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Biofuel Series

Biodiesel & Biogas project-activities

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About us

LIRE is a non-profit organisation dedicated to the sustainable development of a self sufficient renewable energy sector in the Lao PDR. The institute offers agronomical, technological and socio-economic research services, and works to provide a free public resource of information and advice on the use of renewable energy technologies in Laos. LIRE strives to support the development of the country by exploring commercially viable means to establish renewable energy technologies in rural parts of the country, in areas without connection to the national grid and with little access to technical expertise.

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Introduction

The consultancy on biodiesel and biogas project at the Lao Institute for Renewable Energy during the period of 8th February to 7th March 2012 has implemented activities listed below.

Biodiesel project

- Writing procedures for decreasing the amount of free fatty acid and phosphorus in the crude oil;
- Laboratory testing: water treatment;
  Citric acid treatment;
  Lime treatment;
  Rice husk ash treatment;
  Esterification of free fatty acid from Jatropha crude oil;

Biogas project

- Scope of the study;
- Design of biogas pilot digester;

I Biodiesel project

Activities that have been implemented during the consultancy on biodiesel project have focused on procedures writing, the processing of rice husk ash sample and laboratory testing.

1 Procedures writing

Procedures have been written for implementing laboratory testing for fatty acid esterification, decreasing the amount of fatty acid and phosphorus in the crude oil. The written procedures are available on LIRE server on the following folder: 5.FACT_Study-2008-11/Alpha phase/Laboratory.

The amount of fatty acid and phosphorus that are present in oil should not excess some levels (0.25 % for fatty acid and 10 ppm for phosphorus) because these two compounds can cause problem during trans-esterification. Fatty acid react with catalyst of trans-esterification and produces soap that can make stable emulsion with biodiesel and glycerol resulting in biodiesel contamination, yield loss and potential instability during biodiesel storage (oxidation, polymerization).

Phosphorus is present in vegetable oil in the form of phospholipid. Like fatty acid phospholipid can make emulsion during biodiesel processing and they can also plug fuel system because they are slimy compounds. During the combustion of biodiesel phospholipid can also produce abrasive scaling in the chamber of the engine.

Consequently the amount of fatty acid and phosphorus compounds should be reduce to an acceptable level in the crude oil before processing biodiesel.

1.1 Procedures for reducing the amount of free fatty acid in the crude oil

Two procedures have been written for decreasing the amount of fatty acid in the crude oil. The first procedure consists to make the esterification of fatty acid by methanol and acid catalyst for producing fatty methyl ester. The second procedure consists in the treatment of crude oil with rice husk ash for trapping free fatty acids that are contained in the crude oil.

For the implementation of this later a sample of rice husk ash has been produced at the laboratory of the Pharmaceutical factory number 3 of Vientiane.

1.2 Procedures for reducing the amount of phosphorus in the crude oil

Procedures for decreasing the amount of phosphorus in the crude oil are call degumming procedures because organic phosphorus are present in the form of gum in the oil. Three procedures have been written, water degumming, acid degumming and TOP degumming. Water degumming procedure consists to heat crude oil with water for removing hydratable phospholipids.

Acid degumming consists to heat oil with citric acid for removing hydratable phospholipids, non hydratable phospholipids, calcium and magnesium in crude oil. Like acid degumming TOP degumming procedure also removes hydratable phospholipids, non hydratable phospholipids, calcium and magnesium in crude oil but uses phosphoric acid instead of citric acid.

2 Laboratory testing

Procedures for decreasing the amount of fatty acid and phosphorus compounds have been implemented on two kinds of Jatropha crude oil, that are oil pressed by Lao State Fuel Company and oil pressed by LIRE at the Institute for Renewable Energy located at the KM 14 of Vientiane.

2.1 Procedures for decreasing the amount of fatty acid in crude oil

Three procedures have been implemented for reducing the amount of fatty acid in Jatropha crude oil, rice husk ash treatment, lime treatment and esterification of fatty acid. Rice husk ash (two tests) and lime treatment (one test) have been implemented on the oil that was pressed by LIRE and esterification of fatty acid (one test) has been implemented on the oil pressed by Lao State Fuel Company. The result of the first rice husk ash test is listed in the table below (table 1).

