. This results in the growth of energy use as the manufacture of domestic products relies increasingly on industrial production;

- Expansion of urbanization and modern cities shows change in energy consumption patterns;

- Biofuel developments are still dependent on foreign donors and investors;

- Income generation and employment derived from Biofuel development are not very high.

3.2. *Domestic challenges.*

Key challenges and constraints on the development of renewable energies in Lao PDR are as follows:

- No specific policies or strategies on renewable energy promotion;

- Lack of coordination between stakeholders in Biofuel projects;

- Biofuel development policy has not yet been clearly stated in the National Socio-economic Development Plans or in strategies on growth and poverty reduction, as well as five year plans of the government;

- Lack of specific regulations and laws on Biofuel;

- It was not clear yet, who responsible for approval of Biofuel development projects;

Users have insufficient knowledge and understanding on Biofuel development;
Lack of public funding support for the Biofuel sector, especially for research and development;
Absence of energy pricing regulation is a risk for investors;
Insufficient information on renewable energy potential for provincial level;

4. Policy Goals and Strategies to support biofuel production and development.

4.1. Policy goals and Principle.

The tentative vision for the promotion and development of biofuels are the following:

Lao Government play important role for the development of biofuels also contributes to reducing fossil fuel dependence. Develop biofuels as a new economic subsector that creates a new source of revenue and jobs for the local population, especially in rural areas, thus provide poverty decrease [3].

Promote biofuels production and appropriate technologies suitable for identified land areas. This should not compromise the development of land for food production, or the collection of non-timber forest products important to the local population. It should also avoid areas with cultural or religious sites, while avoiding damage to livelihoods, and helping preserve the cultural assets and natural environments of the Lao people, also in plantation areas.

Ensure that legal and financial conditions are adequate, both for potential investors and farmers who would participate as contracted parties, promote new technology for the production of biodiesel and bioethanol and as well as research for new technologies for the biofuel industry.

4.2. Strategies and Targets.

The Government purpose to increase renewable energy consumption and reduce the importation of fossil fuels, this target will be regularly reviewed and revised, feeding in results of special studies, lessons, learned from on-going project, and international technological developments in part of renewable energy. The government policy is to promote investments in renewable energy production from public and private sectors, and from local and foreign investors [8].

Promote energy-saving strategies and more efficient energy consumption practices, beginning with all government division; the cultivation of oil crops for processing into biodiesel and bioethanol, which could initially fuel low-speed engines and could subsequently fuel high-speed engines;

Promote foreign investment and facilitate the importation of appropriate technologies by providing government incentives, such as tax exemptions and tax holidays;

Promote private sector more take part in research, promotion, development, and investment in biofuels.

To increase the importation and consumption of fossil fuels and utilize of marginal areas, the Government will inspire and actively promote development of fuel crops in the all country with a favorite of smallholder production under control and take care of the government.

5. Conclusion

In summary, Lao PDR is confronting with many challenges to develop biofuel, to increase power of country's economic growth and promote energy stability in a manner that will not impact food security. The country plans to shift from conventional fossil fuel energy sources (for which country completely relies on imports) towards renewable energy sources, which the Lao government has been strongly promoting the production of biofuels. Designated energy crops provide oil as feedstock for biodiesel, and molasses and starch as feedstock for bio-ethanol. Specific to transport sector, a target of 10% of the total transportation energy consumption from biofuel is set for the same period. Therefore, to achieve the goals set of the government, that the Lao government push up increasing the using of renewable energy at least 30% sharing of the total energy production by 2025, to 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, conduct research and use leading technology in un-developed areas, and 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.

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