Table 1 : *Result of the first rice husk test*

	Acid value (mg KOH/g)	Percentage of removing (%)
Jatropha crude oil	7.56	
Test 1	6.89	8.8

The first test has only removed about 9 % of free fatty and another test is in progress for trying to increase the percentage of removing by increasing the amount of rice husk ash. A testing has also been implemented for extracting silica from rice husk ash. Silica has a higher adsorption capacity and a new testing will be implementing with silica extracted from rice husk ash in order to compare the percentage of removing from these two products. Lime treatment and esterification of fatty acid have also been implemented and the result of acid value will be know in the mid of March 2012.

2.1 Procedures for decreasing the amount of phosphorus compounds in crude oil

Two procedures have been implemented for reducing phosphorus compounds in Jatropha crude oil, water degumming and citric acid degumming. TOP procedure was not implemented because of the lack of phosphoric acid local supply. The two procedures have been implemented with the oil from Lao State Fuel Company and the oil from LIRE.

Only the tests from LIRE oil will be sending to the irrigation laboratory for analysis because the oil of Lao State Fuel was pressed for a long time and was not stored in good conditions. The analysis that will be performing on the degummed oil will be the analysis of calcium, magnesium and phosphorus.

The results of the analysis will allow knowing what will be the suitable procedure for decreasing the amount of calcium, magnesium and phosphorus in Jatropha crude oil. For the record and according ASTM and European standards the total quantity of calcium and magnesium in biodiesel should not exceed 5 ppm.

II Biogas project

Activities that have been implemented during the consultancy on biogas project have focused on the scope of the study and the design of biogas pilot digester.

1 Scope of the study

The scope of the study to implement has focused on the steps that have to be implementing before the building of digester and biogas processing for producing electricity in rural area of Lao PDR. The steps that have to be implementing are raw materials testing, analytical procedure to implement and biogas washing process to implement.

1.1 Raw material testing

Three kinds of raw materials will be use for feeding the digester, glycerol, Jatropha seed cake and pig manure. Some chemical analysis should be implementing on these three raw materials in order to assess their potentiality for producing biogas. Biogas testing should also be implementing with these three kinds of raw materials in order to know what will be the suitable ratio of raw materials to mix together for producing biogas.

1.2 Analytical procedure for assessing the amount of hydrogen sulfide in the biogas

The biogas that will be produce will be use for powering engine for producing electricity. For this purpose the biogas should contain no more than 0.15 % in volume of hydrogen sulfide to avoid corrosion problem. The hydrogen sulfide produced by anaerobic digestion is about 1 % in volume and consequently its amount should be reducing by a treatment before powering engine. The amount of hydrogen sulfide contained in the biogas before and after the treatment should be measure in order to assess the efficiency of the treatment. The proposed analytical procedure for hydrogen sulfide is the reaction of hydrogen sulfide with N, N-dimethylphenyl-1,4 diamine (DMPD) in presence of sulfuric acid and small quantity of iron chloride for producing methylene blue (MB^+), a dye with a characteristic blue coloration. The quantity of produced dye can be measure by visible spectrophotometer.

1.3 Washing process for biogas

The purpose of biogas washing is to remove hydrogen sulfide to avoid corrosion problem during the powering of engine and to remove carbon dioxide in order to increase heating value. Hydrogen sulfide can be removing by passing the biogas in chamber containing layer of iron oxide. Carbon dioxide can be removing by washing biogas with water or alkaline solution.

2 Biogas pilot digester design

The digester will be feed with Jatropha seed cake, glycerol and pig manure. Mesophile bacteria grow best between 30 to 35 ^{o}C and highest yield of biogas are obtained if there is few variations in temperature. In order to maintain good temperature conditions, the digester will be heat by solar energy and the thickness of wall of the digester will be optimized for avoiding large temperature variation during the day and the night.

The digester will be build in brick, cement and reinforced concrete including equipment for measuring temperature, pressure and quantity of biogas produced, level of supernatant and sludge and for mixing. According the quantity of biogas to produce per day (1 cubic meter), the dimensions of digester has been calculated and the quantities of pig manure and water for feeding the digester have been estimated. After analysis of pig manure the exact dimensions of digester will be calculating as well as the thermal design of the digester in order to optimize the thickness of the wall for maintaining a temperature in digester around 30 to 35 ^{o}C.